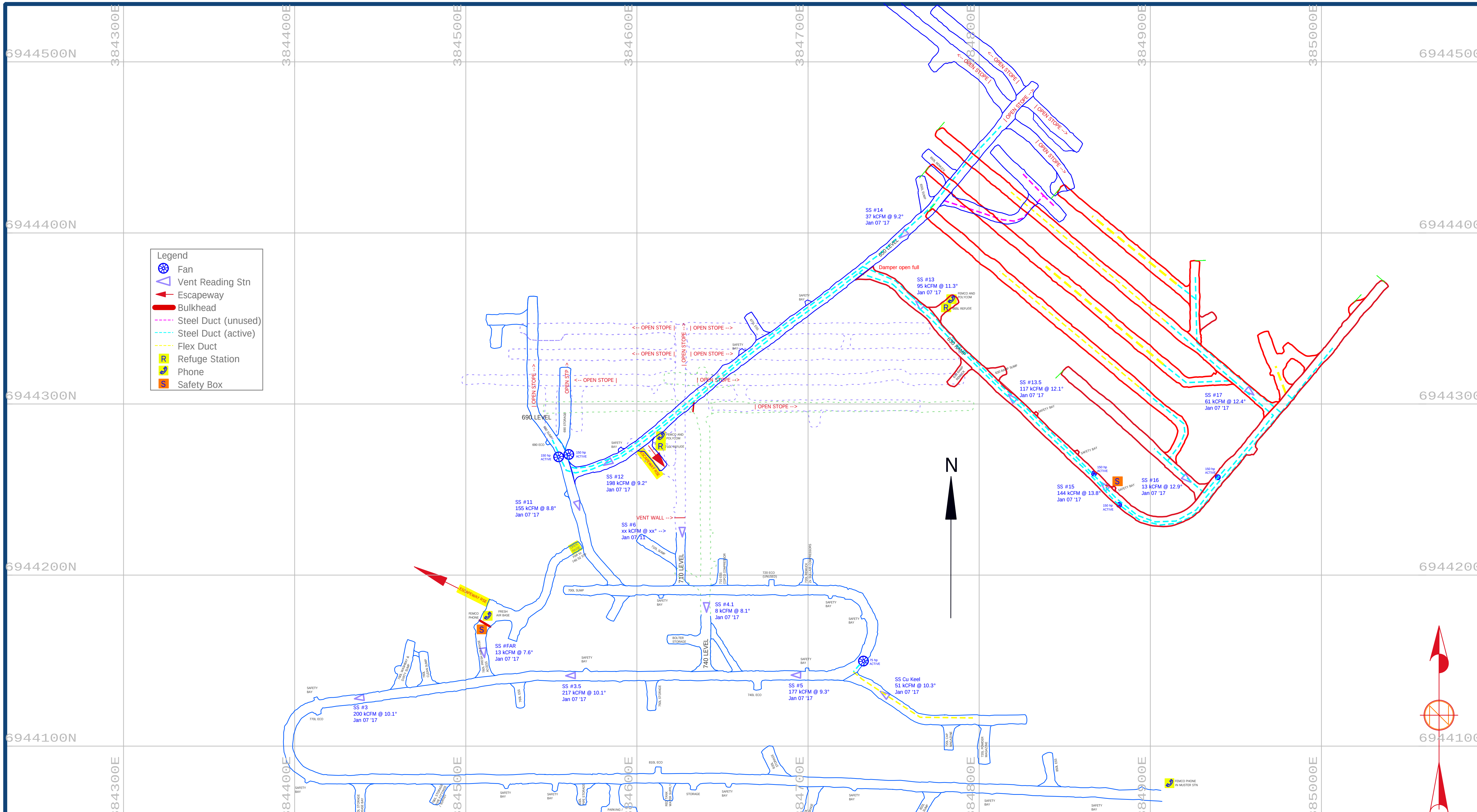
Appendix A – Minto Mine Underground Development Map



40 0 20 40 60 80 100

Metres

Weekly Vent Survey

DATE:	DRAWN BY:
07-Jan-2017	NH

capstone

MINTO MINE

Appendix B – Minto Mine Spill Contingency Plan

Minto Mine

2017 Spill Contingency Plan

Prepared by:

Minto Explorations Ltd.

Minto Mine

February 2017

Summary of Revisions (2017)

Section Revised	Description of Revision	Reason for Revision
All	• Updated dates and references to previous years SCP.	• Annual review and update
3.0	• Added reference to Type "B" Water Use License, and; • Changed structure of section to better separate the references to various licenses and regulations.	• To enhance relevant to all licenses, and improve readability
3.2	• Updated reference version of the Emergency Response Plan.	• Annual review and update
4.0	Updated Table 4-1 with the following: • Changed "non-poisonous gases" to poisonous gases, updated TDG code, and quantity; • Removed reference to "non-corrosive gases"; and, • Added quantity of "> 50 litres" for threshold quantity for Misc. Dangerous Goods (TDG Class 9.1)	• To comply with Schedule A of Yukon Environment Act (1996/193)
4.1	• Updated who is responsible for issuing the Environmental Incident Notification (previously Environment department).	• To incorporate procedure change in 2016
4.2	• Changed listed items for 24-Hour Spill Report line from dashes to bullets.	• Improve readability
4.2	• Clarified when Environment Canada should be contacted. • Table 4-2: updated contact information for EMR (Matthew Jenner); • Table 4-2: updated contact information for SFN (Jennifer Lee), and; • Table 4-2: corrected spelling for Environment Canada contact (Travis Teel).	• To ensure procedure and external contact information is current.
5.3	• Provided file location for the Minto Mine Spill Response Procedure and the LTF Standard Operating Procedure.	• To document where relevant files can be accessed.
6.0	• Removed sentence "Further training and skill development will take place in Spill Response Exercise to be staged in 2016" as it was no longer relevant. • Added a reference to loaner spill kits. • Updated Figure 6-1 to account for new/changed spill kit locations. • Updated Table 6-1 with revised contents of spill kits and addition of loaner spill kits. • Added information and picture about purchased Alpha Folding Weir Skimmer.	• Annual update of information
7.1.7	• Changed section title from "KPIs and Scheduled Re-Training" to "Training KPI's".	• Improve document readability and relevance.

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1 Introduction

Minto Mine (administered by Minto Explorations Ltd. (Minto)) is a high-grade copper and gold mine that is located 240 km north of Whitehorse, Yukon. Operations started in October 2007. The mineral deposits mined at the site were identified during exploration programs occurring in the area in the 1970's; exploration activities occurred sporadically since that time until construction of the mine and related facilities began in earnest in 2006.

This Spill Contingency Plan (SCP) is an update to the previous SCP, submitted in February 2016. The content of this SCP is derived from the *Plan Requirement Guidance for Quartz Mining Projects* (Yukon Government, 2013). The SCP has been updated annually and submitted as part of Minto's Water Use Licence and Quartz Mining Licence annual reports.

The purpose of the SCP is to establish guidelines for staff, contractors and suppliers working at the site with a formal framework of actions to be taken when responding to spills during mine operation. The SCP includes practices and planning of future efforts to further reduce the potential for environmental contamination and other spill-related impacts. The SCP describes the fuels, chemicals and other materials used at the Minto Mine, reporting thresholds for those materials, a spill action plan for responding to unintentional spills of those materials, reporting sequences and forms, training requirements, spill prevention activities and routine monitoring and maintenance.

1.1 Project Description

Minto Explorations Ltd. (Minto), a wholly owned subsidiary of Capstone Mining Corporation (Capstone), owns and operates the Minto Project located 240 km (150 miles) northwest of Whitehorse, Yukon. The Minto Mine is a high-grade copper and gold mine with ongoing operations since October 2007. The Project area encompasses the Minto Creek Valley which collects and drains in to the Yukon River (Figure 1-1). The Minto Mine is currently in Phase V/VI of operations. An overview of major infrastructure at the Minto Mine and the expansion of Phase V/VI is shown on Figure 1-2.

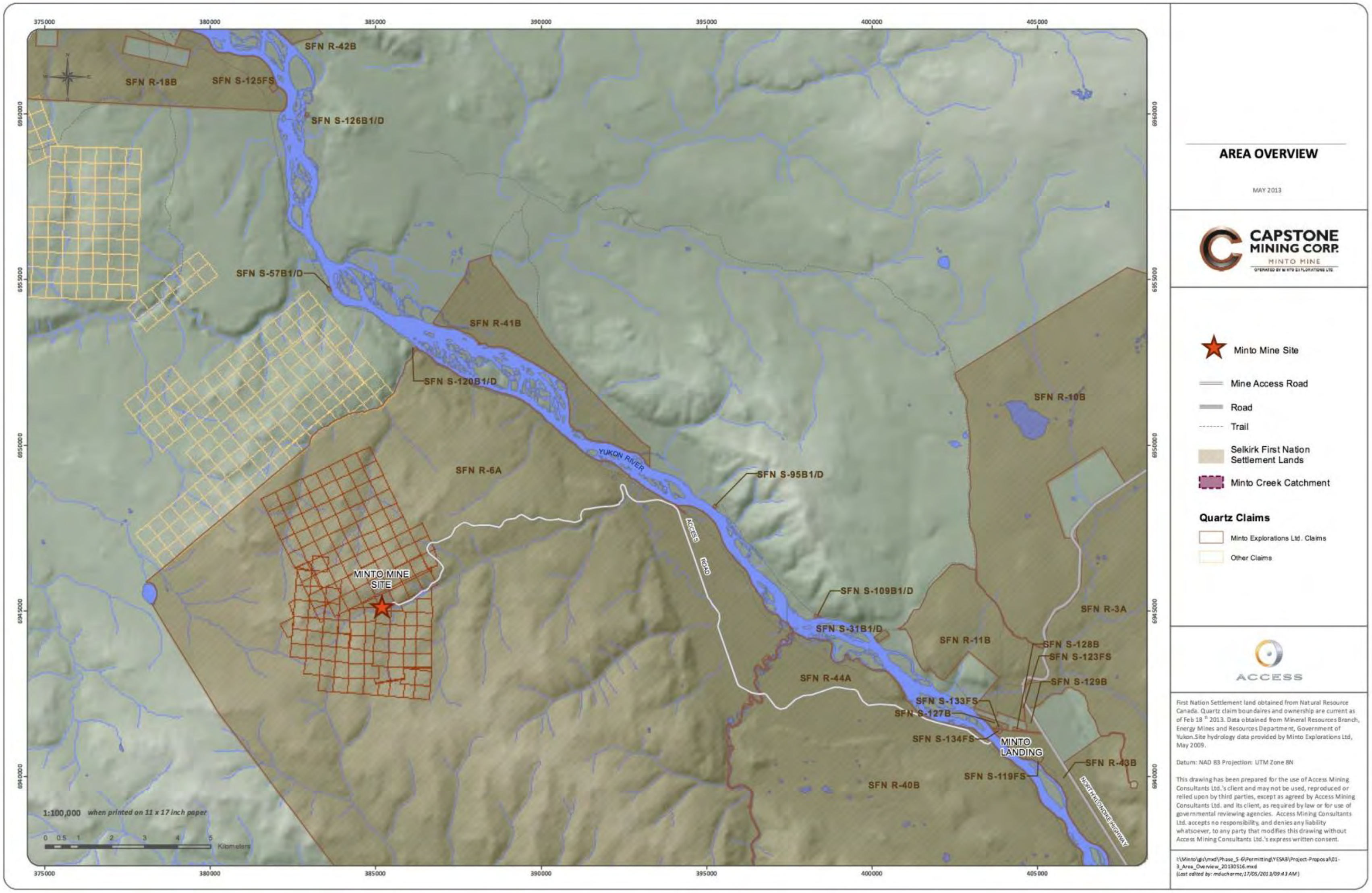

Figure 1-1: Minto Mine Area Overview

Figure 1-2: Minto Mine Area Overview – Existing and Phase V/VI Proposed Infrastructure

2 Definitions

The following definitions apply to the components of the SCP outlined herein.

Dangerous Good - A product, substance or organism included by its nature or by the regulations in any of the classes listed in the schedule to the act (*Yukon Transportation of Dangerous Goods Act)*.

Deposit out of the normal course of events - A deposit that can reasonably be expected to occur at the mine and that can reasonably be expected to result in damage or danger to fish habitat or fish or the use by man of fish, and the identification of the damage or danger (*Metal Mining Effluent Regulations, Part 3, SOR/2002-222)*.

Discoverer - The person that discovers an incident that could possibly result in a spill or has resulted in a spill.

Spill - A release of a substance in to the natural environment that is abnormal in quantity or quality in light of all circumstances of the release; or is in excess of an amount specified in the regulations (*Yukon Environment Act, Part 11*):

> **Emergency Spill -** A release of a hazardous product where there is potential for that product to enter a waterway or cause significant danger to life, health or environment.
>
> **Non-Emergency Spill -** All spills that do not meet criteria of an *emergency spill* and that the responsible party is competent to manage safely and efficiently in terms of assessment, prevention, containment and clean-up.

Substance - A hazardous substance, pesticide, contaminant or special waste often referred to as a "**deleterious substance".**

3 Purpose and Scope

Minto will ensure that all requirements related to Spill Response and reporting within these documents are implemented throughout the property for the life of mine. If statutory and regulatory responsibilities change over time updating of this Plan will result.

This SCP is prepared in support of:

- Minto's Type "A" Water Use License QZ14-031 (WUL) and Type "B" Water Use License MS15-094, which state that:

  > *"The Licensee shall apply the relevant procedures in the Spill Contingency Plan. The Licensee shall review the spill contingency plan annually and shall provide a summary of that review, including any revisions to the plan, as a component of the annual report."*

- *Part 3 – Deposits Out of the Normal Course of Events*, Section 30 of the *Metal Mining Effluent Regulations* (MMER), which indicates that:

> *"The owner or operator of a mine shall prepare an emergency response that describes the measures to be taken in respect of a deleterious substance within the meaning of subsection 34(1) of the Act to prevent any deposit out of the normal course of events of such a substance or to mitigate the effects of such a deposit."*

- *Part 7 – Emergency Response Assistance Plans and Security Plans of* the *Transportation of Dangerous Goods Act*:

> ***"****No person shall import, offer for transport, handle or transport dangerous goods in a quantity or concentration that is specified by regulation — or that is within a range of quantities or concentrations that is specified by regulation — unless the person has an emergency response assistance plan that is approved under this section."*

- Satisfying the requirements of the Quartz Mining License QML-0001 Schedule B, that requires:

> "A *plan that describes the measures designed to minimize the potential impact to the environment following a fuel or chemical spill."*

The SCP will apply to Minto Mine and the main access route for one year, whereby the owner or operator shall update and test the SCP to ensure it continues to meet the requirements of both the WUL, subsection 30(2) of the MMER, and the QML.

3.1 Purpose

The purpose of the SCP is to outline a general set of procedures to be followed to assess, prevent, contain and clean-up a spill at the Minto Mine. For procedures to be effective, Minto must ensure that employees and contractors, through experience and training, possess the skills necessary to safely assess, prevent, contain and clean-up a spill or potential spill. These procedures are necessary to ensure continuity and develop the foundation for a robust and effective SCP. The SCP is also designed to establish clear reporting and clean-up procedures as they apply to emergency and non-emergency spills and incidents.

This document also addresses opportunities to improve spill preparedness, response, and mitigation for deposits out of the normal course of events that have the potential to impact the Yukon River and its tributaries within the project site.

All Minto employees and contract staff must be familiar with the general spill reporting procedures outlined in this document and will be introduced to them as part of their site orientation.

3.2 Scope

The objectives of the SCP are to:

- identify potentially hazardous materials located on site;
- identify spill prevention measures;

- establish a high order of preparedness in the event that a spill occurs;
- ensure an orderly and timely decision-making, response and reporting process; and
- describe current and planned protective measures for all areas of the Mine Site

The *Minto Mine Emergency Response Plan* (Minto, 2017) contains other information that relates to Emergency spill procedures. The Emergency Response Team (ERT) and members of the Environmental Department have been trained on responding to Hazmat Spills. It is beyond the scope of this document to define the specific Spill Response Procedures and decision loops involved in an ERT response. Any details pertaining to a response from ERT to assess, prevent, contain and clean-up a spill at a spill incident is the responsibility of the Site Safety Department. General procedures for spill response procedures to emergency spills will be detailed herein.

3.2.1 Hardcopy Locations

Copies of the SCP are kept on-site at all times in the following locations: Mill Control Room; Site Safety Office; Environmental Office; General Manager's Office; Site Services Office; and on the Copper Queen Tug. Contact information is provided in Table 4-2.

4 Communication and Spill Reporting

Any spill that occurs at the Minto Mine site must be reported through the internal reporting chain of command and follow the procedures for assessment, prevention, containment and clean-up and reporting. Should a spill exceed the thresholds set by the Yukon Government (Table 4-1) then it must be reported to external authorities.

A spill in excess of the thresholds outlined in Table 4-1 or any spill that is abnormal in quality or quantity is considered a "reportable spill" under the *Yukon Spill Regulations* (O.I.C. 1996/193), pursuant to the *Environment Act*.

Table 4-1: Reportable Spill Thresholds

Product	TDG[1.] Code	Threshold Quantity
Explosives	1	Any amount
Flammable gases	2.1	> 100 litres
Non-flammable gases	2.2	> 100 litres
Poisonous gases	2.3	Any amount
Corrosive gases	2.4	Any amount
Flammable liquids	3	> 200 litres
Flammable solids	4	> 25 kg
Spontaneously combustibles	4	> 25 kg
Dangerous when wet	4	> 25 kg
Oxidizers	5.1	> 50 kg or 50 litres
Organic peroxides	5.2	> 1 kg or 1 litre
Poisonous substances	6.1	> 5 kg or 5 litres
Corrosive materials	8	> 5 kg or 5 litres
Miscellaneous Dangerous Goods	9.1	> 50 kg or 50 litres
Special wastes	9.3	> 5 kg or 5 litres

1. TDG = *Transportation of Dangerous Good Regulations* (Government of Canada, 1985)

4.1 Internal Reporting (All Spills)

All spills (whether reportable externally or not) must be reported by the discoverer to their immediate supervisor and then to either Site Safety or the Environmental Department by radio or telephone following assessment of the scene. The supervisor of the responsible department will issue an Environmental Incident Notification, with assistance from the Environment department, to notify the site and its directors including senior management. This typically occurs concurrently with spill response (prevention, containment and clean-up) activities.

Following the spill response, responsible department supervisors are required to document the spill on an Environmental Incident Report, available through the Environmental Department, and provided in Appendix A. The report requires inclusion of photos, a description of clean-up activities, subsequent actions, identifies root cause and determines any required corrective actions.

4.2 External Reporting (Reportable Spills Only)

Under federal and territorial regulations, the environmental lead will call the 24-hour Yukon Spill Report line should a spill of a reportable quantity occur (Table 4-1). Although several government agencies at the federal, territorial and municipal levels may ultimately be informed, only the Yukon 24-Hour Spill Report line is required for reporting purposes. The environmental lead will ensure that the appropriate information is collected before reporting to the Spill Report line.

Any spill of an amount greater than those listed in Table 4-1 or a spill of any amount that enters the Yukon River or a tributary of the river is a "reportable spill".

The following information should be provided to the 24-Hour Spill Report line:

- Name
- Phone number
- Product spilled
- Quantity spilled
- Quality of product (thin, viscous etc.)
- Location of spill
- Distance to water
- Distance to drinking water wells
- What happened
- Responsible party
- Actions to contain the spill

When reporting the spill to the Spill Report line, the environment lead will obtain the Environment Yukon Spill Reporting Number and first/last name of the person whom the report has been made to (in the event of a reporting discrepancy).

Minto will also contact: the Selkirk First Nation Lands Director; and Energy Mines and Resources Client Services and Inspections via email or phone after discovery of a reportable spill. Should the spill enter a waterway or be categorized as a major spill, Minto will also contact Environment Canada. A detailed written report will be submitted to the regulatory authorities within 10 days after the event. The contact information for the various Minto employees, emergency response and external reporting personnel is provided in Table 4-2.

Table 4-2: Contact Information for Minto Personnel and External Agencies

Resource	Email	Contact Number
Minto Internal Communications Contact Info		
Health and Safety Department	safety@mintomine.com	604 759-0860 ext. 4644
Environmental Department	minto_environment@mintomine.com	604 759-0860 ext. 4659
Ron Light, General Manager	ronl@mintomine.com	604 759-0860 ext. 4639
Ryan Herbert, Environmental Manager	ryanh@mintomine.com	604 759-0860 ext. 4659

Resource	Email	Contact Number
Emergency Phone Contacts		
Yukon 24- Hour Spill Line		867 667-7244
CANUTEC-Dangerous Goods Help (Transport Canada)		1-888-CANUTEC or 613 996-6666
Fire Department – Pelly Crossing (Emergency)		867 537-3000
Police – Pelly Crossing		867 537-5555
Health Centre - Carmacks		867 863-4444
Hospital – Whitehorse		867 667-8700
Fire Department – Whitehorse		867 668-8699 or 867 668-2462
Police – Whitehorse		867 667-5555
YG Department of Environment, Water Resources Branch		867 667-3227
YG Environmental Protection Branch		867 667-3436
Selkirk First Nations, George Magrum, Lands Manager		867 537-3331
YG EMR, Client Services and Inspections		867 667-3199
External Reporting and Contacts for Submission of Spill Reports		
YG EMR, Matthew Jenner, Natural Resources Officer - Mining	Matthew.Jenner@gov.yk.ca	867 863-5271
Selkirk First Nation, Jennifer Lee, SFN Director of Governance	governance@selkirkfn.com	867 537-3331 ext. 213
YG Environmental Health Services, Craig Van Lankveld, Environmental Health Officer	craig.vanlankveld@gov.yk.ca	867 667-8316
Environment Canada, Travis Teel, Enforcement Officer	Travis.Teel@ec.gc.ca	867-393-6705

5 Spill Action Plan

Implementation of the spill action plan requires knowledge of spill response supplies and locations, spill response procedures (Sections 5.1 and 5.2) and clean-up protocols (Section 5.3). In addition to the internal and external reporting requirements, spills must further be categorized as "emergency" or "non-emergency" incidents as the action plans and reporting requirements will differ according to the type of spill.

5.1 Spill Response Procedures: Non-Emergency

The majority of spills that are likely to occur on the Minto Mine Site will include a simple stepwise process initiated by the discoverer. If the safety at the scene is in doubt then it is imperative that the Site Safety department is notified immediately. A "non-emergency" spill is defined as a spill of any product that the discoverer, or other personnel within close proximity, of the incident can competently, safely, and efficiently manage in terms of assessment, prevention, containment and clean-up. This typically includes fuels, blasting agents, oils, lubricants or coolants and many of the reagents involved in mill operations. Once the scene is assessed for safety by the discoverer or supervisor and deemed non-emergency, they will prevent, contain and clean-up and contact the environmental team as soon as practical. If assistance is required to deal with the incident, the environmental team is to be notified by radio/telephone immediately.

A complete inventory of Dangerous Goods stored and used at the Minto Mine, including details on material handling and clean-up, reporting thresholds, special precautions, PPE requirements, and disposal methods is provided for reference during spill response activities (Appendix B).

5.2 Spill Response Procedures: Emergency

An "emergency spill" is a release of a hazardous product where there is potential for that product to enter a waterway or cause significant danger to life, health or environment. When a spill is discovered, the first step is to assess the scene for safety and **if safe to do so** immediately control and contain the spill by any means necessary. If the discoverer or other personnel within close proximity of the incident do not have the required training, resources or equipment to deal with the incident then the individual must report a "Code 1" callout. This protocol will initiate response of the Safety Department, Environmental Lead and the Emergency Response Team. The Emergency Spill Response Command Structure and General Spill Procedure are detailed in Figure 5-1 and Figure 5-2, respectively. If the scene is safe and the discoverer and the immediate supervisor have the means necessary to control, contain and recover the spill then they should proceed as such.

Once called via a "Code 1" the Safety Coordinator/Medic will respond to the scene and conduct an initial assessment and assume command of the scene. If the Safety Coordinator/Medic is required to treat patients, command is transferred to the Health and Safety Superintendent/Officer or Emergency

Response Team Captain. Unified Command Structure will be initiated once the General Manager, Area Manager, or Environmental Lead is on scene. The Unified Command Structure is a cooperative effort command between the General Manager, Health and Safety Superintendent/Officer, Area Manager of involved Department and the Environmental Lead. Transfer of command includes a detailed verbal report of the incident and activities conducted and underway.

A “Code 1” Protocol initiated by an emergency spill will trigger the specific spill response procedure based on the product type, quantity and environmental and safety conditions.

Initial spill response will be conducted in accordance to *Transport Canada’s 2012 Emergency Response Guidebook* (Transport Canada, 2012). This Guidebook will assist Incident Command with information to identify the material, use the guide to reference potential hazards, public safety and emergency response information. The *Table of Initial Isolation and Protective Action Distances* will be used to dictate isolation and protection for large and small spills. However, this is not a comprehensive spill mitigation and response document and will only assist responders in making initial decisions upon arriving at the scene of a dangerous goods incident. It should not be considered as a substitute for emergency response training, knowledge or sound judgment. The *Emergency Response Guidebook* does not address all possible circumstances that may be associated with a dangerous goods incident. The *Minto Mine Emergency Response Plan* (Appendix C) has additional specific procedures for responding to the most commonly transported and hazardous materials including Nitric Acid, Gasoline, Diesel, Ammonium Nitrate, Sodium Sulfide and Propane.

In addition to on-site response, Minto, through its carriers of dangerous goods, has contracts in place with spill responders. These are full service response agencies that have commitments to mobilize fully trained emergency response teams and equipment 24 hours a day, 7 days a week.

5.2.1 CANUTEC Transport Canada

In the event that a spill requires additional technical resources Minto is registered with CANUTEC, a division of Transport Canada, for 24 hour Spill Response support and information to deal with emergency situations. If a spill occurs beyond the boundaries of the Minto property, the owner of the transportation firm and the owner or consignor of the dangerous goods will communicate with the regulators. For incidents that occur on the Minto property, the Environmental Department will ensure reporting to regulators is performed accordingly.

5.2.2 Surrounding and Downstream Communities

Notification of downstream water users of a spill, if required, is the responsibility of the Yukon Government, Environmental Protection Branch. Minto will additionally notify the authorities including police and fire departments and the Selkirk First Nation community of Pelly Crossing.

5.2.3 Public Relations

The General Manager is the designated spokesman for Minto. The General Manager may delegate his responsibility for public relations if required to do so by the scale of the incident.

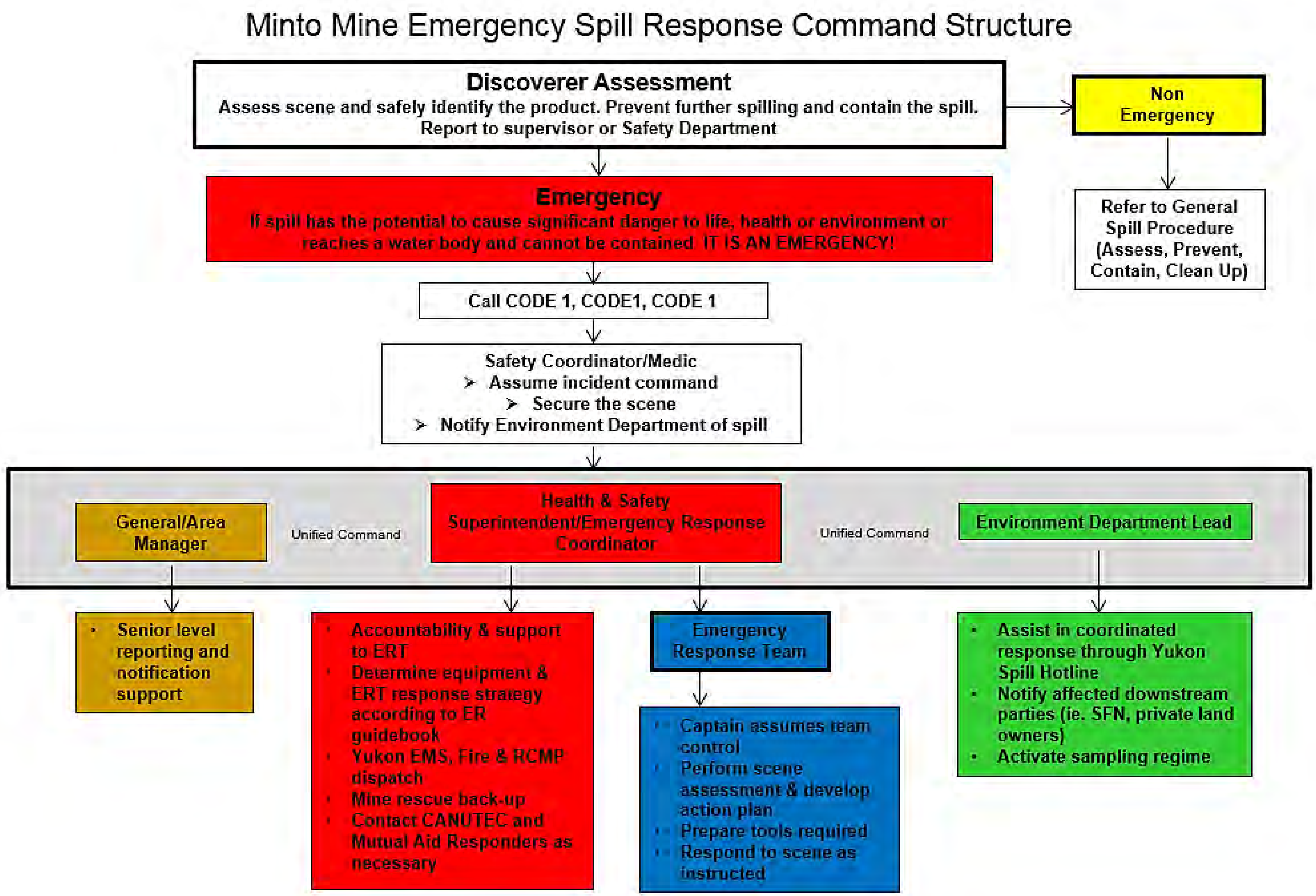

Figure 5-1: Minto Mine Emergency Spill Response Command Structure

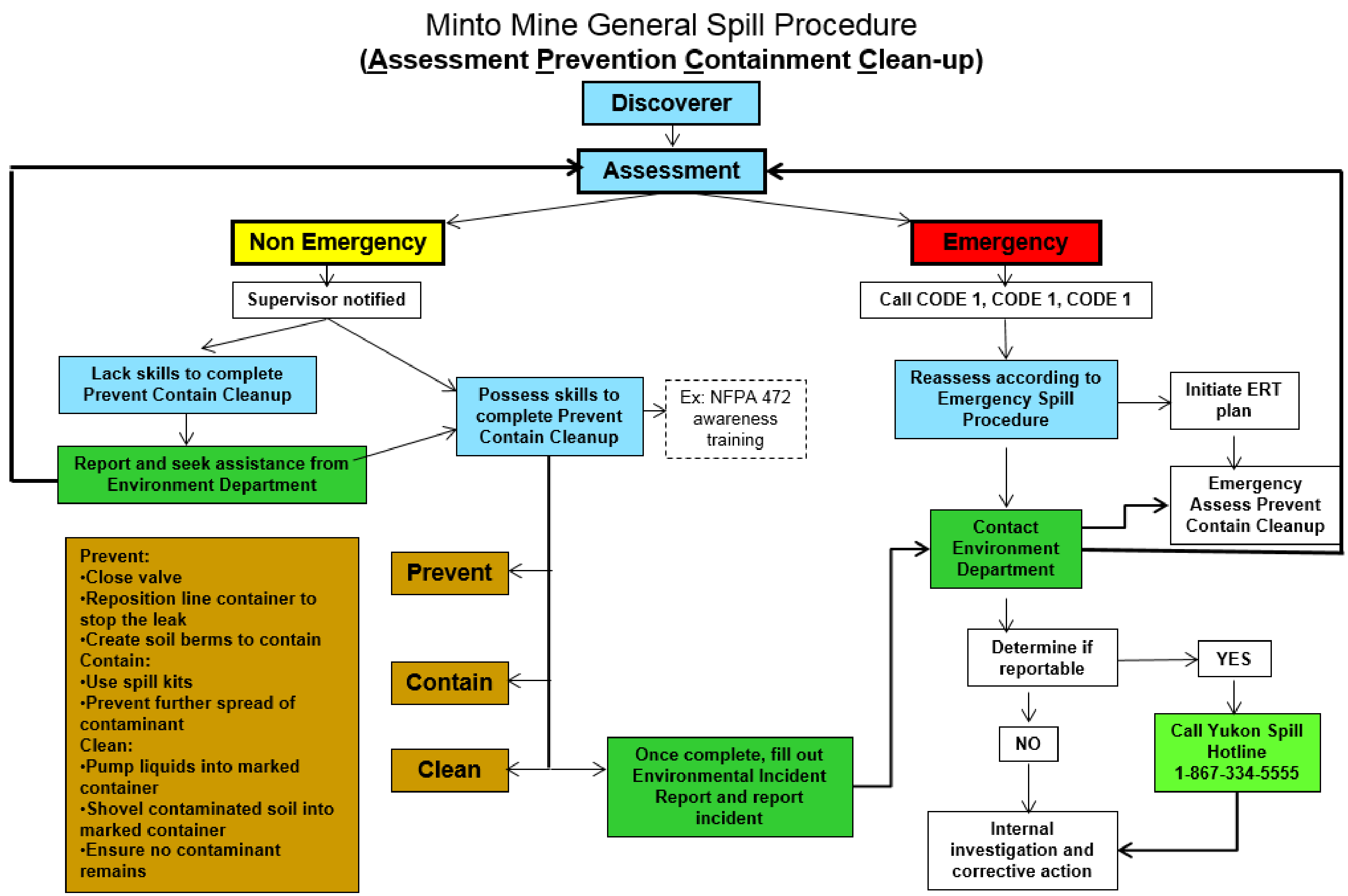

Figure 5-2: Minto Mine General Spill Procedure

5.3 Disposal and clean-up

Disposal and treatment methods of contaminated material are outlined below, and are further detailed in the *Minto Mine Spill Response Procedure: Non-emergency spills on soil* and the *Minto Mine Land Treatment Facility Standard Operating Procedure* documents. The Minto Mine Site has a Land Treatment Facility to accept incoming contaminated material from petroleum hydrocarbon and ethylene glycol spills. Depending on the state and substrate of the surface material, the clean-up and disposal location will differ. Brief practical descriptions of the clean-up procedures are summarized in Table 5-1.

Table 5-1: Disposal and Movement of Contaminated Material from Spill Sites

WASTE TYPE	DESCRIPTION	MOVEMENT OF MATERIAL FROM SPILLS
Oil or Glycol Contaminated Soil	Soil, Organics, and granular material (avoid coarse rock) contaminated as a result of a hydrocarbon or glycol spill	Contaminated soil will be transferred to the Land Treatment Facility. Contaminated soil will first be placed in the staging cell and labelled to be later categorized and treated. Contact Environment dept. before dropping off material in the Land Treatment Facility. Small spills will be stored in a composite pile in the staging area. Larger spills will be stored separately in staging while waiting for lab results.
Oil or Glycol Contaminated Rock	Blasted rock and coarse material and/or bedrock, contaminated as result of a hydrocarbon spill or glycol spill	If blasted rock contains ore and has been cleared by Mill operations ore will be processed through the mill. Non-ore containing rock will be placed in the main pit and in-situ bioremediation will be applied to the pile.
Oil or Glycol Contaminated Snow/ Ice/Water	Snow, Ice, and/or Water that has been contaminated as a result of a hydrocarbon spill or glycol spill	Contaminated snow/water will be transferred to the Land Treatment Facility. The contaminated product will be placed in a separate pile in the cell.

**** Any amount of material that has more than 30,000 ppm oil or glycol is considered special waste and must be disposed of off-site to a Special Waste Facility**

6 Spill Response Supplies

Spill kits (yellow and blue drums) are located throughout the Minto Mine Property at locations indicated in Figure 6-1. Additionally, there are blue drums located at the km 12 gravel pit, Big Creek and at the east and west terminals of Minto Landing. The contents of the yellow and blue barrels are summarized in Table 6-1. Spill kits are also supplied for each heavy and light truck at the Minto Mine. Contractor supervisor trucks have spill kits permanently affixed to the truck body. All contract trucking agencies coming to the mine are required to carry spill kits within or affixed to the truck. Spill kits are loaned to short term visitors if required.

Table 6-1: Spill Kit Contents

Spill Kit Item	Yellow Barrel	Blue Barrel	Yellow Truck Bag	Loaner Spill Kit (20 L Pail)
Tyvek splash suits	2	2		
Chemical master gloves	2	2	1	2
Garbage bags with ties	5	5	3	1
Oil only booms (5” x 10’)	2	4	1	
Oil only mats (16” x 20”)	50	50		10
Universal sorbent mat	20	20	10	5
Sorbent socks	10	10		1
Tarp	1	1		
Duct tape	1	1		
Utility knife	1	1		
Field notebook and pencil	1	1		
Instruction sheet (laminated)	1	1	1	1

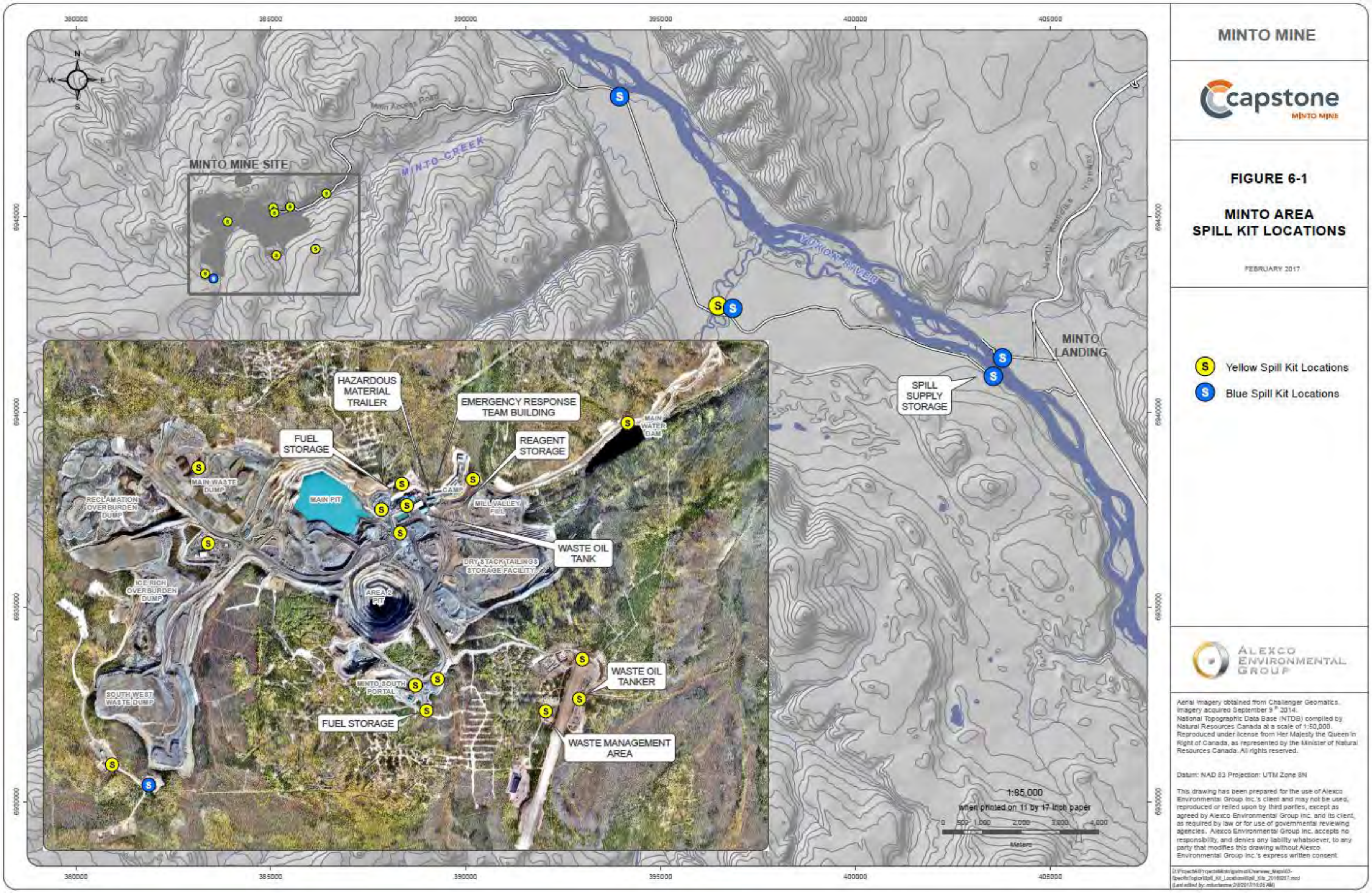

Figure 6-1: Minto Mine Area Overview – Hazmat Storage and Spill Supplies

Heavy machinery at the mine site is available for use in spill response and clean-up, as required under contract. Additionally, Minto has a 1991 Chevrolet Top Kick Fire truck with a 3200 litre/minute pump with 3800 litre supply tank and 3000 litre drop tank. This truck can support all spill response activities with SCBA, Class A and B foam capabilities, decontamination needs, as well as fire suppression/protection tools and equipment common to a truck of this nature. All ERT members are competent with the operation of this fire truck and related equipment in accordance with NFPA standards.

In 2013, Minto, on advice from Emergency Response Action Plan providers, procured a 20 foot Hazmat trailer and a helicopter-portable In-Viro-Drum vacuum unit (Figure 6-2) capable of being transported to locations not reachable with a vacuum truck. It has a liquid cooled three cylinder Kubota diesel engine and 250 CFM non-sparking blower, which makes it safe to vacuum flammable liquids and solids from water or dry land. It comes with a Double Port Vac Drum that allows for transfer of product from the drum to one of our 9500 litre bladders, while the drum continues to be filled. This system allows for quick, efficient and effective clean-up of hazardous products from hard to reach locations.

In 2016, Minto purchased a S.S. Alpha Adjustable Folding Weir Skimmer. Weir skimmers float on the surface of water and are designed to remove pollutants from the surface of calm or sheltered waters and shore line areas. Connected to a shore-based portable pump (e.g. Honda), contaminants can be removed from the water surface and transferred to a drum or other container for proper disposal.

Figure 6-2: In-Viro Drum and vacuum unit, 24’ Packman vessel, and Alpha Skimmer for spill response operations.

Minto Mine also acquired a 24 foot Packman man boat, which is described, further in the “Barge Emergency Contingency Plan” (Appendix D).

Spill contingency equipment and earth moving equipment located at Minto Mine are listed in Table 6-2. All contractor equipment is available for use in spills and clean-up operations.

Table 6-2: Spill contingency equipment located at Minto Mine

Quantity of Units	Equipment		Quantity of Units	Equipment
1	416 Backhoe		1	Assorted Wooden Plugs
1	3800 Litre Vacuum Truck		4	773DTruck
Various	Dozers, Excavator, Loaders		9	777 Truck
1	In-Viro Drum Portable Vacuum unit		1	Hazmat trailer 20’
2	9500 Litre bladders		1	Top Kick fire truck
1	24’ Packman Response Vessel		500’	Sorbent Boom (various sizes)
2	10,000 Litre Fuel Trucks		1	Storage Sea Can at Landing
1	Roll Over Kit		3	Trash pumps
1	Pipe Plug kit		1	S.S. Alpha Adjustable Folding Weir Skimmer Pump

7 Spill Prevention and Response Training

Education and training are critical to the success of any site-wide initiative, and the most important tool to ensuring the success of the SCP. Minto has a comprehensive training program in place that ensures all workers and supervisors are aware of their responsibilities and the practices that personnel and contractors must adhere to. Records are kept of the names of all employees or contractors that receive training, tracked though the either the Simply Safety software program or in the Environmental Department tracking sheets. Annual re-training is scheduled for all Minto and major contractor employees.

7.1 Existing Spill Prevention and Response Training

Employees are trained to understand the potentially hazardous situations that spills can create with respect to the health and safety of workers and the environment. They are trained to understand responsibilities as employees to Assess, Prevent, Contain, and Clean-up as well as to report any spills. The SCP is made available to all employees and employees will be advised of revisions or changes to the SCP.

7.1.1 Orientation

Employees and visitors are required to sign off on the environmental policy as part of the employee, contractor and visitor orientations that include a summary of the response required when a spill has occurred. The orientation has a strong focus on ensuring proper reporting of spills, so that the appropriate response and clean-up can occur.

7.1.2 "Big 6" Training

As part of the orientation, all Minto employees and major contractors receive training that is a computer based PowerPoint presentation, followed by a written test. The "Big 6" package focuses on some of the most common safety training required for site, which includes WHMIS (Workplace Hazardous Material Information System), fall protection, confined spaces, lock out, hot work training and Environmental Awareness. The Environmental Awareness portion of the training is comprised of four modules, with one module dedicated to Spill Response covering reporting and basic steps for assessing, preventing, containing and cleaning-up spills.

7.1.3 Targeted Practical Training

Training sessions are put on by the Environmental Department, and efforts are made to tailor the training to the attending group (i.e. underground miners, surface contractors, site services, etc.). Smaller groups are identified and targeted for specialised spill prevention training that is more job-specific. These include, but are not be limited to; maintenance personnel (mechanics), waste and water truck operators, fuelling personnel, and warehouse workers. Training in smaller groups focusses on spill prevention techniques.

7.1.4 Training for Fuel Handling Employees

Currently there are Safe Work Practices (SWP) designed for bulk fueling at the fuel farm and for fueling of equipment in the field. These SWPs include descriptions of the stepwise procedure for safely performing the task and also includes steps to take for emergency shut-off. Both the procedure and the equipment are audited during Workplace Inspections and Planned Job Observations by immediate supervisors and the Environmental Department.

7.1.5 ERT Training

An Emergency Response Team (ERT) has been established to, among other duties, respond to emergency spills. The Emergency Response Team periodically receives training to the National Fire Protection Association (NFPA) 472 Hazardous Material awareness level, and are required to thoroughly understand this document in order to respond to spills or incidents of a specific nature. This training is required as a foundation to develop site specific contingency planning for response tactics in areas specific to the Minto Mine associated activities that present a risk to the Yukon River and its tributaries.

7.1.6 Emergency Spill Response Drills

Table top exercises and/or field drills will help to prepare the ERT and other mine staff to respond to a major spill safely by identifying any deficiencies in the equipment or processes in place. On October 26th, 2014 a combined field and table top exercise took place with the following objectives:

- Help individuals become more knowledgeable with the ERP and SCP;
- Identify gaps in the plan;
- Improve communication between stakeholders and departments; and
- Learn new ways and better ways to execute the plan.

The announced exercise was initiated to test part of the Emergency Response Plan as it applies to Spills and the SCP. It focused on the crisis, interaction and escalation of problems within:

- Administrative;
- Operational;
- Managerial; and
- Facilities.

The scenario was as follows:

- A tanker truck with pup and trailer of diesel overturns on Oct 26th on icy roads at 3:20pm at south end of Big Creek. It is still dark and it is a Sunday and roads are icy and snowing lightly.

The exercise lasted approximately 2 hours and involved management staff onsite and offsite, the ERT, major contractors, The Yukon Spill Hotline, CANUTEC, Transnorth Helicopters, WCB, Parkland Fuel, and

Quantum Murray. A post–incident debrief revealed both opportunities and successes at the field operations and management level.

7.1.7 Training KPI's

Individuals who receive training are tracked, and training numbers are used as a key performance indicator (KPI) with annual targets. In addition, tracking is used to ensure annual retraining is delivered and statistics measured against key performance indicators.

8 Routine Maintenance and Monitoring

The Fuel Farm is inspected twice monthly for any leakages and, through the Human Machine Interface (HMI) readout, regular inventory is tracked daily to identify any incidental losses. An overfill protection system is installed on the two main diesel tanks using a visual indicator and a relay to the control room that will alarm on the HMI to alert maintenance personnel. The area also receives inspections by a qualified engineer and recommendations are recorded and deficiencies corrected as per the *CCME Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products* (Canadian Council of Ministers of the Environment, 2003).

The tug and barge receive frequent inventory inspections for spill equipment and have had major overhauls in the last few years to ensure that the operation is continually improving. Maintenance activities are also carried out regularly and systems are inspected as per Transport Canada Regulations. The daily start-up procedure includes checking for leaks and ensuring all systems are performing to specifications. Annual maintenance activities have included the following: propeller repairs, controls work, system checks and repairs. Substantive refits have included: cylinder heads, exhaust manifold seals, motor mounts, transmission mounts and replacement of water pumps. A new transmission, propulsion seals and propellers have been installed and aligned. Other improvements have included welding reinforcements on the bow of the barge for landings, electrical upgrades, and the installation of an anchor with hawser.

The open pit mining equipment is outfitted with Wiggins Fast Fuel Systems on newer contractor open pit equipment that is a fail-safe system for overflow protection. All fuel trucks receive a daily walk-around inspection to ensure emergency shutoffs and hatches and tank valves are operating properly and are free of leaks. These are recorded daily.

The Waste Management Area (WMA) is restricted to access between 10-3 pm every Sunday by an attendant familiar with the protocols for waste segregation, incineration, special waste handling and landfilling. The attendant will inspect all loads that come into the WMA to ensure that waste has been properly sorted before any material is off loaded. The Environmental Department is directly responsible for the administration, compliance and procedures associated with the management of waste. They are also responsible for providing support and manpower to prepare shipments for backhauling and to ensure the WMA is maintained in accordance with the Commercial Dump Permit (# 81-005). The Environmental Monitors are responsible for conducting weekly inspections to ensure that the WMA is in compliance.

9 References

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Appendix A: Spill Report and Environmental Incident Report Forms

Spill Report Form

Spill Name:	

General Report Information: **(To be completed by the supervisor of responsible department or company)**

EIR #:		Location of Incident:	
Date of Incident:		Time of Incident:	
Contaminant Type:		Volume of Spill (L):	
Equipment (Type):		Equipment (#):	
Company or Department:		Supervisor	
Hours since last PM:		Proximity to nearest waterbody:	
Previous indication of leak (i.e. Prior Drip) (Yes/No):		Estimated cost of spill:	

Failure of Mechanism: **(Check one box below)**

Blown Hose		Failed Hose Connection		Human Error	
Unforseen		Blown or Leaking Seal		Unknown	
Other					

Brief Description of Cause: **(conditions at time of spill, what was happening at the time, specific direct cause of spill, etc.)**

Clean Up Actions Undertaken:

Land Treatment Facility Information: **(To be filled out by Environment Department)**

Material Moved to LTF (Yes/No):		Material Sampled (Yes/No):		Quantity (m^3):	
Notes:					

Corrective Actions: **(Must fill out for all reportable and preventable spills)**

Action Item #	Responsible Department	Corrective Action	Due Date

Reporting Sequence:			
First Observer:	Name	Company	Date/Time
Reported To:	Name	Company	Date/Time
Reported To Environmental:	Name	Company	Date/Time
Reported To General Manager:	Name	Company	Date/Time

Regulatory Tracking: (To be completed by Environment Department)					
24 Hour Spill Hotline (867) 667-7244:					
Reported By:		Reported To:		Date/Time:	
Selkirk First Nation Lands Director (867)-537-3331					
Reported By:		Reported To:		Date/Time:	
EMR - Client services and Inspections (867) 456-3882: (or site inspectors)					
Reported By:		Reported To:		Date/Time:	
Environment Canada in the event of a discharge to a waterway (867)-667-3400					
Reported By:		Reported To:		Date/Time:	
Detailed written report and MSDS to YWB, EMR, EC and SFN (Required within 10 days of spill):					
Submitted By:		Date of Submission:			

Photos:	

Appendix B: Reporting Threshold, Special Precautions, PPE Requirements, and Cleanup and Disposal Methods

Minto Mine - Inventory of Dangerous Goods

Reporting Threshold, Special Precautions, PPE Requirements, and Cleanup and Disposal Methods

Common Name (Synonyms)	Chemical Name	Manufacture / Supplier	Phase	TDG Class	WHMIS Class	NFPA Rating	Reporting Threshold	Use	Special Precautions	PPE Required	Special Cleanup and Disposal Info
Acetone	2-Propanone	Anachemia	Liquid	3	B-2, D-2B	1, 3, 0	200 L	Solvent	Extremely Flammable	Goggles, gloves. SCBA if in confined space	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant foam. Do not allow into waterway or drains. Contain spread of spill and soak up with absorb all, absorbant pads. Clear up using non-sparking tools. Place liquid and absorbents into tighly sealed container, label clearly and dispose of as hazardous waste offsite.
Acetylene	C_2H_2	AIRGAS INC	Pressurized gas dissolved	2.1	A, B-1, F	1, 4, 3	any if container larger than 100 L	Welding/cutting gas	Extremely flammable, pressurized gas dissolved in an extremely flammable liquid (Acetone)	Goggles, gloves. Respirator or SCBA if in confined space	Eliminate all sources of ignition, if possible without risk, shut off bottles. If bottle is ruptured after the gas has been expelled, the bottle will release the Acetone. At that point treat as an Acetone spill.
AERO 6493 Promoter	Alkyl hydroxamate	Cytec Canada	Liquid above 15C	9		2, 1, 2	5 L	Metal flotation in mill			Soak up with absorbent (do NOT use sawdust. Use PLASTIC tools). In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Place recovered spilt liquid in labelled drums for disposal as Special waste. Incinerate used absorbent pads.
AERO MX-5149	Modified Thionocarbamate 15-40%Xanthate esther 40-70%	Cytec Canada	Liquid	3	B3, D-1B, D-2B	3,2,0	200 L	Metal flotation in mill	Flammable	Closed system, safety glasses, gloves	Remove sources of ignition. Cover spills with some inert absorbent material; sweep up and place in a waste disposal container. Flush spill area with water.
Aerodri 100 Dewatering Agent		Cytec Canada	Liquid	3	B3, B-2, D-2A	2, 3, 0	200 L		Avoid contact with strong oxidizers or acids.	Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste. Soak up with absorbent materials and dispose of offsite in clearly labeled containers
Alconox		Anachemia	solid	not regulated	D-2B	1, 0, 0	50 kg			Safety Glasses, Gloves	Clean up uncontaminated material for reuse. Incinerate waste.
ALIQUAT 336	Methytrioctyl-ammonium Chloride	Sigma-Aldrich Canada	Liquid	6	D-2B	2, 1, 1	5 kg		Toxic if swallowed. Very corrosive. Will burn skin and eyes. Avoid contact with strong oxidizers. Hygroscopic: avoid contact with moist air.	Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
AlphaSolve II	>50% Sodium Hydroxide <50% Silicate	Alpha Resources	Solid						Avoid contact with strong oxidizers.	Safety Glasses, Impervious Gloves.	Highly caustic. Will produce heat and steam on contact with water. May boil and spatter. May generate hydrogen gas on contact with metals. Sweep or vaccum and, if not re-useable, send offsite as hazardous waste, in tightly closed, well labeled containers.
Aluminex 5	Aluminum Chloride Hydroxide Sulphate 15%	NALCO	Liquid	8	E		5 L	Coagulant		Safety Glasses, Gloves	Soak up with absorbent materials. These can be incinerated. Any remaining spilt liquid should be stored in closed container, labelled and disposed of off-site as Special Waste.
Aluminum Standard - AA		Anachemia	Liquid	8	E	4, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
AM28 Flotation Reagent	Mixture of Potassium Hydroxide Alkyl hydroxamate	Axis House (Pty) Ltd.	Liquid	not regulated	D-2B	2,1,0		Floatation Reagent	corrosive solid.	Safety Glasses, Gloves	Soak up with absorbent (do NOT use sawdust. Use PLASTIC tools). In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Place recovered spilt liquid in labelled drums for disposal as Special waste. Incinerate used absorbent pads.
Amco Clear Turbidity Standard		GFS Chemicals	Liquid	not regulated	not regulated					Safety Glasses, Gloves	Contain spill. Incinerate waste or place in landfill
Ammonia, Refrigerant	Ammonia, Anhydrous	GT&S, INC	Liquefied Gas	2.3, 8	does not appear classified??	3, 0, 0	any amount		Liquefied gas, will produce extreme cold when released. Death has occurred at 5000ppm exposure for 5 minutes. Evacuate release area upwind and avoid low areas.	Goggles, gloves. SCBA.	Toxic gas and will react with a large number of substances, many in a violent manner, Gas will dissipate quickly in air. Small spills can be dissolved in water at ratio of 1:10 Not very flammable. Do not attempt to neutralise.

Minto Mine - Inventory of Dangerous Goods

Reporting Threshold, Special Precautions, PPE Requirements, and Cleanup and Disposal Methods

Common Name (Synonyms)	Chemical Name	Manufacture / Supplier	Phase	TDG Class	WHMIS Class	NFPA Rating	Reporting Threshold	Use	Special Precautions	PPE Required	Special Cleanup and Disposal Info
Ammonium Nitrate prill	Ammonium Nitrate	Agrium	solid	5.1	C, D-2B	1.0.3	50 kg		Oxidizing material, does not burn but may contribute to combustion of materials that can burn	Safety Glasses, Gloves	In case of fire, cool containing vessels with water jet in order to prevent pressure build-up/explosion. Use flooding quantities of water. Evacuate surrounding area. If fumes or gases present, fire fighters should wear self-contained breathing apparatus. In event of spill, prevent from entering waterways. Will dissolve and disperse in water.
Ammonium Nitrate Emulsion	Ammonium Nitrate Emulsion	on-site	Liquid	5.1		2,0,3	50 kg	Explosive	Oxidizing material, does not burn but may contribute to combustion of materials that can burn	Safety Glasses, Gloves, chemical suits, SCBA may be required	In case of fire, cool containing vessels with water jet in order to prevent pressure build-up/explosion. Use flooding quantities of water. Evacuate surrounding area. If fumes or gases present, fire fighters should wear self-contained breathing apparatus. In event of spill, prevent from entering waterways. Use non-combustible material to soak up.
Arsenic Standard - AA		Anachemia	Liquid	8	D-2A, E	4, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Ascorbic Acid	L-Ascorbic Acid (Vitamin C)	Anachemia	solid	not regulated	not regulated	1, 1, 1	5 kg		also known as Vitamin C	Safety Glasses, Gloves	Contain spill. Incinerate waste or place in landfill
Brake & Electrical Parts Kleen	CO_2 aerosol of Heptane and Isopropyl alcohol	Kleen-Flo Tumbler Industries	aerosol	Limited quantity	Consumer commodity; A, B5, D2-B	1, 3, 0			Highly flammable	Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
Buffer Solution pH 10		Anachemia	Liquid	not regulated	D-2A	1, 0, 0		Analytical Lab use	Dilute Sodium Hydroxide	Safety Glasses, Gloves	Contain spill. Absorb with sand, vermiculite or sorbal. Incinerate waste.
Buffer Solution pH 4		Anachemia	Liquid	not regulated	not regulated	1, 0, 0		Analytical Lab use		Safety Glasses, Gloves	Contain spill. Absorb with sand, vermiculite or sorbal. Incinerate waste.
Buffer Solution pH 7		Anachemia	Liquid	not regulated	not regulated	1, 0, 0		Analytical Lab use		Safety Glasses, Gloves	Contain spill. Absorb with sand, vermiculite or sorbal. Incinerate waste.
Cadmium Standard - AA		Anachemia	Liquid	8	D-2A, E	4, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use flooding quantities of water. Contributes to combustion of other materials. Neutralize with soda ash or lime. Contain spill, keep from entering ground water. Neutralized spill can be pumped to the pit or tailings system.
Calcium Chloride		J.T. Baker	solid	not regulated	D-2B	1, 0, 2, 3	any amount		Road Salt, will corrode metals	Safety Glasses, Gloves	Sweep up spilled material and it my be deposed of in dilute form to the pit or tailings system. In case of fire use appropriate measures for surrounding fire.
Carbon Dioxide in Argon		Mittler Supply Inc.	Pressurized gas	2.2	A, D-2B	1, 0, 0	any if container larger then 100 L		Non-Flammable but will replace the O_2 in confined space	Goggles, gloves. SCBA if in confined space	close valve if possible without risk, or allow the vent. In case of fire use any media suitable for surrounding fire. Use water spray to cool fire exposed containers.
Caustic Soda (solid)	Sodium Hydroxide	Fisher Scientific	solid	8	E	3, 0, 1	5 kg		very corrosive solid	Safety Glasses, Gloves	Sweep up spilled material for reuse. In case of fire use appropriate measures for the surrounding fire. Minimise direct water spray on material. This material melts and 318^{o}C and when molten reacts violently with water. Neutralize the residue with a dilute solution of acetic acid. Neutralized solution can be disposed of in the pit or tailings system.
Caustic Soda (solution)		DOW	Liquid	8	E	3, 0, 1	5 L		very corrosive liquid	Safety Glasses, Gloves	Contain spill and pump to plastic barrel for re-use. In case of fire use appropriate measures for the surrounding fire. Neutralize the residue with a dilute solution of acetic acid. Neutralized solution can be disposed of in the pit or tailings system.
Caustic Potash	Potassium Hydroxide	Brenntag Canada	Solid	8	D-1B, E	3,0,1	5 kg		water reactive, contact with metals may evolve flammable hydrogen gas.	Safety Glasses, Gloves, fume hood	Sweep up or vacuum spillage, collect in suitable container for disposal. Avoid dust formation.
Chevron 2-Cycle Oil		Chevron Lubricants Canada	Liquid	not regulated	B-3	1, 2, 0	100 L		flammable oil for 2-storke fuel	Safety Glasses, Gloves	contain spill and use absorbent and incinerate waste
Chevron ATF+3 Automatic Transmission Fluid		Chevron Lubricants Canada	Liquid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron Automatic Transmission Fluid MD-3		Chevron Lubricants Canada	Liquid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron Clarity Synthetic Machine Oil		Chevron Lubricants Canada	Liquid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.

Common Name (Synonyms)	Chemical Name	Manufacture / Supplier	Phase	TDG Class	WHMIS Class	NFPA Rating	Reporting Threshold	Use	Special Precautions	PPE Required	Special Cleanup and Disposal Info
Chevron Compressor Oil 260		Chevron Lubricants Canada	Liquid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron Coupling Grease	Grease	Chevron Lubricants Canada	Semi-Solid	not regulated	not regulated	1, 1, 0	100 L or 100 kg			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger absorbent material in plastic drums and shipped off site for disposal.
Chevron Delo 300 Motor Oil		Chevron Lubricants Canada	Liquid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron Delo Grease EP	Grease	Chevron Lubricants Canada	Semi-Solid	not regulated	not regulated	1, 1, 0	100 L or 100 kg			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger absorbent material in plastic drums and shipped off site for disposal.
Chevron Diesel Engine Oil Delo 6170 CFO		Chevron Lubricants Canada	Liquid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron Drive Train Fluid HD		Chevron Lubricants Canada	Liquid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron ECO Hydraulic Oil AW		Chevron Lubricants Canada	Liquid	not regulated	not regulated	0, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron Gas Engine Oil 930 and 940		Chevron Lubricants Canada	Liquid	not regulated	not regulated	0, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron Mid-grade unleaded gasoline		Chevron Products	Liquid	3	B-2, D-2A, D-2B	2, 3, 0	200 L		Extremely Flammable, Vapours are harmful and they may be explosive. Non-sparking tools required. Vapours will collect in low areas and travel along the ground to an ignition source.	Goggles, gloves. Respirator or SCBA if in confined space	Eliminate all sources of ignition. Ventilate area if required. Dike the spill and pump to containers for recycling. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Allow waste absorbent to evaporate and then Incinerate waste.
Chevron NWS Manual Transmission Fluid 6044GR		Chevron Lubricants Canada	Liquid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron RPM Universal Gear Lubricant		Chevron Lubricants Canada	Liquid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Chevron Supreme Antifreeze/Coolant	Ethylene Glycol	Chevron Lubricants Canada	Liquid	not regulated under 5000 lb.	D-2A	1, 1, 0	25 L		may be fatal by ingestion	Safety Glasses, Gloves	contain spill. Can be pumped, filtered and reused. Small amounts can use absorbent and incinerate waste. Larger absorbent material in plastic drums and shipped off site for disposal.
Chevron Ulti-Plex® Grease EP		Chevron Lubricants Canada	Semi-Solid	not regulated	not regulated	1, 1, 0	100 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger absorbent material in plastic drums and shipped off site for disposal.
Chloramine T	Chloramine-T trihydrate	Fisher	solid	8	D-2A, E	3, 1, 1	5 kg		Container may explode under fire conditions. Will release toxic fumes with fire or when mixed with strong oxidizers or acids	Goggles, gloves. SCBA if in confined space	Eliminate all sources of ignition. Ventilate area if required. In case of fire. Material by itself is non-flammable, may decompose violently >100°C, use dry chemical, CO_2 foam or water spray. DISPOSAL mix with flammable solvent and incinerate.
Chromium Standard - AA		Anachemia	Liquid	8	D-2A, E	3, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Citric Acid	Citric Acid, Monohydrate	Anachemia	solid	not regulated	E	2, 1, 0	5 L		Will cause severe eye damage. Avoid oxidizers, acids, bases and bleach.	Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. In case of fire, use flooding quantities of water. Will decompose at high temperatures and emit acrid smoke and fumes.
Copper Standard - AA		Anachemia	Liquid	8	E	4, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Crystal 78	Sodium Silicate	Quadra Chemicals	Liquid	not regulated	D-2B		25 L		Caustic solution. Avoid mixing with strong acids. Contact with metals such as aluminum, tin, lead and zinc generates hydrogen gas.	Goggles, gloves. Respirator	solution can be pumped into plastic drum and possibly recycled in mill circuit, or shipped off site. In case of fire use appropriate measures for surrounding fire.
Cyquest DP-6	Sodium polyacrylate in water	Cytec Canada	Liquid	not regulated	not regulated	1,1,0		Mill reagent	Slippery	Goggles, Impervious gloves	Soak up with absorbent materials. These can be incinerated. Any remaining spilt liquid should be stored in closed container, labelled and disposed of off-site as Special Waste.

Common Name (Synonyms)	Chemical Name	Manufacture / Supplier	Phase	TDG Class	WHMIS Class	NFPA Rating	Reporting Threshold	Use	Special Precautions	PPE Required	Special Cleanup and Disposal Info
Delo Diesel Fuel System Cleaner		Chevron Lubricants Canada	Liquid	3	B-3, D-2A, D-2B		200 L			Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
Diesel Fuel No. 2		Chevron Products Company	Liquid	3	B-3, D-2A, D-2B	0, 2, 0	200 L			Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
DIISOBUTYL KETONE	2,6-Dimethyl-4-heptanone	J.T. Baker	Liquid	3	B-2, D-2A	2, 2, 0	200 L		Avoid contact with strong oxidizers or acids.	Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
Drierite, indicating		Anachemia	solid	not regulated	D-2A	1, 0, 1				Safety Glasses, Gloves	Eliminate all sources of ignition. In case of fire use measures dictated by surrounding fire. Will decompose at 1450°C liberating Cl_2 and SO_2. This product can be dried and reused, recycled.
Envirobind KFZ		Power Chemicals Ltd.	Liquid	not regulated	not regulated	1, 0, 0		Dust Suppression	Avoid contact with oxidizing agents or strong acids.	Goggles, Gloves	Do not use absorbents. Contain spill using noncombustible materials such as vermiculite, earth or sand.
Envirobind KTF		Power Chemicals Ltd.	Liquid	not regulated	not regulated	1, 0, 0		Dust Suppression	Avoid contact with oxidizing agents or strong acids.	Goggles/Glasses, Gloves	Do not use absorbents. Contain spill using noncombustible materials such as vermiculite, earth or sand.
Envirobind PCW		Power Chemicals Ltd.	Liquid	not regulated	not regulated	1, 0, 0		Dust Suppression	Avoid contact with strong oxidizing materials.	Goggles/Glasses, Gloves	Dike or contain. Absorb irrecoverable material onto inert oil absorbent medium, package, and label for legal disposal. Wash hard surfaces with water. Contaminated absorbent material may be disposed of in an approved landfill
FLEET CHARGE 50/50 Antifreeze	Ethylene Glycol	OLD WORLD INDUSTRIES	Liquid	9	D-2A	1, 1, 0	25 L		may be fatal by ingestion	Safety Glasses, Gloves	contain spill. Can be pumped, filtered and reused. Small amounts can use absorbent and incinerate waste. Larger absorbent material in plastic drums and shipped off site for disposal.
Fleet Charge PG Antifreeze/Coolant	Propylene Glycol	OLD WORLD INDUSTRIES	Liquid	not regulated	not regulated	0, 1, 0	25 L			Safety Glasses, Gloves	contain spill. Can be pumped, filtered and reused. Small amounts can use absorbent and incinerate waste. Larger absorbent material in plastic drums and shipped off site for disposal.
Flomin C 3505 Collector	Potassium amyl xanthate (PAX)	Flomin Inc.	solid	4	not regulated	2, 2, 1	25 kg		Product is spontaneously combustible. Avoid contact with heat, moist air, and water.	Safety Glasses, Gloves	Sweep up spilled material and place in closed container for reuse. Solutions of product my be deposed of on the pit or tailings system. In case of fire use appropriate measures for surrounding fire.
Flomin F 500 Frother	4-METHYL-2-PENTANOL (Methyl isobutyl carbinol - MIBC)	Flomin Inc.	Liquid	3	B-2, D-2B	2, 2, 0	200 L		Acids, acid chlorides, alkalis, oxidizing agents. Will attack some forms of plastics, rubber and coatings	Goggles, gloves. Respirator or SCBA if in confined space	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
Floran Catalyst	Proprietary Inorganic Peroxide Blend	Floran Technologies	Liquid	5	C, D-2B	2, 0, 1, OX	50 L		Non-Flammable but will aid combustion of other materials	Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use flooding quantities of water. Contributes to combustion of other materials. Contain spill, keep from entering ground water. Absorbed pill can be disposed in the pit or tailings system.
Frost Killer (Tannergas)	Methyl alcohol	TANNER SYSTEMS, INC.	Liquid	3, 6.1	B-2, D-1B, D-2A,D-2B	1, 3, 0	200 L		Extremely Flammable, Vapours are harmful and solution is poisonous	Goggles, gloves. Respirator or SCBA if in confined space	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
FUEL INJECTOR CLEANER		Radiator Specialty Co	Liquid	3	B-3, D-2A, D-2B		200 L			Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
Gasoline, Unleaded		Petro-Canada	Liquid	3	B-2, D-2A, D-2B	2, 3, 0	200 L		Extremely Flammable, Vapours are harmful and they may be explosive. Non-sparking tools required. Vapours will collect in low areas and travel along the ground to an ignition source.	Goggles, gloves. Respirator or SCBA if in confined space	Eliminate all sources of ignition. Ventilate area if required. Dike the spill and pump to containers for recycling. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Allow waste absorbent to evaporate and then Incinerate waste.
Glycerin	IPAC	Power Chemicals Ltd.	Liquid	Not regulated	Not regulated				Avoid contact with reducing agents and oxidizing agents.	Goggles, gloves.	Dike spilled product to prevent runoff
Havoline DEX-COOL Extended Life 50/50 Anti-Freeze/Coolant	Ethylene Glycol	Chevron Lubricants Canada	Liquid	not regulated	D-1b, D-2A	2, 0, 0	25 L		may be fatal by ingestion	Safety Glasses, Gloves	contain spill. Can be pumped, filtered and reused. Small amounts can use absorbent and incinerate waste. Larger absorbent material in plastic drums and shipped off site for disposal.

Common Name (Synonyms)	Chemical Name	Manufacture / Supplier	Phase	TDG Class	WHMIS Class	NFPA Rating	Reporting Threshold	Use	Special Precautions	PPE Required	Special Cleanup and Disposal Info
HAVOLINE DEX-COOL extended life anti-freeze/coolant-B	Ethylene Glycol	Chevron Lubricants Canada	Liquid	not regulated	D-1b, D-2A	2, 1, 0	25 L		may be fatal by ingestion	Safety Glasses, Gloves	contain spill. Can be pumped, filtered and reused. Small amounts can use absorbent and incinerate waste. Larger absorbent material in plastic drums and shipped off site for disposal.
Havoline Power Steering Fluid		Chevron Products	Liquid	not regulated	not regulated	0, 1, 0				Safety Glasses, Gloves	contain spill. Small amounts can use absorbent and incinerate waste. Larger material pumped into plastic drums and used in a waste oil heating system.
Hot 4-in-1 Heating Oil Treatment	Proprietary Blend	FPPF Chemical Company, Inc.	Liquid	3	B-3, D-1A, D-2A, D-2B	3, 2, 0	200 L		Fuel Additive, fumes will collect in low area's.	Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
Hydrated Lime	$Ca(OH)_2$	Chemical Lime Company of Canada Inc.	Solid	not regulated	D-2A, E				Will cause severe caustic burns. Avoid strong acids, and aluminum	Safety Glasses, Gloves	sweep up uncontaminated material for reuse. Neutralize with dilute acid and may be disposed of in pit or tailings system.
Hydraulic Oil SAE 10W		EXXON MOBIL	Liquid	not regulated	not regulated	0, 1, 0	200 L			Safety Glasses, Gloves	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
Hydrex 3223		Veolia	Liquid	8	E	1, 0, 0	5kg or 5L	Coagulant in the WTP		Safety glasses with side shields or goggles, face shield, chemical resistant gloves. Suitable respiratory equipment in poorly ventilated areas.	Contain spill. Ventilate area if required. Use absorbent. Place contaminated materials in sealed container for disposal and dispose of via a licensed waste disposal contractor.
Hydrex 6186		Veolia	Solid	not regulated	not regulated	0, 1, 0		Flocculant in the WTP		Safety glasses with side shields or goggles.	Sweep or vacuum spilled material. Do not get water on spilled material. Flush area with water after product recovery. Place recovered material in sealed container and dispose of via a licensed waste disposal contractor.
Hydrochloric Acid		Anachemia	Liquid	8	D-1A, E	3, 0, 1	5 L		Concentrated acid, Extremely corrosive. Ventilate or stay upwind	Goggles, gloves. Respirator or SCBA if in confined space	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Hydrofluoric acid, 47 - 51%		Fisher	Liquid	8, 6.1	D-1A, D-2A, E	4, 0, 1	5 L		**Extremely corrosive and Toxic acid. Causes very severe acid burns with symptoms being delayed. Skin contact of <10% can be fatal from cardio-pulmonary problems. IMMEDIATE medical attention is required for all exposures.**	**Goggles, gloves. Respirator or SCBA if in confined space (Actually SCBA should be used anywhere unless spill is in a fumehood)**	Neutralize with soda ash. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to a plastic barrel and then disposed of in the pit or tailings system.
IPAC 6832		Quadra Chemicals	Liquid	not regulated	not regulated				water soluble	Safety Glasses, Gloves	No special clean up procedures,
Iron Standard - AA		Anachemia	Liquid	8	E	1, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Isopropylxanthic acid sodium salt (SIPX)		Quadra Chemicals Ltd.	Solid	4.2	B-6, D-1B, D-2B		25 kg	Collector in Mill	Keep away from water - contact with water liberates extremely flammable gases. Keep away from heat, sparks and flame - fine dust clouds may form explosive mixtures with air. Use only with adequate ventilation.	Goggles, Gloves, Respirator (air-purifying or air-fed)	Move containers from spill area. Avoid allowing the spilled material to get wet or using water to clean up spillages or residues, unless the quantity remaining is very small. Vacuum or sweep up material and place in a designated, labeled waste container. Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor.
Javex Liquid Bleach	NaOCl	Colgate Palmolive	Liquid	not regulated	E, D-2B, C				Self heating and may catch fire.	Safety Glasses, Gloves, SCBA	Ventilate area and allow qualified personnel to stop/control spill. Small spills: flush area with plenty of water and mop up. Large spills: dike the ingredient and transfer to appropiate containers. Consult Federal, Provincial and Municipal regulations for disposal. May be neutralized with sodium bisulphite or dilute hydrogen preoxide.
KAX 51	Proprietary Blend (mix of isoamyl alohol, potassium amyl xanthate, and potassium hydroxide)	Prospec Chemicals	Solid	4.2	B-6, D-1B, E		25 kg	Collector in Mill		Safety Glasses. Face Shield, Gloves, SCBA	If in the liquid state: Stop spill at source. Contain any spilled material to prevent discharge into the environment. Eliminate all sources of ignition. Persons not wearing protective equipment should be excluded from the area. Absorb with inert dry material. Put into an approved metal salvage drum for disposal. If in the solid state: Eliminate all sources of ignition. Restrict access to area until completion of clean-up. Ensure clean-up is conducted by trained personnel only. Do not touch spilled material. Do not use water on spilled material as heat will be generated. Put spilled material into approved salvage drums for disposal. Flush cleaned area with water, making sure no water enters xanthate containers.

Common Name (Synonyms)	Chemical Name	Manufacture / Supplier	Phase	TDG Class	WHMIS Class	NFPA Rating	Reporting Threshold	Use	Special Precautions	PPE Required	Special Cleanup and Disposal Info
KOPR-KOTE	Graphite, Cu & MoS_2 mixture	Jet-Lube of Canada	paste	not regulated	not regulated	1,1,1				Safety Glasses, Gloves	Wipe up spill with rages and incinerate waste.
Lead Standard - AA		Anachemia	Liquid	8	D-2A, E	4, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Lime		Chemical Lime Company of Canada Inc.	powder	not regulated	E	3, 0, 1			Will cause severe caustic burns. Avoid strong acids, and aluminum	Safety Glasses, Gloves	sweep up uncontaminated material for reuse. Neutralize with dilute acid and may be disposed of in pit or tailings system.
Liquid Nitrogen	Nitrogen	Praxair Canada Inc.	Liquefied Gas	2.2 Non-flammable gas	A	3, 0, 2	any if container larger then 100 L		Use air supplied respirator when working in confined space, Loose-fitting cryogenic gloves, Metatarsal shoes for cylinder handling. Protective clothing where needed. Cuff less trousers should be worn outside of shoes	Extremely cold liquefied gas, Will cause severe frost bite Use SCBA when working in confined space,	Evacuate all personnel from danger area. Allow spilled liquid to evaporate. Use self-contained breathing apparatus where needed. Shut off flow if you can do so without risk. Ventilate area or move cylinder to a well-ventilated area. Test for sufficient oxygen, especially in confined spaces, before allowing re-entry
LIQUID WRENCH SUPER LUBRICANT (AEROSOL)	Proprietary Blend	Radiator Specialty Co	aerosol	2.1	A, B5, D-1A, D2-B		any if container larger then 100 L		containers may rupture if exposed to high temperatures.	Safety Glasses, Gloves	Allow container to completely discharge while eliminating ignitions sources. Wipe up spill with rages and incinerate waste.
Loctite Belt Dressing	Proprietary Blend t	Henkel Canada, Inc.	aerosol	2.2	A, D-2A, D-2B		any if container larger then 100 L		containers may rupture if exposed to high temperatures.	Safety Glasses, Gloves	Allow container to completely discharge Wipe up spill with rags and incinerate waste.
LPS 2 Spray Lubricant	Proprietary Blend	LPS Laboratories	aerosol	2.2	A, D-2A, D-2B		any if container larger then 100 L		containers may rupture if exposed to high temperatures.	Safety Glasses, Gloves	Allow container to completely discharge Wipe up spill with rages and incinerate waste.
Magnesium Nitrate Matrix Modifier		Spex CertiPrep	Liquid	8	D-2A, E	3, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
MAXGOLD™ 900 Promoter	Proprietary Blend	Cytec Canada	Liquid	3	B-3, D-2A	3, 2, 0	200 L		slightly yellow liquid that has a slight sulphur smell. In confined space use respirator with organic vapour cartridges	Goggles, gloves. Respirator or SCBA if in confined space	eliminate ignition sources, use absorbent on small spills, for large spill pump to plastic drum for shipment off site. In case of fire use dry chemical extinguisher, CO_2 or foam. Water likely not effective.
MERCSORB Mercury Amalgamation Powder		NPS Corporation	solid	4		0, 1, 1	25 kg		Dry zinc dust will not ignite spontaneously, but once ignited, it may burn readily in air	Safety Glasses, Gloves	Sweep up spilled material and place in closed container for reuse. In case of fire use appropriate measures for surrounding fire.
Mercury Indicator Powder	Proprietary Blend	NPS Corporation	solid	not regulated		2, 1, 0			Odorless, yellowish-tan to gray powder. Dust may form a flammable or explosive mixture in air. When heated to decomposition, toxic fumes of sulfur oxides are produced	Safety Glasses, Gloves	Sweep up spilled material and place in closed container for reuse. In case of fire use appropriate measures for surrounding fire. This product in itself is considered to be non-hazardous.
Mercury Standard - AA		Anachemia	Liquid	8	D-2A, E	3, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Mercury Vapor Suppressor	Proprietary Blend	NPS Corporation	solid	not regulated		2, 1, 0			Odorless, black, irregular, dry granular solid. Wet activated carbon removes oxygen from the air causing a severe hazard to workers in confined space.	Safety Glasses, Gloves	Sweep up spilled material and place in closed container for reuse. Contaminated waste can be incinerated. In case of fire use appropriate measures for surrounding fire. This product in itself is considered to be non-hazardous.
Methanol		Anachemia	Liquid	3, 6.1	B-2, D-1B, D-2A,D-2B	1, 3, 0	200 L		Extremely Flammable, Vapours are harmful and solution is poisonous	Goggles, gloves. Respirator or SCBA if in confined space	Eliminate all sources of ignition. Ventilate area if required. Use absorbent. In case of fire, use dry chemical, CO2, Alcohol-resistant Foam or water spray. Incinerate waste.
MIBC	Methyl Isobutyl Carbinol	Flomin Inc.	Liquid	3		2, 2, 0	200 L	Frother in Mill	Product liquid and vapor are flammable. Keep away from heat and sources of ignition. Product vapors or mist may be irritating to eyes and respiratory system. Product liquid may cause eye and skin burns. Harmful if swallowed.	Googles or Face Shield, Gloves, Respirator (NIOSH/MSA)	Dike spill and collect for disposal or reuse. Use adsorbents on residual material. Flush spill area with water. Keep flush material out of waterways. Dispose of cleanup material in an approved manner.
MIBK	4-Methyl-2-pentanone	Fisher Scientific	Liquid	3	B-2	2, 3, 0	200 L		clear liquid that has a slightly sweet smell. In confined space use respirator with organic vapour cartridges	Safety Glasses, Gloves	Clear liquid that is immiscible with water. Use absorbent for small spills and incinerate waste. Large spills, eliminate ignitions sources and pump to plastic drum for shipment off site.
Molybdenum Standard - AA		Anachemia	Liquid	not regulated	not regulated	0, 0, 0				Safety Glasses, Gloves	Contain spill. Incinerate waste or place in landfill
Mucasol universal detergent		Sigma-Aldrich Canada	Liquid	not regulated	D-2B	2, 0, 0				Safety Glasses, Gloves	

Common Name (Synonyms)	Chemical Name	Manufacture / Supplier	Phase	TDG Class	WHMIS Class	NFPA Rating	Reporting Threshold	Use	Special Precautions	PPE Required	Special Cleanup and Disposal Info
Nickel Standard - AA		Anachemia	Liquid	8	D-2A, E	1, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Nitric Acid		Anachemia	Liquid	8	C, D-1A, E	4, 0, 0, OX	5 L		Concentrated acid, Extremely corrosive. Ventilate or stay upwind. **Strong Oxidizer**	Goggles, gloves. Respirator or SCBA if in confined space	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Nitric Acid 40%		Quadra Chemicals	Liquid	8	C, D-1A, E	4, 0, 0, OX	5 L		Concentrated acid, Extremely corrosive. Ventilate or stay upwind. **Strong Oxidizer**	Goggles, gloves. Respirator or SCBA if in confined space	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Oxygen		BOC Canada Limited (Linde)	Pressurized gas	2.2	A, C	0, 3, 0, OX	any if container larger then 100 L		Strong Oxidizer will Contribute to combustion of other materials.	Safety Glasses, Gloves	close valve if possible without risk, or allow the vent. In case of fire use any media suitable for surrounding fire. Use water spray to cool fire exposed containers.
Oxygen Refrigerant		Air Liquide Canada	Liquefied Gas	2.2	A, C	0, 3, 0, OX	any if container larger then 100 L		Strong Oxidizer will Contribute to combustion of other materials. Liquefied gas, will produce extreme cold when released.	Safety Glasses, Gloves	close valve if possible without risk, or allow the vent. In case of fire use any media suitable for surrounding fire. Use water spray to cool fire exposed containers.
Palladium Nitrate Matrix Modifier		Spex CertiPrep	Liquid	8	D-2A, E	3, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Phosphoric acid		Sigma-Aldrich Canada	Liquid	8	D-1A, D-2B, E		5 L		Concentrated acid, Extremely corrosive. Ventilate or stay upwind.	Goggles, gloves. Respirator	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.
Pine Oil (Terpene SW Blend)		Quadra Chemicals Ltd.	Liquid	not regulated	B-3, D-2B			Frother in Mill	Combustible liquid and vapor. Causes respiratory tract, eye and skin irritation. Use only with adequate ventilation. Keep container tightly closed and sealed until ready for use. Wash thoroughly after handling. Avoid oxidizing materials.	Goggles, Gloves, Respirator (air-purifying or air-fed)	Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble or absorb with an inert dry material and place in an appropriate waste disposal container. Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor.
PAX	Potassium Amyl Xanthate	Quadra Chemicals Ltd.	Solid	4.2	B-6, D-2B		25 kg	Collector in Mill	Keep away from water - contact with water liberates extremely flammable gases. Keep away from heat, sparks and flame - fine dust clouds may form explosive mixtures with air. Use only with adequate ventilation.	Goggles, Gloves, Respirator (air-purifying or air-fed)	Move containers from spill area. Avoid allowing the spilled material to get wet or using water to clean up spillages or residues, unless the quantity remaining is very small. Vacuum or sweep up material and place in a designated, labeled waste container. Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor.
Polyclear A2501		Quadra Chemicals Ltd.	Solid	not regulated	not regulated			Tailings thickener flocculant	Keep away from heat, sparks and flame - fine dust clouds may form explosive mixtures with air. Take precautionary measures against electrostatic discharges.Use only with adequate ventilation. Avoid oxidizing materials.	Safety Glasses, Gloves	Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Use spark-proof tools and explosion-proof equipment. In case of fire use appropriate measures for surrounding fire. Place in sealed container and dispose of via a licensed waste disposal contractor.
Polyclear 2528	Polyclear Floc	Quadra Chemicals Ltd.	solid	not regulated	not regulated				concentrated solution is extremely slippery, use caution	Safety Glasses, Gloves, respiratory equipment if risk assesment deems necesarry	Sweep up spilled material and it my be deposed of in dilute form to the pit or tailings system. In case of fire use appropriate measures for surrounding fire.
Polyclear 31080C		Quadra Chemicals Ltd.	Liquid	9	D-2B			Dewatering Aid in Mill	Use only with adequate ventilation. Avoid contact with strong oxidizers or halogens	Goggles, Gloves, Respirator (air-purifying or air-fed)	Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble or absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.
Polyfroth W31		Quadra Chemicals Ltd.	Liquid	not regulated	not regulated			Frother in Mill	Harmful or fatal if swallowed. Can enter lungs and cause damage. May cause target organ damage	Goggles, Gloves, Respirator (air-purifying or air-fed)	Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble or absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.
Potassium hydroxide	KOH	Science lab	Solid	8	D-1B	3, 0, 1	5 kg		very corrosive solid	Safety Glasses, Gloves	Use appropriate tools to put the spilled solid in a convenient waste disposal container. If necessary: Neutralize the residue with a dilute solution of acetic acid.
Potassium Iodide		Anachemia	solid	not regulated	D-2A	1, 1, 1			light and water exposure will cause breakdown	Safety Glasses, Gloves	Eliminate all sources of ignition. In case of fire use measures dictated by surrounding fire. Will decompose at high temperatures and emit toxic I_2 fumes. Use appropriate SCBA.
Potassium permanganate		CAIROX	Solid	5.1	C, E	1, 0, 0, OX	50 kg		corrosive solid. Oxidizing solid	Safety Glasses, Gloves	Sweep up solid spill for possible reuse. If necessary reduce material in aqueous solution with sodium thiosulfate (hypo), In case of fire use flooding quantities of water, material will contribute to combustion.
Propane		Superior Propane	Liquefied Gas	2.1	A, B-1		any if container larger then 100 L		Extremely flammable. Liquefied gas, will produce extreme cold when released.	Goggles, gloves. SCBA if in confined space	close valve if possible without risk, or allow the vent. In case of fire use any media suitable for surrounding fire. Use water spray to cool fire exposed containers.
Selenium Standard - AA		Anachemia	Liquid	8	E	1, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.

Minto Mine - Inventory of Dangerous Goods
Reporting Threshold, Special Precautions, PPE Requirements, and Cleanup and Disposal Methods

Common Name (Synonyms)	Chemical Name	Manufacture / Supplier	Phase	TDG Class	WHMIS Class	NFPA Rating	Reporting Threshold	Use	Special Precautions	PPE Required	Special Cleanup and Disposal Info
Sodium Borohydride		Anachemia	solid	4.3	B-6, B-4, D-1B, E	3, 1, 2	25 kg		Flammable solid. Reacts violently with water and acids to produce flammable H_2 gas. Strong reducing agent.	Safety Glasses, Gloves	Eliminate ignition sources, sweep up dry material. In case of fire use only dry chemical extinguisher, DO NOT USE WATER OR CO_2
Sodium Hydroxide Solutions (various strengths)	NaOH (The Anachemia MSDS is current, treat all solutions in the same manner regardless of strength.)	Various Suppliers	Liquid	8	E	3, 0, 1	5 L		Caustic solution. Avoid mixing with strong acids. Contact with metals such as aluminum, tin, lead and zinc generates hydrogen gas.	Safety Glasses, Gloves	Neutralize the residue with a dilute solution of acetic acid. Neutralized solution can be disposed of in the pit or tailings system.
Sodium Nitrite		Anachemia	solid	5.1, 6.1	C, D-1B, D-2A	3, 0, 2, OX	50 kg		**Strong Oxidizer** will Contribute to combustion of other materials.	Safety Glasses, Gloves	Eliminate all sources of ignition. In case of fire, use flooding quantities of water. Will decompose at high temperatures and emit acrid smoke. Strong oxidizer, may form compound that are sensitive to shock, friction. Sweep up solid spill for disposal. Dispose of contaminated solution in the pit or tailings system.
sodium sulphide Flakes	Sodium sulphide Hydrated	Quadra Chemicals	solid	8	D-1B, E		5 kg		caustic, very corrosive solid	Goggles, gloves. And a respirator, avoid creating dust and avoid any acids. Contact with acids liberate toxic H_2S	Sweep up spilled material an place in plastic sealed container for shipment off site.
TMT 15%	trisodium salt	Quadra Chemicals	Liquid	not regulated (treated as Cl. 9 Miscellaneous)	D-2B		25 L		water soluble	Safety Glasses, Gloves	No special clean up procedures, treated as Class 9 Miscellaneous as product does not meet Class 6 Toxicity standards but is an environmental hazard.
Urea	Carbamide	Anachemia	solid	not regulated	not regulated	1, 0, 0			Avoid contact with strong oxidizers. In fire conditions it can produce oxides of nitrogen. Also ammonia, and HCN	Safety Glasses, Gloves	Sweep up spilled material and it my be deposed of in dilute form to the pit or tailings system. In case of fire use appropriate measures for surrounding fire.
Vitec 7000		Avista Technologies	Liquid	not regulated	2A	1, 0, 0		Antiscalant in WTP	Avoid mixing with strong bases, strong oxidizers, very strong acids, water reactive materials	SCBA or SABA in confined space, Safety goggles/glasses, Chemical impervious gloves	Soak up or wet vacuum spilled liquid. Neutralize residue with sodium bicarbonate or other neutralizing agent for very dilute acids.Decontaminate the area thoroughly. Place all spill residues in suitable container and dispose of via a licensed waste disposal contractor.
VARSOL 3139 SOLVENT	Petroleum Hydrocarbons	Imperial Oil Chemicals	Liquid	3	B-3, D-2B	1, 2, 0	200 L		Flammable solvent	Safety Glasses, Gloves	Clean up uncontaminated material for reuse. Incinerate waste.
VoltEsso 35		Imperial Oil Chemicals	Liquid	not regulated	not regulated	1, 1, 0			electrical insulating oil	Safety Glasses, Gloves	Clean up uncontaminated material for reuse. Incinerate waste.
Zinc Standard - AA		Anachemia	Liquid	8	E	1, 0, 0	5 L		Dilute Nitric Acid <5%	Safety Glasses, Gloves	Neutralize with soda ash or lime. Contain spill, **do not** allow un-neutralized acid to enter water systems. Neutralized spill can be pumped to the pit or tailings system.

Appendix C: ERT Response to HazMat Spills

ERT Response to Hazmat Spill

Spill Contact: Yukon Territory Spill Line 1-867-667-7244

Canutec: 1-613-996-6666 Cell: *666

1. **Site Management and control**

   Initial responders will :

   - Approach the scene from uphill and upwind.
   - Establish command uphill and upwind of spill at an appropriate distance.
   - Establish 2 isolation perimeters: one that separates the hot zone from the warm zone and another that separates the warm zone from the cold zone. Emergency Response Guide or Canutec shall be referenced for perimeter size.
   - Evacuate affected area or 'protect in place', as req'd. Emergency Response Guide or Canutec shall be referenced for evacuation zone.
   - Identify contaminated persons and ensure they remain isolated until they can be decontaminated.
   - Establish a staging area.
   - Designate an information officer.
   - Possible unification of command.

2. **Identification of the problem**

   I/C will identify the:
   - Spilled product, as per witness testimony, placards, labels, bill of lading, type of container, etc. If product cannot be identified from command position, then a recon team will be tasked with identification.
   - Size of container.
   - Size and nature of release.
   - Conditions and # of victims at accident site.
   - Topography of area, and exposures threatened.

3. **Hazard & Risk Evaluation**

   A risk evaluation will be conducted, taking into consideration:
   - Product hazards
   - Access & Egress

- Size of Spill
- Condition of container
- Proximity of exposures
- Personnel available to perform operations, and their level of training/experience
- Information from MSDS, ERG, Canutec, etc., minimum 3 sources

4. Personal Protective Equipment

PPE will be selected for Ops, RIT, and Decon teams, considering:

- Flammability/explosiveness of product
- Toxicity of product
- Route of entry of product
- Permeation rate of PPE
- Breakthrough time of PPE
- Availability of PPE
- Visibility and workability while wearing PPE

5. Information management and resource coordination

The information officer will begin to gather information about the product once it has been identified. The information officer can use the MSDS, ERG, Canutec, or many other resources to gather information, such as:

- Properties of the product
- Hazards of the product
- Expected travel of product released
- Populations/ environment in jeopardy
- PPE req'd by responders
- Decontamination requirements

Command will prioritize the information and ensure that the correct people receive the correct information.

6. Implementing Response Objectives

Command will develop an overall strategy, which may be offensive (entry of hot zone to gain quick control), defensive (contain from the cold zone to prevent spread), or passive (isolate only, and wait for incident to run its course), considering:

- Life safety
- Incident stabilization
- Environmental protection
- Property salvage

Command will delegate tactics to operations teams, such as:

- Reconnaissance for unknown product
- Evacuation for toxic gas leak, fire, or explosive hazard
- Fire control for flammable gas, flammable liquid, or oxidizer
- Search and rescue
- Leak control
- Neutralization of corrosives
- Deployment of boom, drain covers, etc.
- Building of dams, dykes, etc.

To follow: specific tactic options will be discussed in more detail, pertaining to hazardous materials that are commonly found in large quantities at the Minto Mine.

Entry teams will enter with a clear objective, but must assess for the next team's objective. For example, the 1st entry team may be tasked with rescuing the driver of a fuel truck that rolled down a bank and is spilling fuel. Although their objective is to rescue, while they are on scene they should observe where the leak is, consider what could be used to stop it, where the fuel is going, and what is needed to contain it. They should bring a camera, so that pictures can be brought back to command. This will give command crucial information and better prepare the next team for their task.

7. Decontamination

Considerations for decontamination should begin at the outset of the incident. A decontamination construct will exist in the warm zone prior to any team entering the hot zone. It will typically consist of a large berm fashioned out of a large chemical resistant tarp, wrapped over a charged 2 ½" hose-line. There will be a charged 1 ½" hose-line nearby for emergency decontamination. Within the berm, there will be a series of smaller berms, in which, personnel will stand while being decontaminated. Personnel conducting the decontamination will be wearing the appropriate PPE (typically 1 class below ops) and will use detergent and water to gently scrub and rinse ops personnel and rescuees as they exit the hot zone. Tools and anything else exiting the hot zone will be decontaminated as well.

Once decontamination is complete, all product collected by the berms, will be handled as per the MSDS.

8. Termination

Once emergency operations are complete, the scene will be handed over to clean-up & recovery operations. Command will ensure that the hand-off includes all pertinent information about the spilled product:

- Properties
- Hazards
- Location
- Safe-handling
- Exposure signs and symptoms
- Req'd PPE
- Disposal procedures

Command will conduct an on-site debrief. As well, a more formal debrief will be conducted, with all parties involved, at a later time. The incident will be documented, including exposure records for all personnel that entered the warm and/or hot zones.

Nitric Acid 40%

Note: when it comes to corrosives such as Nitric Acid, the solution to pollution is NOT dilution. For a spill of 1   45 gal drum, it would take over 450,000 gal of pure water to make the solution habitable for fish. It would take over 45,000,000 gal of pure water to neutralize it.

Site management and control

- Set up perimeter with at least 50m radius.
- Command, staging, & decon shall be positioned uphill.
- Unify command with Safety Superintendent, Mine Manager, Environmental Dept., product Carrier (if spill occurs during delivery to mine).

Identification

- UN# 2031
- Liquid state
- Colourless to yellow
- Transported in 45 gallon drums
- # of 45 gal drums possibly damaged will help estimate size of spill.
- What is downhill from spill? Could acid reach a stream?

Hazard & risk evaluation

- Strong acid, very corrosive.
- Severely hazardous to eyes and skin
- Ingestion could cause death
- Inhalation hazard, although low vapour pressure 1.3kPa (wants to be a liquid).
- Could be devastating to stream life.
- Strong oxidizer, could have explosive reaction with organic or combustible materials

PPE

- If there is a fire situation, PPE will consist of full turn-out gear and SCBA.
  Otherwise
- Know and heed permeability rate and breakthrough times of all PPE.
- Acid resistant, class B suit with hood.
- Full-face respirator with appropriate chemical cartridges.
- Chemical resistant gloves & boots
- Chemical resistant tape used to seal between boots/suit, gloves/suit, and mask/hood.

Information management and resource coordination

- See MSDS for product information.
- Know the product's route of travel.
- Was anyone exposed?
- Will non-human life be exposed?
- Standard decon set-up will be constructed.
- Have tools cribbed for entry teams.
- Ensure there is enough PPE at the site to complete the task.
- Ensure there is enough neutralizing agent at the site to complete the task. ***See below for chart***
- Ensure there is drinking water for responders.
- Have hazmat trailer, ambulance & fire truck in staging area, as req'd
- Have Site Services staged for digging, damming, product extraction, as req'd.

Implementing Response Objectives

- Rescue injured/exposed personnel.
- Prevent from entering streams
- Prevent from contacting combustibles and organics.
- If possible, stop the leak.
- If possible, contain by covering drains/culverts, damming, diverting to a berm, etc.
- Use over-pack to contain leaking drums that still contain product.
- Neutralize spilled product with weak caustic – primary neutralizing agent is Ansul Spill X-A, alternatively hydrated lime or baking soda (if available). Be cautious of chemical reaction.
- Use Litmus paper to test for pH when neutralizing with lime or baking soda.
- Site Services Vac-truck is an option for cleaning up product before or after neutralized, as necessary.

Decontamination

Standard decon set-up will be utilized in warm zone:

- Large berm fashioned out of large chemical resistant tarp, wrapped over charged 2 ½" hose-line, 2 small berms, will be in series, within the large berm.
- Decon personnel shall don class C suits without need for respiratory or splash protection, other than safety glasses.
- Ensure all personnel that entered hot zone are properly decontaminated.
- Ensure that all tools that entered the hot zone are properly decontaminated.

Termination

- Once operation complete, vac-truck can be utilized to clean up solution contained with the decon berms.
- Safe and proper disposal of all spent PPE.

- Transition of command.
- Debrief

Quick Access Chart for Estimating Amount of Caustic Req'd to Neutralize 40% Nitric Acid

For **Spill X-A**, use 1:1 ratio by volume, or 10lbs Spill X-A per 1 gal Nitric Acid.

Amount of Nitric Acid Spilled (in Gal.)	Amount of Baking Soda Req'd (in Lbs.)
1	5.6
2	11
5	28
10	56
20	110
45	252
90	504
135	756
180	1,008

Amount of Nitric Acid Spilled (in Gal.)	Amount of Lime Req'd (in Lbs.)
1	2.4
2	4.8
5	12
10	24
20	48
45	108
90	216
135	324
180	432

Charts derived from formulas below

Specific Gravity Nitric Acid: 1.2455

Concentration: 40%

1 gal HNO3 x 1.24 x 8.34 lbs/gal x 0.40 = 4.14 lbs HNO3

HNO3 + NaHCO3 → NaNO3 + H2O + CO2 Therefore 1 mol Nitric Acid per 1 mol Sodium Bicarb (Baking Soda)

2HNO3 + Ca(OH)2 → Ca(NO3)2 + 2H2O Therefore 2 mol Nitric Acid per 1 mol Calcium Hydroxide (Lime)

HNO_3 = 63 amu

$NaHCO_3$ = 85 amu

$Ca(NO_3)_2$ = 74 amu

(4.14 lbs HNO_3/63 amu-HNO_3) x 85 amu-$NaHCO_3$ = 5.6 lbs $NaHCO_3$

Therefore 1 gallon of Nitric Acid req's 5.6 lbs of baking soda

(4.14 lbs HNO_3/2(63) amu-HNO_3) x 74 amu-$Ca(OH)_2$ = 2.4lbs $Ca(NO_3)_2$

Neutralization Formulas and Quick Access Charts **Formulas**

The key to effective and efficient neutralization, is knowing how to use the following formulas.

1. The first formula indicates how much acid is spilled in weight.

Step #1- Determine the quantity of acid spilled, usually in gallons.
Step #2- Determine the specific gravity of the acid usually provided in MSDS.
Step #3- Determine the concentration of the acid spilled usually in %.
Step #4- The weight of water is 8.34 pounds per gallon.

After the above figures are known plug them into the following formula.

Quantity of spill X specific gravity X weight of water X concentration = weight of the spill

Example
One gallon of sulfuric X 1.84 X 8.34 X 98% = 15.04 pounds of sulfuric

2. The second formula will determine the quantity of the neutralizer needed. The type of neutralizer needs to be selected based on costs and availability. Plug numbers into the following formula.
3.

Weight of the acid spilled X number in the chart for the selected neutralizer.

Example

15.04 pounds of sulfuric X 1.06 for Soda Ash = 15.94 pounds of Soda Ash

Determination through Chemistry

To calculate the amount of neutralization agent needed the balanced chemical reaction must be written and the equivalent weights of acid and base determined.

Example: 1,000 gallons of 38% hydrochloric acid will be neutralized with lime.

Step #1 – Write the complete balanced neutralization reaction:
$2HCl + CaO \rightarrow CaCl_2 + H_2O$
This equation shows that 2 moles of HCl are required in the reaction with one mole of calcium oxide (lime).

Step #2 – Calculate the molecular weight of each compound:
HCl – H = 1, Cl = 35.5, Total = 36.5 amu
CaO – Ca = 40, O = 16, Total = 56

Step #3 – Calculate the weight of the HCl spill:
1,000 gallons X 1.20 X 8.34 X 0.38 = 3,803.04 pounds of HCl
Step #4 – Calculate the amount of neutralizer needed:
From Step #1 it was found that 2 moles of HCl are needed to react with 1 mole of CaO. From Step #2 it was found that 1 mole of HCl weighs 36.5 amu's so 2 moles weigh 73.0 amu's. The formula is**; weight of acid/formula weight of acid X formula weight of base = pounds of the neutralizer needed.**
3,803.04/73 X 56 = 2,917.4 pounds of lime

Finer Points
The final amount is an approximation and in actual practice more neutralizing agent should be obtained. The neutralization process needs to be checked at several spots to assure pH levels are acceptable and uniform.

Neutralization Precautions
Remember, the neutralization process is exothermic and it may involve splashing of product. Safety is paramount and proper protective equipment is very important. Also, the neutralizer is hazardous in its own right and needs to be handled with care. Consider expense and availability in selecting neutralizer. Other weak bases that may be used and their molecular weights are; sodium bicarbonate ($NaHCO_3$)- 85, and magnesium hydroxide ($Mg(OH)_2$)-58.

Neutralization Chart Information
Acids

Hydrochloric Acid, HCl, MW = 36.5, density/specific gravity is 1.19, weight of a gallon is 3.77 pounds at 38% concentration. Synonyms are chlorohydric acid and muriatic acid.

Nitric Acid, HNO_3, MW = 63, density/specific gravity is 1.41, weight of a gallon is 8.23 pounds at 70% concentration. Synonyms are Aqua Fortis and Azotic Acid. (Aqua Regia is a mixture of nitric and hydrochloric acids).

Phosphoric Acid, H_3PO_4, MW = 98, density/specific gravity is 1.69, weight of a gallon is 11.98 pounds at 85% concentration. Synonyms are orthophosphoric acid.

Sulfuric Acid, H_2SO_4, MW = 98, density/specific gravity is 1.84, weight of a gallon is 15.04 pounds at 98% concentration. Synonyms are Oil of vitriol and "oleum" is fuming sulfuric acid.

Bases

Ammonium hydroxide, NH_4OH, MW = 35, clear solution, synonyms are ammonia solution and aqua ammonia. Strong ammonia odor evolves from liquid. High vapor pressure.
Calcium carbonate, $CaCO_3$, MW = 100, white powder, synonyms are crushed limestone and dolomite. Low heat of reaction that gives off carbon dioxide gas.
Calcium hydroxide, $Ca(OH)_2$, MW = 74, white powder, synonyms are slaked lime, hydrated lime, and calcium hydrate.
Calcium oxide, CaO, MW = 56, white powder, synonyms are quicklime, lime, and unslaked lime. Most economical, lowest cost, neutralizer. **Best choice!** Maximum pH is 12.45 at 25C.
Magnesium carbonate, $MgCO_3$, MW = 84, synonyms are magnesia alba and carbonate magnesium.
Magnesium hydroxide, $Mg(OH)_2$, MW = 58, white powder, synonyms are milk of magnesia and magnesia hydrate. Good neutralization agent. Maximum pH is 10.6 at 25C.
Potassium hydroxide, KOH, MW = 56, white flakes, synonyms are caustic potash. High heat of reaction with toxic fumes. Maximum pH is 14 at 25C.
Sodium bicarbonate, $NaHCO_3$, MW = 85, white powder, synonyms are baking soda and sodium acid carbonate. Low heat of reaction with carbon dioxide gas evolution.
Sodium Carbonate, Na_2CO_3, MW = 106, white powder, synonyms are soda ash. **Second most economical neutralization agent next to lime.** Maximum pH is approximately 11 at 25C.
Sodium hydroxide, NaOH, MW = 40, white powder, synonyms are caustic soda, soda lye, caustic, and lye. High heat of reaction with toxic fumes. Maximum pH is 14 at 25C.

Quick Access Charts

Sulfuric Acid neutralization using Baking Soda (Sodium Bicarbonate)

Amount of Sulfuric Acid spilled	Amount of Baking Soda needed in pounds
1 gallon	25.6
2 gallons	51.2
3 gallons	76.8
4 gallons	102.4
5 gallons	128.0
10 gallons	256.0
50 gallons	1280.0
55 gallons	1408.0
100 gallons	2560.0

Hydrochloric Acid neutralization using Baking Soda

Amount of Hydrochloric Acid spilled	Amount of Baking Soda needed in pounds
1 gallon	5.5
2 gallons	11.0
3 gallons	16.5
4 gallons	22.0
5 gallons	27.5
10 gallons	55.0

50 gallons	275.0
55 gallons	302.5
100 gallons	550.0

Nitric Acid neutralization using Baking Soda

Amount of Nitric Acid spilled	Amount of Baking Soda needed in pounds
1 gallon	7.4
2 gallons	14.8
3 gallons	22.2
4 gallons	29.6
5 gallons	37.0
10 gallons	74.0
50 gallons	370.0
55 gallons	407.0
100 gallons	740.0

Sodium Sulfide

Site management and control

- Set up perimeter with at least 50m radius if water introduced, or 25m if solid.
- Command, staging, & decon shall be position upwind and uphill.
- Unify command with Safety Superintendent, Mine Manager, Environmental Dept., product carrier (if spill occurs during delivery to mine).

Identification

- UN# 1849
- Solid state
- Yellow
- Smell sulfurous or like rotten eggs with introduction of moisture.
- Transported in 1000 Kg 'Super-Sacks'.
- # of super-sacks possibly damaged, will help estimate size of spill.
- Is water being introduced to the spill? If so, what is downhill form the spill? Could run-off reach a stream?
- Are corrosives being introduced to spill? If so, what is downwind?

Hazard & risk evaluation

- Strong caustic.

- Severely corrosive to digestive tract, respiratory system, eyes, and skin.
- Dust is powerful systemic poison. Inhalation could cause headache, dizziness, unconsciousness, pulmonary edema, asphyxiation, death.
- Contact with acid releases toxic and flammable Hydrogen Sulfide.
- Routes of entry include absorption, inhalation, and ingestion.
- Keep spilled product dry
- If water introduced, avoid run-off, contact with soil, waterways.

PPE

- If there is a fire situation, PPE will consist of full turn-out gear and SCBA.
  Otherwise
- Know and heed permeability rate and breakthrough times of all PPE.
- SCBA if significant H2S release, otherwise, full-face respirator & OV cartridges with pre-filter.
- Corrosive resistant, class B suit with hood.
- Chemical resistant gloves & boots
- Chemical resistant tape used to seal between boots/suit, gloves/suit, and mask/suit.

Information management and resource coordination

- See MSDS for product information.
- Was anyone exposed?
- Will non-human life be exposed?
- Standard decon set-up will be constructed.
- Have tools cribbed for entry team.
- Ensure there is enough PPE at the site to complete the task.
- Ensure there is drinking water for responders.
- Have hazmat trailer, ambulance & fire truck in staging area, as req'd
- Have Site Services staged for digging, damming, product extraction, as req'd.

Implementing Response Objectives

- Rescue injured/exposed personnel.
- Keep product dry.
- Monitor atmosphere for H2S and SO2.
- If water introduced, contain run-off by covering drains/culverts, damming, diverting to a berm, etc. Solution collected can be mixed with oxidizing agent, such as hydrogen peroxide or sodium hypochlorite to prevent evolution of H2S.
- If product has entered a stream, consider using over-flow dams to contain product, for extraction.
- Vacuum or sweep up dry product
- Disposal as per Environmental Dept. recommendations

Decontamination

Standard decon set-up will be utilized in warm zone:

- Large berm fashioned out of large chemical resistant tarp, wrapped over charged 2 ½” hose-line, 2 small berms, will be in series, within the large berm.
- Decon personnel shall don class C suits without need for respiratory or splash protection, other than safety glasses.
- Ensure all personnel that entered hot zone are properly decontaminated.
- Ensure that all tools that entered the hot zone are properly decontaminated.

Termination

- Once operation complete, solution in decon berms to be disposed of, as per Environmental recommendations.
- Safe and proper disposal of all spent PPE.
- Transition of command.
- Debrief

LPG (Propane)

Note: Minto gas detectors are calibrated to methane, and must be corrected to propane prior to use, during propane leak mitigation.

Site management and control

- Set up initial perimeter of at least 100m. For large tank where there is fire, set up perimeter of at least 1600m.
- Command, staging, & decon shall be positioned uphill and upwind.
- Eliminate sources of ignition.
- Unify command with Safety Superintendent, Mine Manager, Environmental Dept., product carrier (if spill occurs during delivery to mine).

Identification

- UN# 1075
- Colourless liquid and vapour while stored under pressure.
- Colourless and odourless gas in natural state at any concentration.
- Commercial propane has an odorant added which is commonly ethyl.
- Transported by tanker truck.
- Stored in 12,000L tank at ramp to camp and twin 18,000L tanks at Km 0 of the access road.

- What is downhill from spill?
- Is there threat to life?
- Is there threat to a stream?

Hazard & risk evaluation

- Extremely flammable gas.
- Vapour could be ignited by any source of ignition.
- Vapour is heavier than air and may travel considerable distance to an ignition source, and flash back.
- Stored under pressure, as a liquid.
- Product extraction methods could create static if not bonded/grounded, and serve as an ignition source.
- Massive explosion hazard where flame impingement on tank.

PPE

- Full turn-out gear with SCBA.

` **Information management and resource coordination**

- See MSDS for product information.
- Consider contacting Canutec.
- Know the product's route of travel.
- Ensure tools are cribbed for entry teams.
-
- Have fire truck at scene and ambulance in staging area, as req'd

Implementing Response Objectives Leak in an enclosed space

- Evacuate structure.
- Close supply valve remotely if possible.
- Eliminate any source of ignition.
- Use positive pressure to ventilate space, ensure that it is exhausting to safe location.

If no remote isolation valve:

- Entry team (2 ERT members) & RIT team (2 ERT members) will don full turn-out gear & SCBA.
- Any electronic equipment being carried, such as radio or gas detector, must be intrinsically safe.
- Entry team will enter with charged 1 ½" hose-line and gas detector equipped with LEL sensor, while RIT stages in the cold zone .

- Once entry team is at ‘reach of stream’ distance from the leak, the nozzleman (Entry member 1) will set-up, with nozzle fixed on Entry member 2. Entry member 2 will continue toward valve, with gas detector.

  If LEL sensor rises above 20%, entry team will retreat until ventilation can be made adequate.

- Once Entry member 2 reaches the valve, he will close the valve, then back away until he reaches entry member 1.
- Entry team will exit the structure, until it has been adequately ventilated.
- Once adequately ventilated, ERT members, wearing appropriate PPE, will sweep the structure with gas detector(s), to ensure there are no pockets of gas, before deeming the structure ‘safe to enter’.

<u>LPG line on fire, with no impingement</u>

Note: a propane leak that is burning is safer than one that is not burning, as long as there is no impingement on a tank or structure. Therefore, in this scenario, gas will be allowed to burn until the valve can be shut off.

- Evacuate immediate area.
- If possible, close isolation valve from remote location.

  If no remote isolation valve:

- Eliminate any further source of ignition.
- 2 or more ERT members in full turn-out gear & SCBA will be on 1 ½” hose-line.
- Nozzle will be turned to full fog, which will create a water-curtain between the fire and the fire fighters.
- The fire team will approach the isolation valve, keeping the water-curtain between themselves and the fire at all times, being careful not to put the fire out with the stream
- When the valve is reached by the team, the 2nd member on the line will let go of the hose and approach the valve, while the nozzleman maintains the water-curtain between the fire and the valve/fire team.
- The 2nd member will close the valve then back away from the fire until he regains his position on the hose.
- The team will maintain the water-curtain while they back away from the damaged gas-line.
- Once the team is at a safe distance, a 45 degree pattern can be fixed on the broken gas-line to cool it, and disperse any residual gases.

LPG leak, not enclosed, not on fire

Note: LPG has a very high vapour pressure (1013 kPa) so it wants to be a gas, a high vapour density (1.52) so it's heavier than air, and a low flash point (-103.4 C). This combination means that it can form an explosive gas cloud that will stay close to the ground, may linger in incident area, or migrate downwind and/or downhill, possibly settling in low lying areas.

- Evacuate immediate area as well as areas downwind/downhill as per ERG recommendations.
- If possible, close isolation valve from remote location.
- From 'reach of stream', set up ground monitor and fix a 45 degree fog pattern on area of concern. This will push gas cloud away from area and disperse it. Be sure to push it to a safe location.

If no remote isolation valve:

- Entry team (2 ERT members) & RIT team (2 ERT members) will don full turn-out gear & SCBA.
- Any electronic equipment being carried, such as radio or gas detector, must be intrinsically safe.
- Entry team will enter with charged 1 ½" hose-line and gas detector equipped with LEL sensor, while RIT stages in the cold zone.
- While ground monitor continues to 'make it rain' in the hot zone, nozzleman (entry member 1) will fix nozzle on entry member 2, as entry member 2 approaches the isolation valve, with gas detector.

If LEL sensor rises above 20%, entry team will retreat until water stream can be made more effective

- Once Entry member 2 reaches the valve, he will close the valve, then back away until he reaches entry member 1.
- Entry team will retreat to the cold zone until gases are adequately dispersed
- Once the gas is adequately dispersed, ERT members, wearing appropriate PPE, will sweep the area with gas detector(s), including low-lying areas where gas may have migrated to, before deeming the area 'safe to enter'.

Fire where there is flame impingement on LPG tank

- Evacuate all non-ERT members for at least 1,800 m where there is flame impingement on either the 12,000 L tank or the tandem 18,000 L tanks.
- Command will know and understand the signs of imminent BLEVE.
- If Command witnesses signs of imminent BLEVE from an upright tank, there shall be no attempt made to cool tanks, rather, all focus shall be on a rapid evacuation of all personnel, at least 1,800m.
- If tank has been knocked over, there may be little or no warning signs of BLEVE, therefore no attempt shall be made to cool, rather, all focus shall be on a rapid evacuation of all personnel, at least 1,800m.
- If a BLEVE is not imminent, an attempt will be made to connect a ground monitor to the stand-pipe at the Tailings bldg.
- A narrow fog stream will be fixed on the tank at the area of flame impingement.
- The monitor will be left unmanned and the remaining ERT will evacuate at least 1,800m.

Where a tanker truck carrying propane has over-turned on the access road, causing damage to the tank trailer and subsequent rapid release of propane, the strategy for the hazmat portion of the incident response, will be passive and conducted from an upwind/uphill location, at a safe distance, as per the ERG. Transfer of residual product for the scenario, will be conducted by outside resource.

Decontamination

- 1 ½" charged hose-line, as emergency decon

Termination

- Debrief

BW GasAlert Micro 5 is intrinsically safe, as per: *http://directories.csa-international.org/xml_transform.asp?xml=certxml%5C080259_0_000-4828-82.xml&xsl=xsl/certrec.xsl*

- GasAlert Micro 5 Portable Gas Detector, Model M5-xwt1t2-r-p-d-a-b-cc & M5PID-xwt1t2-r-p-d-a-b-cc; utilizing electrochemical, catalytic bead and photo-ionization sensors; Intrinsically Safe when powered by one of the following AA Size Batteries /

Battery Pack
- Duracell MN1500; T-Code T4; Ambient -20 to +40°C; T-Code 139.8°C (T3C); Ambient -20 to +50°C
- Energizer E91; T-Code 153°C(T3C); Ambient -20 to +40°C; T-Code 163°C (T3B); Ambient -20 to +50°C
- NiMH Rechargeable Battery Pack "M5-BAT01"; T-code T4; Ambient -20 to +50°C
- Lithium Polymer Rechargeable Battery pack “M5-BAT07B”; T-Code T4; Ambient -20 to +50°C

Diesel, Kerosene, CFE 150

Note: LEL sensor will not detect presence of long-chain hydrocarbon vapour. Photo-ionization detector (PID) should be used, if available.

Site management and control

- Set up perimeter with at least 50m radius.
- Command, staging, & decon shall be positioned uphill and upwind.
- Eliminate sources of ignition.
- Unify command with Safety Superintendent, Mine Manager, Environmental Dept, Dyno Nobel (if spilled product is CFE 150), product carrier (if spill occurs during delivery to mine).

Identification

- UN# 1202.
- Liquid state.
- Colour varies.
- Petroleum odour.
- Transported by B-train, tidy-tanks.
- Stored in tanks at fuel farm.
- What is downhill from spill??
- Is there threat to life?
- Is there threat to a stream?

Hazard & risk evaluation

- Combustible liquid.
- Vapour could be ignited by any source of ignition.
- Extraction methods could create static if not bonded/grounded, and serve as an ignition source.
- Ambient temperature relevant.

- Irritant to eyes and skin
- Ingestion and inhalation hazard
- Toxic to aquatic life.

PPE

- If there is a fire situation, PPE will consist of full turn-out gear with SCBA.
  Otherwise
- For offensive strategies, such as rescue or plugging, full turn-out gear with SCBA
- For defensive strategies, such as diverting, damming, booming, diking, class B suit.
- Respirator with OV cartridges.
- Oil resistant gloves & boots

Information management and resource coordination

- See MSDS for product information.
- Know the product's route of travel.
- Standard decon set-up will be constructed.
- Ensure tools are cribbed for entry teams.
- Ensure there is enough PPE at the site to complete the task.
- Ensure there is drinking water for responders.
- Have hazmat trailer, ambulance & fire truck in staging area, as req'd.
- Have Site Services staged for digging, damming, product extraction, as req'd.

Implementing Response Objectives

- Rescue injured personnel.
- Consider using fog stream to protect rescuers.
- Fire-fighting: Use dry chemical, CO2, Class B foam, or water with fog pattern.
- If using fog, considering increased run-off hazard
- Prevent from entering streams.
- If possible, stop the leak: close valves, use plugs, plug n' dyke, gaskets, straps, jacks, cribbing, etc.
- Containment berm at source, 'Surrey Condom'.
- If possible, contain by covering drains/culverts, diking, diverting to a berm, absorbing, etc.
- If product has entered a stream, use booms, hydrocarbon-only absorbent socks and pads, under-flow dams, diversion-booms, skimmers to contain and extract, as per instructions found later in this document.
- If transfer of product req'd, ensure entire system is bonded/grounded.
- Use non-sparking tools, such as pneumatics.
- Site Services Vac-truck is an option for cleaning up product.

Decontamination

Standard decon set-up will be utilized in warm zone:

- Large berm fashioned out of large chemical resistant tarp, wrapped over charged 2 ½" hose-line, 2 small berms, will be in series, within the large berm.
- Decon personnel shall don class C suits without need for respiratory or splash protection, other than safety glasses.
- Ensure all personnel that entered hot zone are properly decontaminated.
- Ensure that all tools that entered the hot zone are properly decontaminated.

Termination

- Once operation complete, vac-truck can be utilized to clean up solution contained with the decon berms.
- Safe and proper disposal of all spent PPE.
- Transition of command.
- Debrief

Gasoline

Note: Minto gas detectors are calibrated to methane and must be corrected to gasoline, or alternatively pentane, prior to use during gasoline spill mitigation

Site management and control

- Set up perimeter. Consider radius up to 800m depending on amount of product and level of explosion hazard.
- Command, staging, & decon shall be positioned uphill and upwind.
- Eliminate sources of ignition.
- Unify command with Safety Superintendent, Mine Manager, Environmental Dept., product carrier (if spill occurs during delivery to mine).

Identification

- UN# 1203.
- Liquid state.
- Colourless to slightly yellow.
- Recognizable odour.

- Transported by B-train, tidy-tanks.
- Stored in tank at fuel farm.
- What is downhill from spill??
- Is there threat to life?
- Is there threat to a stream?

Hazard & risk evaluation

- Flammable liquid. Extremely flammable in presence of ignition source, at nearly any temperature.
- Vapour could be ignited by any source of ignition.
- Vapour is heavier than air and may travel considerable distance to an ignition source, and flash back.
- Product extraction methods could create static if not bonded/grounded, and serve as an ignition source.
- Explosion hazard where flame impingement on tank.
- Irritant to eyes.
- Ingestion and inhalation hazard
- Toxic to aquatic life.

PPE

- If there is a fire situation, PPE will consist of full turn-out gear with SCBA.
  Otherwise
- For offensive strategies, such as rescue or plugging, full turn-out gear with SCBA
- For defensive strategies, such as diverting, damming, booming, diking, fire resistant class B suit.
- Respirator with OV cartridges, only if LEL's are being monitored, otherwise, do not dampen sense of smell. Rather, move upwind of product vapour.

Information management and resource coordination

- See MSDS for product information.
- Know the product's route of travel.
- Standard decon set-up will be constructed.
- Ensure tools are cribbed for entry teams.
- Ensure there is enough PPE at the site to complete the task.
- Ensure there is drinking water for responders.
- Have hazmat trailer, ambulance & fire truck in staging area, as req'd
- Have Site Services staged for digging, damming, product extraction, as req'd.

Implementing Response Objectives

- Offensive tactics for rescue of injured personnel only.
- Consider blanketing affected area with class B foam, prior to rescuers entering hot zone.

- Use fog stream to suppress vapours and protect rescuers.
- Rescuers will carry intrinsically-safe radios and gas-detector.
- Prevent from entering streams
- If possible, stop the leak.
- If possible, contain by covering drains/culverts, diking, diverting to a berm, absorbing, etc.
- If product can or has has entered a stream, use booms, hydrocarbon-only absorbent socks and pads, under-flow dams, diversion-booms, as per instructions found later in this document.
- Safe handling and disposal of all waste product.

Decontamination

Standard decon set-up will be utilized in warm zone:

- Large berm fashioned out of large chemical resistant tarp, wrapped over charged 2 ½" hose-line, 2 small berms, will be in series, within the large berm.
- Decon personnel shall don class C suits without need for respiratory or splash protection, other than safety glasses.
- Ensure all personnel that entered hot zone are properly decontaminated.
- Ensure that all tools that entered the hot zone are properly decontaminated.

Termination

- Once operation complete, safe disposal of decon berm contents
- Safe and proper disposal of all spent PPE
- Hand-over command of operation to Environmental Dept.
- Debrief

Ammonium Nitrate

Site management and control

- Set up perimeter with at least 25m radius.
- Command, staging, & decon shall be positioned upwind.

- Eliminate sources of ignition.
- Unify command with Safety Superintendent, Mine Manager, Environmental Dept, Dyno Nobel, product carrier (if spill occurs during delivery to mine).

Identification

- UN# 1942.
- Solid state. Prills or granules.
- White.
- Odorless.
- Is there threat to a stream?

Hazard & risk evaluation

- Oxidizer .
- Exposure to high heat may evolve toxic, flammable gases.
- Explosive when confined and exposed to high heat.
- Ingestion and inhalation hazard.
- Toxic to aquatic life.

PPE

- If there is a fire situation, PPE will consist of full turn-out gear with SCBA.
  Otherwise
- Class C suit with long sleeves.
- Dust mask.
- Oil resistant gloves & boots

Information management and resource coordination

- See MSDS for product information.
- Work closely with Dyno.
- Standard decon set-up will be constructed.
- Have tools cribbed for entry teams.
- Ensure there is enough PPE at the site to complete the task.
- Ensure there is drinking water for responders.
- Have hazmat trailer, ambulance & fire truck in staging area, as req'd
- Have Site Services staged for digging, damming, product extraction, as req'd.

Implementing Response Objectives

- Rescue injured personnel.
- Fire-fighting: If flame impingement on tank, use unmanned ground monitor to supply flooding quantities of water via straight-stream, to cool tank. Then, evacuate area 800m in all directions. If signs of imminent explosion are present prior to setting up ground monitor, do not attempt to set it up, just evacuate for 800m in all directions.
- Prevent from entering streams.
- Once in stream, may be unrecoverable. Underflow dams should be constructed, and surface can be skimmed.
- If possible, stop anymore product from being spilled.
- Follow Dyno's recommendations for recovery and clean-up of product.

Decontamination

Standard decon set-up will be utilized in warm zone:

- Large berm fashioned out of large chemical resistant tarp, wrapped over charged 2 ½" hose-line, 2 small berms, will be in series, within the large berm.
- Decon personnel shall don class C suits without need for respiratory or splash protection, other than safety glasses.
- Ensure all personnel that entered hot zone are properly decontaminated.
- Ensure that all tools that entered the hot zone are properly decontaminated.

Termination

- Once operation complete, vac-truck can be utilized to clean up solution contained with the decon berms.
- Safe and proper disposal of all spent PPE.
- Transition of command.
- Debrief.

Emulsion

Site management and control

- Consider initial perimeter of 800m.

- Command, staging, & decon shall be positioned upwind.
- Eliminate sources of ignition.
- Unify command with Safety Superintendent, Mine Manager, Environmental Dept, Dyno Nobel, product carrier (if spill occurs during delivery to mine).

Identification

- UN# 0332.
- Viscous liquid.
- Pink, opaque.
- Slight fuel oil odour.
- Shipped in bulk by tanker truck.

Hazard & risk evaluation

- Emulsion explosives.
- Stable under normal conditions.
- May explode under fire conditions.
- Eye & skin irritant.
- Slight ingestion & inhalation hazard.
- Avoid contact with corrosives.
- Is there threat to a stream?

PPE

- Class C suit with long sleeves.
- Standard PPE

Information management and resource coordination

- See MSDS for product information.
- Work closely with Dyno.
- Standard decon set-up will be constructed.
- Have tools cribbed for entry teams.
- Ensure there is enough PPE at the site to complete the task.
- Ensure there is drinking water for responders.
- Have hazmat trailer, ambulance & fire truck in staging area, as req'd
- Have Site Services staged for digging, damming, product extraction, as req'd.

Implementing Response Objectives

- Rescue injured personnel.
- Fire-fighting: If fire reaches cargo, DO NOT ATTEMPT TO FIGHT FIRE. Cargo may explode. Evacuate in all directions for 1600m.
- Prevent from entering streams.
- If possible, stop anymore product from being spilled.
- Follow Dyno's recommendations for recovery and clean-up of product.

Decontamination

Standard decon set-up will be utilized in warm zone:

- Large berm fashioned out of large chemical resistant tarp, wrapped over charged 2 ½" hose-line, 2 small berms, will be in series, within the large berm.
- Decon personnel shall don class C suits without need for respiratory or splash protection, other than safety glasses.
- Ensure all personnel that entered hot zone are properly decontaminated.
- Ensure that all tools that entered the hot zone are properly decontaminated.

Termination

- Once operation complete, clean out berms under direction of Dyno.
- Safe and proper disposal of all spent PPE.
- Transition of command.
- Debrief.

Appendix D: Tug and Barge Emergency Contingency Plan

Minto Mine

Tug and Barge Emergency Contingency Plan

2017-01

Prepared by:

Minto Explorations Ltd.

Minto Mine

February 2017

First Issue: January 15, 2013

Revision History

Revision Number	**Issue Date**	**Description and Revisions Made**
2013-01	January 2013	First Issue
2017-01	February 2017	Review, revision of document and update of information: • Revised format of document (added revision history and table of contents); • Section 2.0 and 3.1 - Removed references to JDS and mutual aid agreement (not in place); • Section 4.0 - updated level of NFPA training for ERT (472 HazMat awareness level); • Section 4.0 - updated reference to 2014 field and table top exercise.

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List of Appendices

1 Introduction

Minto Mine (Minto) a subsidiary of Capstone Mining Corporation is pleased to submit the following contingency plan (plan) as per requirements of the Selkirk First Nation Access and Land Use Permit "Minto Landing Ice Bridge and Marshalling Area and West Side Barge Landing and Marshalling Area" (the permit). It is Minto's intention that this plan will fulfill the requirement as stated in Schedule 2, Section 9.0 Contingency Plan of the permit. It is not Minto's objective for this plan to mitigate all possible accidents or malfunction in regards to the in stream operation of the Copper Queen tug and barge.

The plan as prepared is adaptive and will be amended as is practicable. This plan is intended to deliver the best possible means of mitigating an accident or malfunction of the loading/unloading or in-stream operation of the tug and barge with the resources available at Minto. Preventing such an occurrence requires a combination of: procedural and engineering controls, based on an awareness of at risk conditions. These documents exist in the form of the Spill Contingency Plan, Emergency Response Plan, and any procedures or plans on the tug or barge from Site Services. This document serves as a contingency plan in the event that an accident or malfunction occurs when loading, unloading, and in-stream operations of the Copper Queen tug and barge (CQTB).

2 General Procedures

Any Response to an Emergency condition will be based on a priority sequence of Life, Environment and Property. Therefore every event will be regarded with these priorities in mind. Initial on scene assessment of the accident or malfunction will be called out on channel one as a "Code 1". The Emergency Response Team will be dispatched, communication established and the barge operator and deckhand will respond to control the scene.

Deckhands will mitigate all emergencies on the barge to the best of their ability given the resources available. General procedure in the event of an emergency would have the barge move to the west landing if possible or practical unless otherwise communicated to the barge captain. To mitigate an emergency in offloading or loading vehicles onto the barge the deckhand will utilize the anchor points on both landings. Slack will be left in the rope to ensure the barge captain is able to maneuver when docked at the landing. Tying off to the anchor points will mitigate complete catastrophe if the barge loses power during loading and offloading and will be discussed further under the specific procedures section of this plan.

To mitigate the risk of losing control of the barge downstream Minto will be installing an anchor on the barge. In the event of an emergency the deckhand would be able to deploy the anchor allowing the barge a safety contingency if control was lost.

3 Specific Procedures

Below is a list of the current on site procedures for dealing with various emergencies in regards to the CQTB at Minto Mine.

1. Emergency Response to Sinking
2. Emergency Response to Loss of Power or Control
3. Emergency Response to Fire Onboard
4. Emergency Response to Man Overboard
5. Emergency Response to Freight or Vehicle Overboard
6. Emergency Response to Medical Emergency on Board of the Barge
7. Emergency Response to Spill Response

3.1 Emergency Response to Sinking of CQTB

1. Activation of Emergency Protocol onboard CQTB calling code 1 to initiate ERT response.
2. Captain and deckhand will deploy Canadian Coast Guard approved life rafts.
3. As per Emergency Response Plan, Incident command (IC) will communicate with Deckhand by radio to determine any further details of events, number of injured or trapped people, risks to property and environment.
4. IC will respond to scene in one emergency vehicle ahead of remaining ERT. IC will upon arrival to scene provide initial scene assessment and gather any additional information available. Minimum ERT response will include full ERT member compliment, Environmental Lead, Hazardous materials response trailer, fire truck, ambulance and all associated equipment. ERT operations to be under the control of the ERT Captain. Additional response needs based on initial assessment and

evaluation by IC will be communicated to the Emergency Communications Center (ECC) as per Emergency Response Plan.

5. Incident Accountability will be established and adhered to throughout the operation.

6. IC will determine the need for rescue of people downstream. Option to deploy rescue ropes via launcher considered for KM 12.

7. Alternate access to river to be determined by nature of incident, KM 20 provides a second potential access. All other access would require trail cutting which is possible but would take more time.

8. IC, ERT Captain, and Environmental Lead (Unified Incident Command Support) will assess ongoing situation and need for additional or fewer resources.

9. Alternate man boat (see Appendix A for details on man boat) will be deployed from landing as needed to support rescue and/or to gain more information regarding location of sunken vessel and determine possible plan for retrieval/securing. Man boat operator will work under the direction of IC.

10. Once rescued, all patients will be treated as per OFA3/EMR protocols transported as per Yukon EMS dispatch confirmation aligned with Minto Emergency Response Plan.

3.2 Emergency Response to Loss of Power or Control of CQTB

The tug operates on two engines so total loss of power is not likely; however, is still possible and below is the emergency procedure that would be activated in the event that total loss or control of the CQTB was to occur.

11. Activation of Emergency Protocol onboard CQTB calling code 1 to initiate ERT response. Captain will also communicate freight details and passenger numbers on board.

12. Passengers and crew will follow instructions from Captain and remaining on board if deemed safe. The Captain and deckhand will follow MED protocol in decision making in regards to passenger safety.

13. Captain and deckhand will deploy Canadian Coast Guard approved life rafts if deemed unsafe to stay on board by Captain.

14. IC will respond to scene or as close to it, in one emergency vehicle ahead of remaining ERT. IC will upon arrival to scene provide initial scene assessment and gather any additional information available. Minimum ERT response will include full ERT member compliment, Environmental Lead, Hazardous materials response trailer, fire truck, ambulance and all associated equipment. ERT operations to be under the control of the ERT Captain. Additional response needs and downstream communication and reporting requirements based on initial assessment and evaluation by IC will be communicated to the Emergency Communications Center (ECC) as per Emergency Response Plan.
15. Incident Accountability will be established and adhered to throughout the operation.
16. Captain will navigate to the best of his ability to the safest downstream location possible. Under the direction of the Captain the deckhand may deploy the anchor to assist in stopping the barge and tug.
17. Captain will communicate to IC location and details of condition of vessel and people and assist in determining plans for action.
18. Once vessel is secured to shore or where landed in river, Man boat will be deployed to assist with additional securing and remove non-essential people to location where they can be transferred back to site or alternate safe location.
19. If available and a benefit, Minto would exercise the use of the mutual aid agreement with JDS.
20. Plan for retrieval will be based appropriate to the conditions and location of vessel. Plan to be developed cooperatively through Barge Captain, Minto ECC and Mutual Aid resources. Equipment and additional resources will be sourced through ECC as per Minto Emergency Response Plan.

3.3 Emergency Response to Fire on the CQTB

21. Activation of Emergency Protocol onboard CQTB calling code 1 to initiate ERT response.
22. If safe to do so, deckhand will attempt to supress fire using equipment on board following Marine Emergency Duty (MED) protocol.

23. Captain and deckhand will deploy Canadian Coast Guard approved life rafts if vessel in immediate danger. If possible and practical the Captain will position barge so that wind is blowing port to star board, to keep smoke/flames away from life raft.
24. If able to do so Barge will cross to West Bank of crossing and continue to use barge supplied fire suppression equipment. All passengers will disembark under direction of deckhand.
25. IC will respond to scene in one emergency vehicle ahead of remaining ERT. IC will upon arrival to scene provide initial scene assessment and gather any additional information available. Minimum ERT response will include full ERT member compliment, Environmental Lead, Hazardous materials response trailer, fire truck, ambulance and all associated equipment. ERT operations to be under the control of the ERT Captain. Additional response needs based on initial assessment and evaluation by IC will be communicated to the Emergency Communications Center (ECC) as per Emergency Response Plan.
26. Incident Accountability will be established and adhered to throughout the operation.
27. Once IC on scene and vessel safely secured, fire suppression will be conducted under the direction of the IC following NFPA 1081 standards. Industrial Fire Brigade.
28. Consideration of environmental sensitivity need to be considered by IC in cooperation with the Environmental Lead (unified incident command support).
29. Defensive spill containment methods to be utilized to control run off and releases from firefighting operations. This may include tactics such as extinguishing agent selection, damming and berming on barge, boom placement around vessel, removal of burning equipment once fire controlled, etc.

3.4 Emergency Response to Man Overboard

30. Activation of Emergency Protocol onboard CQTB calling code 1 to initiate ERT response.
31. Captain and deckhand will throw out provided Canadian Coast Guard approved life-rings to all personnel overboard. The response from the barge crew will conducted as per their MED training.
32. If able to successfully rescue person overboard, deckhand will treat person based on marine first aid protocols awaiting response by ERT and site Medic.

33. If unable to successfully achieve rescue, vessel will continue to West landing and man boat deployed for downstream rescue. Communication to IC on Radio Channel 1 must be available at all times. Man boat operation will be conducted under the direction of IC once in place.
34. Captain will communicate to IC of possible downstream rescue requirement.
35. IC will instruct ERT to stage at KM 12 with option to deploy rescue ropes via launcher considered for KM 12.
36. Incident Accountability will be established and adhered to throughout the operation.
37. IC to stage ambulance for patient pick up.
38. IC will communicate the need for mutual aid to ECC who will follow the Minto ERP by contacting local agencies for assistance on East side of river.
39. Once rescued, all patients will be treated as per OFA3/EMR protocols transported as per Yukon EMS dispatch confirmation aligned with Minto Emergency Response Plan.

3.5 Emergency Response to Freight or Vehicle Overboard of the CQTB

40. Activation of Emergency Protocol onboard CQTB calling code 1 to initiate ERT response. Captain will also communicate freight details and passenger numbers on board.
41. Passengers and crew will follow instructions from Captain (Captain will respond as per MED training) remaining on board if deemed safe.
42. Captain and deckhand will deploy Canadian Coast Guard approved life rafts if deemed unsafe to stay on board by Captain. If at landing passengers will be offloaded to safe location on shore.
43. IC will respond to scene or as close to it, in one emergency vehicle ahead of remaining ERT. IC will upon arrival to scene provide initial scene assessment and gather any additional information available. Minimum ERT response will include full ERT member compliment, Environmental Lead, Hazardous materials response trailer, fire truck, ambulance and all associated equipment. ERT operations to be under the control of the ERT Captain. Additional response needs and downstream communication and reporting requirements based on initial assessment and evaluation by IC will be communicated to the Emergency Communications Center (ECC) as per Emergency Response Plan.

44. Incident Accountability will be established and adhered to throughout the operation.
45. Captain will navigate to the best of his ability to the landing, preferably west landing.
46. Once vessel is secured to shore, man boat will be deployed by deckhand or ERT members to assist with additional securing of vessel and freight, and deployment of containment booms located at landing and on vessel. Man boat operation under the direction of IC once in place.
47. Plan for retrieval of freight will be determined appropriate to the condition and location of freight. Plan developed cooperatively through Barge Captain, Minto ECC and Mutual Aid resources.
48. Equipment and additional resources will be sourced through ECC as per Minto Emergency Response Plan including manpower, expertise, heavy equipment, etc.
49. Special considerations for support in the event of incident occurring on East side of river to include Yukon Emergency Measures Organization, local first responders and alternate equipment operations contractor.

3.6 Emergency Response to Medical Emergency on board CQTB

50. Activation of Emergency Protocol onboard CQTB calling code 1 to initiate ERT response.
51. For serious injury as defined in the ERP, Yukon EMS will be notified immediately.
52. Deckhand will treat patient per Marine Emergency First Aid protocols.
53. Captain will navigate barge to west bank of Yukon River and all vehicles will offload on west bank, giving clear passage for Ambulance.
54. ERT response will include medic, ambulance, fire truck and compliment of team members to assist with patient transfer and packaging.
55. Incident Accountability will be established and adhered to throughout the operation.
56. Yukon EMS dispatch will be updated of situation once history and assessment confirmed.
57. Upon arrival, Minto Medic will take control of scene and advise ERT Captain of resources needed on scene.

58. Upon history and assessment, patient will be treated, packaged and transferred as per OFA3/ERM protocols transported as per Yukon EMS dispatch confirmation aligned with Minto Emergency Response Plan.

3.7 Emergency Response to a Spill

59. Activation of Emergency Protocol onboard CQTB calling code 1 to initiate ERT response.
60. Deckhand will attempt to contain spill using on board spill kit, to prevent spill into Yukon River.
61. IC will respond to scene in one emergency vehicle ahead of remaining ERT. IC will upon arrival to scene provide initial scene assessment and gather any additional information available. Minimum ERT response will include full ERT member compliment, Environmental Lead, Hazardous materials response trailer, fire truck, ambulance and all associated equipment. ERT operations to be under the control of the ERT Captain. Additional response needs, downstream communication, communication with CANUTEC and reporting requirements based on initial assessment and evaluation by IC will be communicated to the ECC as per Emergency Response Plan and Spill Contingency Plan.
62. Incident Accountability will be established and adhered to throughout the operation.
63. If practical the barge captain will navigate the barge to west landing.
64. All passengers will disembark vessel.
65. All vehicles and machinery that is not in the spill zone will disembark.
66. Deckhand and ERT members under the direction of IC will use the man boat to deploy containment booms around the barge.
67. IC with advice from the Environment Lead will develop and implement the SCP for stopping the spill if possible.
68. If the spill cannot be stopped a plan to mitigate the quantity of contaminant spilt to environment will be developed and implemented.
69. If safe and practical to do so Environment Lead will deploy environment staff to sample downstream of spill to measure contamination concentration.

70. IC with advice from the Environment Lead will oversee cleanup of the spill.
71. Special considerations for support in the event of incident occurring on East side of river to access the barge with ERT by man boat.

4 Minto Mine Training

The barge crew were trained and certified in Marine Emergency Duties (MED) A1 and A2 in 2012. The MED course meets the standards of training, certification and watch-keeping, and is run by Transport Canada. The A1 MED course covers basic safety with a focus on hazards and emergencies awareness, firefighting, emergency response, lifesaving appliances and abandonment, survival and rescue. The A2 MED course covers small passenger-carrying vessel safety with the same focus as A1 with the addition of maintenance and inspection of emergency equipment and passenger control. As well the barge crew is trained in Marine First Aid.

The ERT team has been trained to National Fire Protection Association (NFPA) 472 Hazardous Materials awareness level for responders. In 2014, Minto conducted a table top and field exercise in regards to Yukon River response. The table top and field exercise was held in conjunction with ERT, barge crew, environment department, management, major contractors, the Yukon Spill Hotline, CANUTEC, Transnorth Helicopters, WCB, Parkland Fuel, and Quantum Murray. A post–incident debrief revealed both opportunities and successes at the field operations and management level.

Appendix A: Man Boat Specifications

- Brand/Model: Munson Packman Landing Craft
- Hull Length: 24 feet (7.3 meters)
- Beam: 8 feet 6 inches (2.6 meters)
- Hull Type: Packman mono hull
- Power: Twin Yamaha 150hp
- Propulsion: Outboard (25” shaft)
- Outfitting: 52” bow door

Appendix B: Safe Work Procedure for Loading and Unloading the Barge.

Capstone Minto Safe Work Practice

Barge Loading and Offloading

Purpose: To ensure the safe practice of loading and offloading the barge at the Yukon River. To educate workers on the hazards of loading and offloading the barge, and working on landings.

Scope: This Safe Work Practice pertains to the Captain and the crew of the Minto Mine property who are exposed to operating the barge for transport across river.

Definitions:

Certified Flotation Device – Personal Flotation Devices marked "Approved by Department of Transport Canada" or "Approved by Canadian Coast Guard, Department of Fisheries and Oceans"

Hypothermia - A potentially fatal condition that occurs when the body core temperature falls below 95°F (35°C). This can occurs quickly when immersed in cold water.

Responsibilities

Employer / Supervisor Responsibilities

- Make sure appropriate training and assistance are provided to crew.
- Make sure appropriate rescue devices such as a life hook and floatation devices are available to workers

Safety Department Responsibilities

- Ensure this SWP is in alignment with the Yukon Health and Safety Act and Regulations

Worker Responsibilities

- Read, understand, and follow this safe work practice
- If unsure then stop work and ask for assistance
- Wear appropriate PPE defined to their work area.
- Provide training for proper use of PFD to passangers

Reference to Legislative and Site Requirements

- Yukon Occupational Health and Safety Regulations – Part 1 – section 1.34 – Each worker shall be provided with and be required to use an appropriate personal flotation device with the required buoyancy where a worker is employed in a situation where there is a risk of drowning

Safe Work Practice:

The captain and crew will give direction in regards to the following.

1. Landings.

1.1. Assess landing and vehicles to be loaded and unloaded. The use of wooden ramps may be needed. (For more information reference safe work practice for wooden ramps.)

1.2. Use gauge on apron ram to determine the need for landing to be rebuilt. This gauge is located on the ram closest to deckhand shed and has a max angle marked on the gauge. If the apron should go past the marked max angle stop and fix landing. (For more information reference safe work practice for landing maintenance and apron angle.)

2. Transportation.

2.1. Due to landing and vehicle loads ask driver to back on or drive on. This may be determined by many factors, such as:

- Angle and length of landing
- Apron angle and how it contacts the landing
- Underwater debris
- Drivers skill
- Extra low trailers
- Frozen or icy landings
- Load weights

2.2. Deckhand must communicate with captain any concerns about previously mention conditions. It is ultimately the captains' decision on how the barge is loaded.

3. Priority Boarding

3.1. Emergency vehicles on medical runs are given the top priority. Compassionate reasons or special circumstances are considered when loading vehicle traffic. The bus will also be given high priority along with con trucks. Loading priority will be determined by the Captain or the Supervisor.

3.2. Priority may change from day to day and we ask that drivers cooperate and be patient. Ultimately the captain will make the decision based on information available at the time.

4. Communication.

4.1. Drivers are given a handout of standard hand signals as endorsed by WCB and a signature logbook is maintained to who has received the handout and when.

4.2. The deckhand is in charge of directing and communicating with all traffic. Radios, hand signals, face to face communication are all used. An air horn is used as warning to stop the drivers quickly.

5. Hazards.

5.1. Working at or near water has its inherent risks. A JHA should be conducted for any new or unusual work being conducted on or near the water. Some hazards to be aware of are:

- Exposure to the environmental elements of the season
- Slips, trips and falls on uneven ground
- Slipping on slippery rocks and surfaces
- Eroding shore line sloughing or slipping on ice along shoreline
- Falling into cold water
- Ice flows and ice jams
- Swift current
- Drowning
- Hypothermia
- Wildlife
- Slippery deck

6. Emergency Equipment.

6.1. Life ring with rope and pole must be available on the barge. An emergency response container complete with first aid kit, oxygen therapy unit, spare dry coveralls and several blankets is located on the tug. This container is used to reduce the effects of hypothermia until emergency response arrives.

6.2. As the river is 27kms from the mine site emergency response will take at least 40 minutes to arrive at the scene. Deckhands should have marine first aid training and clear knowledge of where all safety equipment is and its condition.

6.3. Honda pump & fire hose along with fire extinguishers are also in place. Deckhands should be well train in this area and will instruct people as needed on what to do in case of an emergency.

7. Training.

7.1. All workers must be trained and competent to operate or run any equipment that pertains to their job.

7.2. At least one worker must have a valid marine first aid ticket in the event of an emergency due to the location of this worksite and the anticipated delay on response time by ERT.

SWP Development and Approval

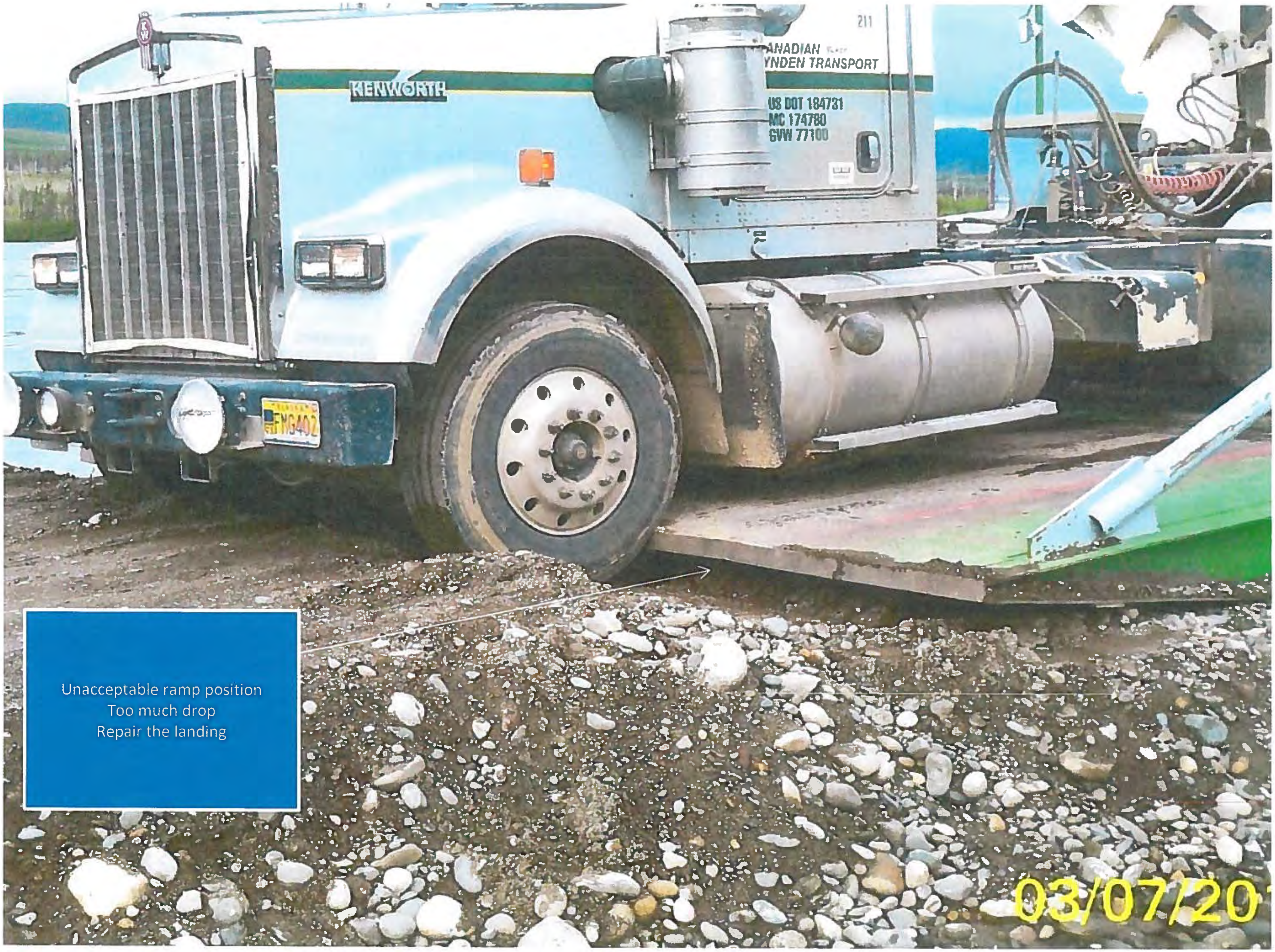
	Print: Developed/ Revised by:	DD/MM/YYYY
Worker:		Date:
Worker:		Date:
JOHSC Representative:	Siana mills	Date:24/08/2012
Supervisor:	Stephen Maunder	Date:26/08/2012
Supervisor:	Captain Dave Johnstone	Date: :26/08/2012
Supervisor:	Jeff Billings	Date: :26/08/2012
Supervisor:		Date:
JOHSC Representative:		Date:
Senior Supervisor:		Date:
Senior Supervisor:		Date:
Departmental Manager:		Date:
	Print & Sign: Reviewed By:	
Safety Department:	MARK GOEBEL	
Safety Department:		Date: Sept19/12
	Print & Sign: Approved By: Determined by Safety Dept. Enter NA if not applicable.	Date:
Departmental Manager:	stephen maunder	Date: 19/09/12
General Manager:		Date: 9.20.2012

Clarification of this safe work practice can be directed to the Safety Department.

Name of SWP:
Location: X:\Health & Safety\Safety Public\Procedures and Safe Work Procedures
Last revision date: April 21 2012


Ideal Ramp Position for Loading


Good Ramp
Position


KENWORTH
ANADIAN
YNDEN TRANSPORT
US DOT 184731
MC 174780
GVW 77100
Unacceptable ramp position
Too much drop
Repair the landing
03/07/20


Ramp Angle Gauge
Minimum and Maximum
Ramp Angle Indicators


Ramp Angle Gauge
Minimum and Maximum Ramp Angle Indicators

Appendix C – Environmental Tracer Study – Status Update

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March 31, 2017
1CM002.051

Capstone Mining Corporation, Minto Mine
PO Box 11
Whitehorse, YT
Y1A 5X9

Attention: Ryan Herbert, Environmental Manager, Minto Mine

Dear Mr. Herbert

RE: Environmental Tracer Study – Status Update

SRK is pleased to provide a summary of activities relevant to the environmental tracer study being conducted at the Minto Mine, Yukon Territory, as well as additional steps to be completed as this study progresses. The following sections provide the context for the tracer study, data collection and data quality review activities to date, and future activities to be completed in the future.

Introduction

An environmental tracer study was initiated to fulfill the conditions of a Water Use License (QZ14-031) issued to Minto Exploration Ltd. (Minto) on August 5, 2015. The objectives of this tracer study are to gain information on local groundwater movement and travel times, and to identify any characteristic geochemical or isotopic signatures of mine-impacted waters at this site. Design of the tracer study follow upon recommendations presented in *Recommendations for Tracer Study – Minto Mine* (December 2015).

The tracers selected for this study were the naturally-occurring isotopes $\delta^{18}O$, $\delta^{2}H$, and tritium (^{3}H) of water molecules, and $\delta^{34}S$ of sulphate molecules. These naturally-occurring tracers were selected rather than injecting new tracers at point sources (e.g. groundwater wells) at the study site, as the naturally occurring tracers will provide information on a larger scale than localized testing. Furthermore, the selected method utilizes natural gradients, and will provide information on groundwater movement under real conditions, whereas injection tracer tests create a forced gradient that may not be representative of site conditions. Samples were collected from groundwater using monitoring wells, surface water, seeps, and snow on the ground surface, and analyzed at Isotope Tracer Technologies Inc. in Waterloo, Ontario, Canada.

Data Collection

Results of δ18O, δ2H, tritium, and δ34S analysis are currently available for samples collected between May 19, 2016 and December 30, 2016. Table 1 summarizes the sampling plan as found in the Minto Mine Groundwater Monitoring Plan Version 2016-02 (Minto Explorations Limited, 2016). In total, 107 samples were analyzed for $\delta^{18}O$ and $\delta^{2}H$, 32 for tritium concentration, and 56 for $\delta^{34}S$. This data has been compiled to allow for the data quality review to be conducted and enable future interpretation.

Table 1: Sampling record for the environmental tracer study

Well or Location	Location Description	Westbay Zone Depth or description	May/June, 2016 O/H	May/June, 2016 Trit	May/June, 2016 ^{34}S	Sept, 2016 O/H	Sept, 2016 Trit	Sept, 2016 ^{34}S	Oct/Nov, 2016 O/H	Oct/Nov, 2016 Trit	Oct/Nov, 2016 ^{34}S	Dec, 2016 O/H	Dec, 2016 Trit	Dec, 2016 ^{34}S
		Groundwater												
MW09-01	Main Dump	Zone 1 (44 mbgs)	X		X	X	X	X	X	X	X	X		X
MW09-03	Minto North	Zone 1 (38 mbgs)	X		X	X	X	X	X	X	X	X		X
		Zone 2 (24 mbgs)	X		X	X	X	X	X	X	X	X		X
		Zone 3 (11 mbgs)	X		X	X	X	X	X	X	X	X		X
MW12-05	Minto Creek valley down gradient of Water Storage Pond	Zone 1 (132 mbgs)	X		X	X	X	X	X	X	X	X		X
		Zone 2 (110 mbgs)	X		X				X	X	X			
		Zone 3 (94 mbgs)	X		X	X	X	X	X	X	X	X		X
		Zone 4 (69 mbgs)	X		X				X	X	X			
		Zone 5 (52 mbgs)	X		X	X	X	X	X	X	X	X		X
		Zone 6 (26 mbgs)	X		X				X	X	X			
		Zone 7 (15 mbgs)	X		X	X	X	X	X	X	X	X		X
MW12-06	Minto Creek valley up gradient of Water Storage Pond	Zone 1 (142 mbgs)							X	X	X			
		Zone 2 (123 mbgs)	X		X	X	X	X	X	X	X	X		X
		Zone 3 (93 mbgs)							X	X	X			
		Zone 4 (66 mbgs)	X		X	X	X	X	X	X	X	X		X
		Zone 5 (35 mbgs)							X	X	X			
		Zone 6 (18 mbgs)	X		X	X	X	X	X	X	X	X		X
MW12-07	Down gradient of Main Pit	Zone 1 (115 mbgs)	X		X	X	X	X	X	X	X	X		X
		Zone 2 (88 mbgs)	X		X	X	X	X	X	X	X	X		X
		Zone 3 (66 mbgs)							X	X	X			
W44	Area 118 underground sump		X		X	X	X	X	X	X	X	X		X
		Surface Water												
MC-1	Minto Creek at canyon		X		X	X	X	X	X	X	X	X		X
W-3	Minto Creek below WSP		X		X	X	X	X	X	X	X	X		X
W-16	Water Storage Pond (WSP)		X		X	X	X	X	X	X	X	X		X
W36/37/8/8a	Minto Creek above WSP		X		X	X	X	X	X	X	X	X		X
W45	Area 2 Pit		X		X	X	X	X	X	X	X	X		X
W12	Main Pit		X		X	X	X	X	X	X	X	X		X
W15	Minto Creek (in mine)		X		X	X	X	X	X	X	X	X		X
W10	Minto Creek (background)		X		X	X	X	X	X	X	X	X		X
		Seeps												
SS32	Background (camp)		X		X	X	X	X	X	X	X	X		X
SS35	Mill valley fill		X		X	X	X	X	X	X	X	X		X
SS36	DSTSF		X		X	X	X	X	X	X	X	X		X
SS7 or SS8	Ore stockpile		X		X	X	X	X	X	X	X	X		X
SS12	Main Dump		X		X	X	X	X	X	X	X	X		X
SS28 or SS29	SW Dump		X		X	X	X	X	X	X	X	X		X
SS31	SW Dump		X		X	X	X	X	X	X	X	X		X
SS51	SW Dump		X		X	X	X	X	X	X	X	X		X
		Precipitation/Snow												
up gradient					X	X	X	X	X	X	X	X		X

1 2 3 4 5

Source: \\srk.ad\dfs\na\van\Projects\01_SITES\Minto\1CM002.051_Minto_2016GroundwaterSupport\MintoIsotopes_1CM002.051_REV03_MSS.xlsx

[1]Yellow cells indicate SRK does not yet have results and/or the sample was not collected
[2]Green cells indicate SRK has received results for the sample
[3]Grey cells indicate no sample was collected because the station was dry or frozen
[4]White cells indicate no sample was scheduled to be collected
[5]Table 1 refers only to isotope, and does not include samples collected for routine water chemistry

Deviations from the original sampling plan occurred for multiple reasons. Monitoring stations MW09-01, MW09-03 Zone 3, as well as many of the seeps (SS35, SS36, SS12, SS28/29, SS31, SS51) were frequently dry or did not produce sufficient water for sampling. Some seep and surface water stations were also periodically frozen (SS7 and MC-1). Sulphate isotopes were not analyzed in May/June due to miscommunication with the lab. For the remaining stations at which samples are classified as not having results or not having been collected, results may not yet be available, specific monitoring zones are not regularly sampled and are not sufficiently developed, or the location did not produce sufficient water for sampling.

Data Quality Review

A total of 107 results of $\delta^{18}O$ and $\delta^{2}H$ analysis were provided to SRK at the time of this review. In addition to the 107 samples, two duplicate samples were submitted, resulting in 1.9% duplication for the sample set. The relative percent difference (RPD) between sample and duplicate was less than 1% for both duplicates collected, and therefore SRK deems the data acceptable.

No duplicate samples were collected for tritium or $\delta^{34}S$, but the analytical laboratory provided the results of repeat analysis to allow for an assessment on data quality to be made. Repeat analyses were conducted on 3 of the 32 samples submitted for tritium analysis (9.4%). For the repeat samples, RPD’s were 34%, 30%, and 4.3%. Generally, RPD for geochemical analysis should be less than 20%. The high RPD may indicate limited accuracy for this type of analysis at low tritium concentrations, such as those encountered at this site; SRK has requested more information on the analytical method and laboratory QA/QC practices from the commercial laboratory.

Repeat analysis was conducted on 39% of samples submitted for $\delta^{34}S$ analysis (n=56), and the average RPD was 4.5%. The maximum RPD was 14.6%, meaning that all repeat analysis passed the RPD requirement of 20%, and the data is deemed acceptable.

Future Work

Interpretation

Minto and SRK plan to review the tracer study results in the context of site groundwater flow and groundwater geochemistry data to refine the site wide groundwater modelling and provide a higher confidence in the ability to predict groundwater movement up and down gradient of the site (Minto Explorations Limited, 2016). A specific area of focus will be understanding the age and source of water at MW12-05, using both environmental tracers and water geochemistry data, with a focus on sulphate concentrations at this location.

References

Minto Explorations Limited (with contributions from SRK Consulting). 2016. Minto Mine Groundwater Monitoring Plan Version 2016-02. Prepared for Minto Mine, July 2016.

Closure

We trust that the information provide herein is to your satisfaction. Please contact Dan Mackie at (604) 681.4196 if you have any questions or concerns.

Yours truly,

SRK Consulting (Canada) Inc.

Marcie Schabert, MSc
Staff Consultant

Dylan MacGregor, MASc, PGeo
Principal Consultant (Geochemistry)

Appendix D – Groundwater Quality Monitoring Program Laboratory Results

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Your P.O. #: 219604
Your Project #: MINTO ENV.MONITORING
Site Location: YUKON
Your C.O.C. #: 2016-02-29B

Attention:MINTO DISTRIBUTION LIST

MINTO EXPLORATIONS LTD.
Yukon/Whitehorse
2 - 25 Pilgrim Way
Whitehorse, YT
CANADA Y1A 6E6

Report Date: 2016/03/04
Report #: R2138985
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B615309
Received: 2016/03/01, 09:50

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	2	2016/03/01	2016/03/02	BBY6SOP-00026	SM 22 2320 B m
Chloride by Automated Colourimetry	2	N/A	2016/03/02	BBY6SOP-00011	SM 22 4500-Cl- G m
Conductance - water	2	N/A	2016/03/02	BBY6SOP-00026	SM 22 2510 B m
Fluoride	2	N/A	2016/03/03	BBY6SOP-00048	SM 22 4500-F C m
Hardness (calculated as CaCO3)	2	N/A	2016/03/02	BBY7SOP-00002	EPA 6020a R1 m
Mercury (Dissolved) by CVAF	2	N/A	2016/03/03	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	2	N/A	2016/03/02	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	1	N/A	2016/03/01	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	1	N/A	2016/03/02	BBY7SOP-00002	EPA 6020A R1 m
Ammonia-N (Preserved)	2	N/A	2016/03/02	BBY6SOP-00009	SM 22 4500-NH3- G m
Nitrate + Nitrite (N)	2	N/A	2016/03/01	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrite (N) by CFA	2	N/A	2016/03/01	BBY6SOP-00010	SM 22 4500-NO3- I m
Nitrogen - Nitrate (as N)	2	N/A	2016/03/01	BBY6SOP-00010	SM 22 4500-NO3 I m
Filter and HNO3 Preserve for Metals	1	N/A	2016/03/01	BBY7 WI-00004	BCMOE Reqs 08/14
Filter and HNO3 Preserve for Metals	1	N/A	2016/03/02	BBY7 WI-00004	BCMOE Reqs 08/14
pH Water (1)	2	N/A	2016/03/02	BBY6SOP-00026	SM 22 4500-H+ B m
Sulphate by Automated Colourimetry	2	N/A	2016/03/02	BBY6SOP-00017	SM 22 4500-SO42- E m
Total Dissolved Solids (Filt. Residue)	2	2016/03/02	2016/03/03	BBY6SOP-00033	SM 22 2540 C m

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Your P.O. #: 219604
Your Project #: MINTO ENV.MONITORING
Site Location: YUKON
Your C.O.C. #: 2016-02-29B

Attention:MINTO DISTRIBUTION LIST

MINTO EXPLORATIONS LTD.
Yukon/Whitehorse
2 - 25 Pilgrim Way
Whitehorse, YT
CANADA Y1A 6E6

Report Date: 2016/03/04
Report #: R2138985
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B615309
Received: 2016/03/01, 09:50

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Morgan Melnychuk, Burnaby Project Manager
Email: MMelnychuk@maxxam.ca
Phone# (604)638-8034 Ext:8034
==
This report has been generated and distributed using a secure automated process.
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B615309
Report Date: 2016/03/04

MINTO EXPLORATIONS LTD.
Client Project #: MINTO ENV.MONITORING
Site Location: YUKON
Your P.O. #: 219604
Sampler Initials: CH

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		OE8830			OE8831		
Sampling Date		2016/02/28 16:55			2016/02/28 17:40		
COC Number		2016-02-29B			2016-02-29B		
	UNITS	**MW12-07-01**	**RDL**	**QC Batch**	**MW12-07-02**	**RDL**	**QC Batch**
ANIONS							
Nitrite (N)	mg/L	0.312 (1)	0.050	8205034	0.243	0.0050	8205034
Calculated Parameters							
Filter and HNO3 Preservation	N/A	FIELD	N/A	ONSITE	FIELD	N/A	ONSITE
Nitrate (N)	mg/L	0.20	0.20	8204157	0.107	0.020	8204157
Misc. Inorganics							
Fluoride (F)	mg/L	1.10	0.010	8207348	1.30	0.010	8207348
Alkalinity (Total as CaCO3)	mg/L	430	0.50	8204835	108	0.50	8204835
Alkalinity (PP as CaCO3)	mg/L	<0.50	0.50	8204835	<0.50	0.50	8204835
Bicarbonate (HCO3)	mg/L	524	0.50	8204835	131	0.50	8204835
Carbonate (CO3)	mg/L	<0.50	0.50	8204835	<0.50	0.50	8204835
Hydroxide (OH)	mg/L	<0.50	0.50	8204835	<0.50	0.50	8204835
Anions							
Dissolved Sulphate (SO4)	mg/L	312 (2)	5.0	8205990	674 (2)	5.0	8205990
Dissolved Chloride (Cl)	mg/L	7.1	0.50	8205989	1.1	0.50	8205989
Nutrients							
Total Ammonia (N)	mg/L	0.58	0.0050	8205481	0.049	0.0050	8205517
Nitrate plus Nitrite (N)	mg/L	0.52 (1)	0.20	8205032	0.349	0.020	8205032
Physical Properties							
Conductivity	uS/cm	1420	1.0	8204834	1440	1.0	8204834
pH	pH	7.92		8204833	8.03		8204833
Physical Properties							
Total Dissolved Solids	mg/L	1080	10	8205304	1120	10	8205743

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) RDL raised due to sample matrix interference.
(2) Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B615309
Report Date: 2016/03/04

MINTO EXPLORATIONS LTD.
Client Project #: MINTO ENV.MONITORING
Site Location: YUKON
Your P.O. #: 219604
Sampler Initials: CH

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		OE8830	OE8831		
Sampling Date		2016/02/28 16:55	2016/02/28 17:40		
COC Number		2016-02-29B	2016-02-29B		
	UNITS	**MW12-07-01**	**MW12-07-02**	**RDL**	**QC Batch**
Misc. Inorganics					
Dissolved Hardness (CaCO3)	mg/L	646	681	0.50	8204500
Elements					
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	0.010	8206274
Dissolved Metals by ICPMS					
Dissolved Aluminum (Al)	ug/L	23.2	21.0	3.0	8204790
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	0.50	8204790
Dissolved Arsenic (As)	ug/L	1.26	1.97	0.10	8204790
Dissolved Barium (Ba)	ug/L	55.1	11.9	1.0	8204790
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	0.10	8204790
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	1.0	8204790
Dissolved Boron (B)	ug/L	631	394	50	8204790
Dissolved Cadmium (Cd)	ug/L	<0.010	0.011	0.010	8204790
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	1.0	8204790
Dissolved Cobalt (Co)	ug/L	<0.50	<0.50	0.50	8204790
Dissolved Copper (Cu)	ug/L	<0.20	<0.20	0.20	8204790
Dissolved Iron (Fe)	ug/L	56.0	226	5.0	8204790
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	0.20	8204790
Dissolved Lithium (Li)	ug/L	24.9	27.3	5.0	8204790
Dissolved Manganese (Mn)	ug/L	228	108	1.0	8204790
Dissolved Molybdenum (Mo)	ug/L	<1.0	19.3	1.0	8204790
Dissolved Nickel (Ni)	ug/L	<1.0	<1.0	1.0	8204790
Dissolved Phosphorus (P)	ug/L	<10	<10	10	8204790
Dissolved Selenium (Se)	ug/L	1.01	0.20	0.10	8204790
Dissolved Silicon (Si)	ug/L	8560	6590	100	8204790
Dissolved Silver (Ag)	ug/L	<0.020	0.023	0.020	8204790
Dissolved Strontium (Sr)	ug/L	9400	10600	1.0	8204790
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	0.050	8204790
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	5.0	8204790
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	5.0	8204790
Dissolved Uranium (U)	ug/L	0.36	1.59	0.10	8204790
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	5.0	8204790
Dissolved Zinc (Zn)	ug/L	<5.0	8.7	5.0	8204790
Dissolved Zirconium (Zr)	ug/L	<0.50	<0.50	0.50	8204790
Dissolved Calcium (Ca)	mg/L	216	217	0.050	8204589
RDL = Reportable Detection Limit					

Maxxam Job #: B615309
Report Date: 2016/03/04

MINTO EXPLORATIONS LTD.
Client Project #: MINTO ENV.MONITORING
Site Location: YUKON
Your P.O. #: 219604
Sampler Initials: CH

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		OE8830	OE8831		
Sampling Date		2016/02/28 16:55	2016/02/28 17:40		
COC Number		2016-02-29B	2016-02-29B		
	UNITS	**MW12-07-01**	**MW12-07-02**	**RDL**	**QC Batch**
Dissolved Magnesium (Mg)	mg/L	25.6	33.4	0.050	8204589
Dissolved Potassium (K)	mg/L	2.93	2.92	0.050	8204589
Dissolved Sodium (Na)	mg/L	89.4	73.0	0.050	8204589
Dissolved Sulphur (S)	mg/L	120	242	3.0	8204589
RDL = Reportable Detection Limit					

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GENERAL COMMENTS

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

MINTO EXPLORATIONS LTD.
Client Project #: MINTO ENV.MONITORING
Site Location: YUKON
Your P.O. #: 219604
Sampler Initials: CH

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8204790	Dissolved Aluminum (Al)	2016/03/01	98	80 - 120	104	80 - 120	<3.0	ug/L	10	20
8204790	Dissolved Antimony (Sb)	2016/03/01	106	80 - 120	101	80 - 120	<0.50	ug/L	NC	20
8204790	Dissolved Arsenic (As)	2016/03/01	103	80 - 120	102	80 - 120	<0.10	ug/L	NC	20
8204790	Dissolved Barium (Ba)	2016/03/01	NC	80 - 120	105	80 - 120	<1.0	ug/L	0.71	20
8204790	Dissolved Beryllium (Be)	2016/03/01	98	80 - 120	93	80 - 120	<0.10	ug/L	NC	20
8204790	Dissolved Bismuth (Bi)	2016/03/01	99	80 - 120	103	80 - 120	<1.0	ug/L	NC	20
8204790	Dissolved Boron (B)	2016/03/01	NC	80 - 120	96	80 - 120	<50	ug/L	2.0	20
8204790	Dissolved Cadmium (Cd)	2016/03/01	102	80 - 120	100	80 - 120	<0.010	ug/L	0	20
8204790	Dissolved Chromium (Cr)	2016/03/01	105	80 - 120	106	80 - 120	<1.0	ug/L	NC	20
8204790	Dissolved Cobalt (Co)	2016/03/01	104	80 - 120	109	80 - 120	<0.50	ug/L	NC	20
8204790	Dissolved Copper (Cu)	2016/03/01	NC	80 - 120	108	80 - 120	<0.20	ug/L	1.7	20
8204790	Dissolved Iron (Fe)	2016/03/01	92	80 - 120	110	80 - 120	<5.0	ug/L	NC	20
8204790	Dissolved Lead (Pb)	2016/03/01	100	80 - 120	101	80 - 120	<0.20	ug/L	NC	20
8204790	Dissolved Lithium (Li)	2016/03/01	100	80 - 120	101	80 - 120	<5.0	ug/L	NC	20
8204790	Dissolved Manganese (Mn)	2016/03/01	NC	80 - 120	103	80 - 120	<1.0	ug/L	5.5	20
8204790	Dissolved Molybdenum (Mo)	2016/03/01	94	80 - 120	95	80 - 120	<1.0	ug/L	NC	20
8204790	Dissolved Nickel (Ni)	2016/03/01	NC	80 - 120	107	80 - 120	<1.0	ug/L	2.2	20
8204790	Dissolved Phosphorus (P)	2016/03/01					<10	ug/L	NC	20
8204790	Dissolved Selenium (Se)	2016/03/01	98	80 - 120	99	80 - 120	<0.10	ug/L	NC	20
8204790	Dissolved Silicon (Si)	2016/03/01					<100	ug/L	2.0	20
8204790	Dissolved Silver (Ag)	2016/03/01	108	80 - 120	99	80 - 120	<0.020	ug/L	NC	20
8204790	Dissolved Strontium (Sr)	2016/03/01	NC	80 - 120	99	80 - 120	<1.0	ug/L	1.3	20
8204790	Dissolved Thallium (Tl)	2016/03/01	100	80 - 120	99	80 - 120	<0.050	ug/L	NC	20
8204790	Dissolved Tin (Sn)	2016/03/01	102	80 - 120	99	80 - 120	<5.0	ug/L	NC	20
8204790	Dissolved Titanium (Ti)	2016/03/01	112	80 - 120	103	80 - 120	<5.0	ug/L	NC	20
8204790	Dissolved Uranium (U)	2016/03/01	97	80 - 120	94	80 - 120	<0.10	ug/L	NC	20
8204790	Dissolved Vanadium (V)	2016/03/01	109	80 - 120	104	80 - 120	<5.0	ug/L	NC	20
8204790	Dissolved Zinc (Zn)	2016/03/01	97	80 - 120	102	80 - 120	<5.0	ug/L	NC	20
8204790	Dissolved Zirconium (Zr)	2016/03/01					<0.50	ug/L	NC	20
8204833	pH	2016/03/02			102	97 - 103				

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8204834	Conductivity	2016/03/01			102	80 - 120	<1.0	uS/cm		
8204835	Alkalinity (PP as CaCO3)	2016/03/02					<0.50	mg/L	NC	20
8204835	Alkalinity (Total as CaCO3)	2016/03/02	NC	80 - 120	101	80 - 120	0.56, RDL=0.50	mg/L	0.44	20
8204835	Bicarbonate (HCO3)	2016/03/02					0.68, RDL=0.50	mg/L	0.44	20
8204835	Carbonate (CO3)	2016/03/02					<0.50	mg/L	NC	20
8204835	Hydroxide (OH)	2016/03/02					<0.50	mg/L	NC	20
8205032	Nitrate plus Nitrite (N)	2016/03/01	NC	80 - 120	105	80 - 120	<0.020	mg/L	NC	25
8205034	Nitrite (N)	2016/03/01	NC	80 - 120	102	80 - 120	<0.0050	mg/L	NC	20
8205304	Total Dissolved Solids	2016/03/03	100	80 - 120	102	80 - 120	<10	mg/L	2.5	20
8205481	Total Ammonia (N)	2016/03/02	NC	80 - 120	105	80 - 120	<0.0050	mg/L	1.7	20
8205517	Total Ammonia (N)	2016/03/02	109	80 - 120	102	80 - 120	<0.0050	mg/L	NC	20
8205743	Total Dissolved Solids	2016/03/03	102	80 - 120	100	80 - 120	<10	mg/L	2.3	20
8205989	Dissolved Chloride (Cl)	2016/03/02	110	80 - 120	95	80 - 120	<0.50	mg/L	NC	20
8205990	Dissolved Sulphate (SO4)	2016/03/02	107	80 - 120	93	80 - 120	<0.50	mg/L	5.6	20
8206274	Dissolved Mercury (Hg)	2016/03/03	89	80 - 120	97	80 - 120	<0.010	ug/L	NC	20
8207348	Fluoride (F)	2016/03/03	103	80 - 120	100	80 - 120	0.015, RDL=0.010	mg/L	0	20

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

Maxxam Job #: B615309
Report Date: 2016/03/04

MINTO EXPLORATIONS LTD.
Client Project #: MINTO ENV.MONITORING
Site Location: YUKON
Your P.O. #: 219604
Sampler Initials: CH

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Andy Lu, Data Validation Coordinator

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam

Burnaby: 4606 Canada Way, Burnaby, BC V5G 1K5 Ph: (604) 734-7276 Fax: (604) 731-2386, Toll Free: (800) 665-8566

CHAIN OF CUSTODY RECORD

Click here to get the COC number

Maxxam Job #: **COC #:** 2016-02-29 B Page: 1 of 1

Invoice To: Require Report? Yes ☑ No ☐

Company Name:	Minto Explorations Ltd
Contact Name:	Elvina Wong
Address:	Suite 900 - 999 West Hastings St
	Vancouver, B.C. PC: V6C 2W2
Phone / Fax#:	Ph: 604-684-8894 Fax: 604-688-2120
E-mail	

Report To:

Company Name:	Minto Explorations Ltd
Contact Name:	Minto Environment
Address:	Suite 900-999 West Hastings St
	Vancouver, B.C. PC: V6C 2W2
Phone / Fax#:	Ph: 604-684-8894 Fax: 604-688-2120
E-mail	minto_environment@mintomine.com

PO #:	219604
Quotation #:	
Project # :	
Proj. Name:	Minto Env. Monitoring
Location:	Yukon
Sampled by	Chris Harry / Dan Potvin

REGULATORY REQUIREMENTS:

- ☐ CSR
- ☑ CCME
- ☐ BC Water Quality
- ☐ Other
- ☐ DRINKING WATER

SERVICE REQUESTED:

- ◉ Regular Turn Around Time (TAT) (5 days for most tests)
- **RUSH** (Please contact the lab) ○ 1 Day ○ 2 Day ○ 3 Day
- Date Required:

SPECIAL INSTRUCTIONS:

Return Cooler ☐ **Ship Sample Bottles (please specify)** ☐

ANALYSIS REQUESTED

Field Filtered? Y N ☐ ☑; Field Acidified? Y ☑ N ☐; Field Acidified? Y ☐ N ☐

	Sample Identification	Lab Identification (Lab Use Only)	Sample Type	Date/Time(24hr) Sampled	Dissolved Metals (DM)	Field Acidified?	Total Metals	Nitrate ☑ Nitrite ☑ Ammonia ☑	Total Suspended Solids (TSS) ☐ TDS ☑	pH ☑ Conductivity ☑ Alkalinity ☑	Chloride ☑ Fluoride ☑ Sulphate ☑	Number of Containers
1	MW12-07-01		Ground W	28/02/2016 16:55	x	x		x	x	x	x	3
2	MW12-07-02		Ground W	28/02/2016 17:40	x	x		x	x	x	x	3
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

01-Mar-16 09:50
Morgan Melnychuk
B615309
NA5 SO131

B615309_COC

*Relinquished By: (Print name and sign)	Date (yy/mm/dd):	Time (24hr):	Received by : (Print name and sign)	Date (yy/mm/dd):	Time (24 hr):	Time Sensitive	Temperature on Receipt (°C)	Custody Seal	Yes	No
Chris Harry	29-Feb-16	7:40	[signature]	2016/03/01	09:50	☑	A) 2 B) 4 C) 2	Present?	☐	☑
							Just sampled & rec'd on ice: ☐	Intact?	☐	☐ NA

*IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORDS. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

BBY FCD-00077R2_C

Maxxam Analytics Success Through Science ©

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 10-MAY-16
Report Date: 25-MAY-16 14:45 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1766586

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-05-10 A
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1766586-1	L1766586-2	L1766586-3
	Description	Water	Water	Water
	Sampled Date	09-MAY-16	10-MAY-16	11-MAY-16
	Sampled Time	14:50	15:35	16:35
	Client ID	MW12-05-01	MW12-05-03	MW12-05-05
Grouping	**Analyte**			
WATER				
Physical Tests	Conductivity (uS/cm)	1970	1790	496
	Hardness (as CaCO3) (mg/L)	912	900	248
	pH (pH)	7.82	7.89	7.97
	Total Suspended Solids (mg/L)	3.3	4.0	<3.0
	Total Dissolved Solids (mg/L)	1550	1360	283
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	148	252	212
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	148	252	212
	Ammonia, Total (as N) (mg/L)	0.0646	0.0400	0.0143
	Chloride (Cl) (mg/L)	10.9	8.9	5.40
	Nitrate and Nitrite (as N) (mg/L)	0.084	0.060	0.594
	Nitrate (as N) (mg/L)	<0.010 DLA	<0.010 DLA	0.196
	Nitrite (as N) (mg/L)	0.0844	0.0602	0.398
	Sulfate (SO4) (mg/L)	958	773	46.8
	Anion Sum (meq/L)	23.2	21.4	5.41
	Cation Sum (meq/L)	24.6	23.0	5.80
	Cation - Anion Balance (%)	2.9	3.7	3.5
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0036	0.0049	0.0060
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	0.00012	0.00023
	Arsenic (As)-Dissolved (mg/L)	0.00082	0.00023	0.00015
	Barium (Ba)-Dissolved (mg/L)	0.0456	0.0445	0.0706
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.118	0.120	0.185
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	0.0000091
	Calcium (Ca)-Dissolved (mg/L)	304	235	52.9
	Chromium (Cr)-Dissolved (mg/L)	0.00037	0.00018	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	0.00055
	Iron (Fe)-Dissolved (mg/L)	0.022	1.13	0.017
	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000194	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0076	0.0056	0.0042
	Magnesium (Mg)-Dissolved (mg/L)	37.0	76.3	28.2
	Manganese (Mn)-Dissolved (mg/L)	0.125	2.44	0.147

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1766586-1	L1766586-2	L1766586-3		
	Description	Water	Water	Water		
	Sampled Date	09-MAY-16	10-MAY-16	11-MAY-16		
	Sampled Time	14:50	15:35	16:35		
	Client ID	MW12-05-01	MW12-05-03	MW12-05-05		
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050		
	Molybdenum (Mo)-Dissolved (mg/L)	0.000241	0.000521	0.00372		
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	0.00065		
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050		
	Potassium (K)-Dissolved (mg/L)	3.38	4.26	2.23		
	Selenium (Se)-Dissolved (mg/L)	0.00144	0.000076	0.000139		
	Silicon (Si)-Dissolved (mg/L)	7.49	8.41	6.42		
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010		
	Sodium (Na)-Dissolved (mg/L)	145	109	17.9		
	Strontium (Sr)-Dissolved (mg/L)	7.67	8.16	0.798		
	Sulfur (S)-Dissolved (mg/L)	389	290	18.1		
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010		
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030		
	Uranium (U)-Dissolved (mg/L)	0.000986	0.00127	0.00271		
	Vanadium (V)-Dissolved (mg/L)	0.00050	<0.00050	<0.00050		
	Zinc (Zn)-Dissolved (mg/L)	<0.0010	0.0015	0.0119		
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Conductivity	B	L1766586-1, -2, -3
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Cadmium (Cd)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Copper (Cu)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Lead (Pb)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Selenium (Se)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Silver (Ag)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Tin (Sn)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Titanium (Ti)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Vanadium (V)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Zinc (Zn)-Dissolved	DLA	L1766586-1, -2, -3
Duplicate	Zirconium (Zr)-Dissolved	DLA	L1766586-1, -2, -3
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1766586-1, -2, -3
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1766586-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1766586-1, -2, -3
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1766586-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1766586-1, -2, -3
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1766586-1, -2, -3
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1766586-1, -2, -3
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1766586-1, -2, -3
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1766586-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1766586-1, -2, -3

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLA	Detection Limit adjusted for required dilution
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

Reference Information

IONBALANCE-VA Water Ion Balance Calculation APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA Water Dissolved Metals in Water by ICPOES EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA Water Dissolved Sulfur in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA Water TDS (Calculated) APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR Water Total Suspended Solids by Gravimetric APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

Reference Information

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-05-10 A

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1766586-COFC

COC Number: 2016-05-10 A

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

...all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: 220404 (GW)

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact:

Sampler: SR/SC

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond, TSS, TDS, Alkalinity, Anions							Number of Containers
	MW12-05-01	9-May-16	14:50	Water		R		R	R		R							4
	MW12-05-03	10-May-16	15:35	Water		R		R	R		R							4
	MW12-05-05	11-May-16	16:35	Water		R		R	R		R							4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 8.1

FINAL COOLER TEMPERATURES °C: 4 2

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 10-may-16	Time: 7:30	Received by:	Date: 10-May16	Time: 2:15	Received by: JC	Date: 11 May	Time: 12:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 11-MAY-16
Report Date: 25-MAY-16 15:09 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1767458

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-05-11 A
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1767458-1	L1767458-2	L1767458-3		
	Description	Water	Water	Water		
	Sampled Date	10-MAY-16	10-MAY-16	10-MAY-16		
	Sampled Time	14:30	15:25	15:55		
	Client ID	MW12-06-02	MW12-06-04	MW12-06-06		
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	1020	1080	868		
	Hardness (as CaCO3) (mg/L)	495	527	432		
	pH (pH)	8.05	8.20	8.26		
	Total Suspended Solids (mg/L)	22.7	12.0	3.3		
	Total Dissolved Solids (mg/L)	660	671	520		
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	358	419	312		
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0		
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0		
	Alkalinity, Total (as CaCO3) (mg/L)	358	419	312		
	Ammonia, Total (as N) (mg/L)	0.0231	0.0069	<0.0050		
	Chloride (Cl) (mg/L)	DLDS <1.0	DLDS <1.0	5.43		
	Nitrate and Nitrite (as N) (mg/L)	0.267	7.60	1.31		
	Nitrate (as N) (mg/L)	0.054	1.48	1.13		
	Nitrite (as N) (mg/L)	0.212	6.12	0.185		
	Sulfate (SO4) (mg/L)	209	175	148		
	Anion Sum (meq/L)	11.5	12.6	9.56		
	Cation Sum (meq/L)	12.5	12.5	10.1		
	Cation - Anion Balance (%)	4.0	-0.2	2.8		
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD		
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD		
	Aluminum (Al)-Dissolved (mg/L)	0.0014	0.0024	0.0025		
	Antimony (Sb)-Dissolved (mg/L)	0.00014	<0.00010	<0.00010		
	Arsenic (As)-Dissolved (mg/L)	0.00614	0.00302	<0.00010		
	Barium (Ba)-Dissolved (mg/L)	0.0310	0.0188	0.0146		
	Beryllium (Be)-Dissolved (mg/L)	0.000041	0.000031	<0.000020		
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Dissolved (mg/L)	2.53	0.954	0.168		
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	0.0000115		
	Calcium (Ca)-Dissolved (mg/L)	136	110	84.3		
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010		
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010		
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	0.00021		
	Iron (Fe)-Dissolved (mg/L)	0.765	0.656	<0.010		
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050		
	Lithium (Li)-Dissolved (mg/L)	0.0083	0.0066	0.0051		
	Magnesium (Mg)-Dissolved (mg/L)	37.6	61.4	53.8		
	Manganese (Mn)-Dissolved (mg/L)	0.0284	0.0449	0.0195		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1767458-1	L1767458-2	L1767458-3		
	Description	Water	Water	Water		
	Sampled Date	10-MAY-16	10-MAY-16	10-MAY-16		
	Sampled Time	14:30	15:25	15:55		
	Client ID	MW12-06-02	MW12-06-04	MW12-06-06		
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050		
	Molybdenum (Mo)-Dissolved (mg/L)	0.00711	0.00817	0.00528		
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050		
	Phosphorus (P)-Dissolved (mg/L)	0.086	<0.050	<0.050		
	Potassium (K)-Dissolved (mg/L)	3.80	3.78	3.47		
	Selenium (Se)-Dissolved (mg/L)	0.000740	0.00073	0.000402		
	Silicon (Si)-Dissolved (mg/L)	11.2	9.02	7.12		
	Silver (Ag)-Dissolved (mg/L)	<0.000010	DLM <0.000020	<0.000010		
	Sodium (Na)-Dissolved (mg/L)	56.6	42.6	32.2		
	Strontium (Sr)-Dissolved (mg/L)	9.54	3.04	1.48		
	Sulfur (S)-Dissolved (mg/L)	65.8	57.1	50.1		
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010		
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030		
	Uranium (U)-Dissolved (mg/L)	0.00257	0.00576	0.00402		
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050		
	Zinc (Zn)-Dissolved (mg/L)	0.0055	0.0092	0.0234		
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Sulfate (SO4)	MS-B	L1767458-1, -2, -3
Matrix Spike	Sulfate (SO4)	MS-B	L1767458-1, -2, -3
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Boron (B)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Iron (Fe)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Aluminum (Al)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1767458-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1767458-1, -2, -3

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLM	Detection Limit Adjusted due to sample matrix effects.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

Reference Information

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

Reference Information

SO4-IC-N-WR	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR	Water	Total Suspended Solids by Gravimetric	APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-05-11 A

GLOSSARY OF REPORT TERMS
Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1767458-COFC

COC Number: 2016-05-11 A

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Service Requested ...in all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: 220404 (GW)

LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#

Major/Minor Code: | Routing Code:

Requisitioner:

Location:

ALS Contact:

Sampler: SR/CP

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	MW12-06-02	10-May-16	14:30	Water		R		R	R		R	4
	MW12-06-04	10-May-16	15:25	Water		R		R	R		R	4
	MW12-06-06	10-May-16	15:55	Water		R		R	R		R	4

Short Holding Time

- *Rush Processing*

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 5.6°

FINAL COOLER TEMPERATURES °C: 2.3 5.3

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-05-11	Time: 10:00	Received by: [signature]	Date: May-12-16	Time: 4:41pm	Received by: Shayon	Date: May.13	Time: 1400

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 12-MAY-16
Report Date: 26-MAY-16 17:15 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1768188

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-05-12 B
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1768188-1				
	Sample ID	L1768188-1				
	Description	Water				
	Sampled Date	11-MAY-16				
	Sampled Time	16:30				
	Client ID	MW12-05-07				
WATER						
Physical Tests	Conductivity (uS/cm)	547				
	Hardness (as CaCO3) (mg/L)	265				
	pH (pH)	7.99				
	Total Suspended Solids (mg/L)	10.7				
	Total Dissolved Solids (mg/L)	302				
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	262				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Total (as CaCO3) (mg/L)	262				
	Ammonia, Total (as N) (mg/L)	0.465				
	Chloride (Cl) (mg/L)	5.72				
	Nitrate and Nitrite (as N) (mg/L)	0.889				
	Nitrate (as N) (mg/L)	0.189				
	Nitrite (as N) (mg/L)	0.700				
	Sulfate (SO4) (mg/L)	22.7				
	Anion Sum (meq/L)	5.92				
	Cation Sum (meq/L)	6.38				
	Cation - Anion Balance (%)	3.7				
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD				
	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	0.0032				
	Antimony (Sb)-Dissolved (mg/L)	0.00033				
	Arsenic (As)-Dissolved (mg/L)	0.00035				
	Barium (Ba)-Dissolved (mg/L)	0.775				
	Beryllium (Be)-Dissolved (mg/L)	<0.000020				
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050				
	Boron (B)-Dissolved (mg/L)	0.626				
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050				
	Calcium (Ca)-Dissolved (mg/L)	58.2				
	Chromium (Cr)-Dissolved (mg/L)	0.00025				
	Cobalt (Co)-Dissolved (mg/L)	<0.00010				
	Copper (Cu)-Dissolved (mg/L)	<0.00020				
	Iron (Fe)-Dissolved (mg/L)	0.067				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	0.0032				
	Magnesium (Mg)-Dissolved (mg/L)	29.0				
	Manganese (Mn)-Dissolved (mg/L)	0.696				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1768188-1				
	Description	Water				
	Sampled Date	11-MAY-16				
	Sampled Time	16:30				
	Client ID	MW12-05-07				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050				
	Molybdenum (Mo)-Dissolved (mg/L)	0.00251				
	Nickel (Ni)-Dissolved (mg/L)	<0.00050				
	Phosphorus (P)-Dissolved (mg/L)	0.096				
	Potassium (K)-Dissolved (mg/L)	2.14				
	Selenium (Se)-Dissolved (mg/L)	0.000750				
	Silicon (Si)-Dissolved (mg/L)	7.04				
	Silver (Ag)-Dissolved (mg/L)	<0.000010				
	Sodium (Na)-Dissolved (mg/L)	22.4				
	Strontium (Sr)-Dissolved (mg/L)	0.786				
	Sulfur (S)-Dissolved (mg/L)	33.3				
	Thallium (Tl)-Dissolved (mg/L)	<0.000010				
	Tin (Sn)-Dissolved (mg/L)	<0.00010				
	Titanium (Ti)-Dissolved (mg/L)	<0.00030				
	Uranium (U)-Dissolved (mg/L)	0.00183				
	Vanadium (V)-Dissolved (mg/L)	<0.00050				
	Zinc (Zn)-Dissolved (mg/L)	0.0028				
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Conductivity	B	L1768188-1
Method Blank	Conductivity	B	L1768188-1
Method Blank	Conductivity	B	L1768188-1
Method Blank	Conductivity	B	L1768188-1
Method Blank	Conductivity	B	L1768188-1
Method Blank	Conductivity	B	L1768188-1
Certified Reference Material	Conductivity	LCS-H	L1768188-1
Certified Reference Material	Conductivity	LCS-H	L1768188-1
Certified Reference Material	Conductivity	LCS-H	L1768188-1
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1768188-1
Matrix Spike	Boron (B)-Dissolved	MS-B	L1768188-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1768188-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1768188-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1768188-1
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1768188-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1768188-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1768188-1
Matrix Spike	Sulfate (SO4)	MS-B	L1768188-1
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1768188-1
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1768188-1
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1768188-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1768188-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1768188-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1768188-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1768188-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1768188-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1768188-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1768188-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1768188-1
Matrix Spike	Iron (Fe)-Dissolved	MS-B	L1768188-1
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1768188-1
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1768188-1
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1768188-1
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1768188-1
Matrix Spike	Aluminum (Al)-Dissolved	MS-B	L1768188-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1768188-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1768188-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1768188-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1768188-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
LCS-H	Lab Control Sample recovery was above ALS DQO. Non-detected sample results are considered reliable. Other results, if reported, have been qualified.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

Reference Information

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR	Water	Total Suspended Solids by Gravimetric	APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-05-12 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1768188-COFC

COC Number: 2016-05-12 B

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

all E&P TATs with your AM - surcharges will apply

Regular [R] ... ard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)		EMERGENCY	
4 day [P4] ☐		1 Business day [E1] ☐	
3 day [P3] ☐		Same Day, Weekend or Statutory holiday [E0] ☐	
2 day [P2] ☐			

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: 220404 (GW)

LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#

Major/Minor Code: | Routing Code:

Requisitioner:

Location:

ALS Contact: | Sampler: SR/SC

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	MW12-05-07	11 ~~12~~-May-16	16:30	Water		R		R	R		R	4

Short Holding Time

• *Rush Processing*

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)
Are samples taken from a Regulated DW System? ☐ YES ☑ NO	
Are samples for human drinking water use? ☐ YES ☑ NO	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
9.5			2.3	5.3	

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-05-12	Time: 10:00	Received by: [signature]	Date: 12-May-16	Time: 4:45	Received by: Shayon	Date: May 13	Time: 1400

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 16-MAY-16
Report Date: 19-MAY-16 17:58 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1769267

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-05-16 B
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1769267-1	L1769267-2	L1769267-3	L1769267-4	L1769267-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	13-MAY-16	13-MAY-16	14-MAY-16	14-MAY-16	14-MAY-16
	Sampled Time	16:35	17:10	07:40	08:15	08:40
	Client ID	MW12-07-01	MW12-07-02	MW12-05-01	MW12-05-02	MW12-05-03
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	1380	1450	1970	651	1770
	Hardness (as CaCO3) (mg/L)	639	696	896	308	870
	pH (pH)	7.56	7.93	8.01	8.43	7.95
	Total Suspended Solids (mg/L)	11.3	5.3	6.0	5.3	7.3
	Total Dissolved Solids (mg/L)	877	1110	1580	389	1360
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	448	107	152	293	252
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	15.6	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	448	107	152	309	252
	Ammonia, Total (as N) (mg/L)	0.915	0.0286	0.602	0.642	0.0430
	Chloride (Cl) (mg/L)	1.3	<1.0 DLDS	11.2	4.93	9.0
	Nitrate and Nitrite (as N) (mg/L)	2.40	0.742	0.427	0.377	0.372
	Nitrate (as N) (mg/L)	0.690	0.209	<0.025 DLDS	<0.0050	<0.010 DLDS
	Nitrite (as N) (mg/L)	1.71	0.532	0.427	0.377	0.372
	Sulfate (SO4) (mg/L)	256	715	998	41.2	783
	Anion Sum (meq/L)	14.5	17.1	24.2	7.19	21.6
	Cation Sum (meq/L)	17.2	17.2	24.2	8.22	22.2
	Cation - Anion Balance (%)	8.4	0.2	0.2	6.7	1.2
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0027	0.0020	0.0039	0.0061	0.0024
	Antimony (Sb)-Dissolved (mg/L)	0.00033	<0.00010	<0.00010	0.00021	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00126	0.00198	0.00084	0.00050	0.00024
	Barium (Ba)-Dissolved (mg/L)	0.0742	0.0128	0.0475	0.607	0.0499
	Beryllium (Be)-Dissolved (mg/L)	0.000044	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	2.02	0.198	0.073	0.044	0.062
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	217	222	298	84.3	224
	Chromium (Cr)-Dissolved (mg/L)	0.00051	<0.00010	0.00042	0.00093	0.00021
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Iron (Fe)-Dissolved (mg/L)	0.022	0.159	0.026	0.022	1.11
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0260	0.0296	0.0078	0.0089	0.0056
	Magnesium (Mg)-Dissolved (mg/L)	23.8	34.3	36.9	23.7	75.5
	Manganese (Mn)-Dissolved (mg/L)	0.189	0.111	0.129	0.239	2.46

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	Sample ID: L1769267-6	L1769267-7	L1769267-8	L1769267-9	L1769267-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	14-MAY-16	14-MAY-16	14-MAY-16	14-MAY-16	14-MAY-16
	Sampled Time	09:00	09:20	10:05	10:20	13:30
	Client ID	MW12-05-04	MW12-05-05	MW12-05-06	MW12-05-07	MW12-06-02
WATER						
Physical Tests	Conductivity (uS/cm)	522	496	486	512	1070
	Hardness (as CaCO3) (mg/L)	246	241	239	262	504
	pH (pH)	8.17	8.01	8.05	8.16	7.97
	Total Suspended Solids (mg/L)	4.0	4.0	3.3	5.3	37.3
	Total Dissolved Solids (mg/L)	290	279	273	284	693
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	246	212	208	246	376
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	246	212	208	246	376
	Ammonia, Total (as N) (mg/L)	0.144	0.0108	<0.0050	0.0337	0.0140
	Chloride (Cl) (mg/L)	5.28	5.57	5.60	5.49	DLDS <1.0
	Nitrate and Nitrite (as N) (mg/L)	0.372	0.518	0.386	0.0340	9.04
	Nitrate (as N) (mg/L)	0.0526	0.211	0.320	<0.0050	1.83
	Nitrite (as N) (mg/L)	0.320	0.307	0.0663	0.0340	7.21
	Sulfate (SO4) (mg/L)	32.5	47.7	45.0	25.4	215
	Anion Sum (meq/L)	5.77	5.42	5.28	5.60	12.6
	Cation Sum (meq/L)	5.93	5.57	5.51	6.01	11.9
	Cation - Anion Balance (%)	1.4	1.3	2.1	3.5	-3.1
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0029	0.0023	0.0023	0.0024	0.0013
	Antimony (Sb)-Dissolved (mg/L)	0.00025	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00024	0.00012	0.00013	0.00027	0.00453
	Barium (Ba)-Dissolved (mg/L)	0.0713	0.0723	0.0622	0.776	0.0281
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	0.000044
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.274	0.047	0.040	0.027	0.206
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	0.0000119	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	50.4	51.1	51.6	58.0	139
	Chromium (Cr)-Dissolved (mg/L)	0.00014	<0.00010	<0.00010	0.00030	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	0.00012	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00020	0.00034	0.00096	<0.00020	<0.00020
	Iron (Fe)-Dissolved (mg/L)	0.054	0.013	<0.010	0.139	1.09
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0030	0.0034	0.0035	0.0028	0.0088
	Magnesium (Mg)-Dissolved (mg/L)	29.3	27.6	26.8	28.4	38.0
	Manganese (Mn)-Dissolved (mg/L)	0.306	0.157	0.0813	0.739	0.0274

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1769267-11	L1769267-12
	Description	Water	Water
	Sampled Date	14-MAY-16	14-MAY-16
	Sampled Time	16:20	16:50
	Client ID	MW12-06-04	MW12-06-06
WATER			
Physical Tests	Conductivity (uS/cm)	1080	846
	Hardness (as CaCO3) (mg/L)	497	434
	pH (pH)	8.14	8.10
	Total Suspended Solids (mg/L)	3.3	<3.0
	Total Dissolved Solids (mg/L)	735	521
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	426	314
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	426	314
	Ammonia, Total (as N) (mg/L)	0.0056	<0.0050
	Chloride (Cl) (mg/L)	<1.0 DLDS	5.93
	Nitrate and Nitrite (as N) (mg/L)	9.93	1.81
	Nitrate (as N) (mg/L)	2.00	1.31
	Nitrite (as N) (mg/L)	7.92	0.499
	Sulfate (SO4) (mg/L)	179	151
	Anion Sum (meq/L)	12.9	9.71
	Cation Sum (meq/L)	14.3	9.90
	Cation - Anion Balance (%)	5.1	0.9
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	<0.0020 DLA	0.0084
	Antimony (Sb)-Dissolved (mg/L)	0.00071	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00515	0.00011
	Barium (Ba)-Dissolved (mg/L)	0.0230	0.0131
	Beryllium (Be)-Dissolved (mg/L)	<0.000040 DLA	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.00010 DLA	<0.000050
	Boron (B)-Dissolved (mg/L)	9.71	0.176
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010 DLA	0.0000070
	Calcium (Ca)-Dissolved (mg/L)	105	84.9
	Chromium (Cr)-Dissolved (mg/L)	0.00022	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00020 DLA	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00040 DLA	<0.00020
	Iron (Fe)-Dissolved (mg/L)	0.434	<0.010
	Lead (Pb)-Dissolved (mg/L)	<0.00010 DLA	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0068	0.0051
	Magnesium (Mg)-Dissolved (mg/L)	56.8	54.0
	Manganese (Mn)-Dissolved (mg/L)	0.0404	0.0155

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1769267-1	L1769267-2	L1769267-3	L1769267-4	L1769267-5
	Sample ID	L1769267-1	L1769267-2	L1769267-3	L1769267-4	L1769267-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	13-MAY-16	13-MAY-16	14-MAY-16	14-MAY-16	14-MAY-16
	Sampled Time	16:35	17:10	07:40	08:15	08:40
	Client ID	MW12-07-01	MW12-07-02	MW12-05-01	MW12-05-02	MW12-05-03
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00128	0.0197	0.000227	0.00105	0.000443
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	0.093	<0.050
	Potassium (K)-Dissolved (mg/L)	3.23	2.82	3.52	2.88	4.09
	Selenium (Se)-Dissolved (mg/L)	0.00407	0.000113	0.000467	0.000610	0.000146
	Silicon (Si)-Dissolved (mg/L)	9.47	6.08	7.51	7.27	8.22
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	97.2	72.8	143	44.5	104
	Strontium (Sr)-Dissolved (mg/L)	8.78	11.0	7.94	2.91	8.28
	Sulfur (S)-Dissolved (mg/L)	147	233	359	86.9	255
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	0.00011	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	0.00048	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.000175	0.00172	0.000954	0.000273	0.00121
	Vanadium (V)-Dissolved (mg/L)	0.00161	<0.00050	0.00050	0.00165	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0025	0.0074	<0.0010	0.0011	<0.0010
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	0.00057	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1769267-6	L1769267-7	L1769267-8	L1769267-9	L1769267-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	14-MAY-16	14-MAY-16	14-MAY-16	14-MAY-16	14-MAY-16
	Sampled Time	09:00	09:20	10:05	10:20	13:30
	Client ID	MW12-05-04	MW12-05-05	MW12-05-06	MW12-05-07	MW12-06-02
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00411	0.00382	0.00331	0.00124	0.00695
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	0.00052	0.00055	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	0.068	<0.050
	Potassium (K)-Dissolved (mg/L)	2.28	2.15	2.08	1.98	3.64
	Selenium (Se)-Dissolved (mg/L)	0.000127	0.000080	0.000163	0.000512	0.000066
	Silicon (Si)-Dissolved (mg/L)	6.76	6.46	6.41	7.09	10.9
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	21.2	15.8	15.4	15.8	38.2
	Strontium (Sr)-Dissolved (mg/L)	0.914	0.751	0.748	0.757	10.2
	Sulfur (S)-Dissolved (mg/L)	12.3	14.6	14.4	67.0	68.0
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.00206	0.00271	0.00288	0.00191	0.00254
	Vanadium (V)-Dissolved (mg/L)	0.00058	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0011	0.0032	0.0073	0.0013	0.0028
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1769267-11	L1769267-12			
	Description	Water	Water			
	Sampled Date	14-MAY-16	14-MAY-16			
	Sampled Time	16:20	16:50			
	Client ID	MW12-06-04	MW12-06-06			
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050			
	Molybdenum (Mo)-Dissolved (mg/L)	0.00892	0.00551			
	Nickel (Ni)-Dissolved (mg/L)	DLA <0.0010	<0.00050			
	Phosphorus (P)-Dissolved (mg/L)	0.347	<0.050			
	Potassium (K)-Dissolved (mg/L)	4.12	3.46			
	Selenium (Se)-Dissolved (mg/L)	0.00101	0.000345			
	Silicon (Si)-Dissolved (mg/L)	11.5	7.22			
	Silver (Ag)-Dissolved (mg/L)	DLA <0.000020	<0.000010			
	Sodium (Na)-Dissolved (mg/L)	98.8	26.0			
	Strontium (Sr)-Dissolved (mg/L)	3.36	1.58			
	Sulfur (S)-Dissolved (mg/L)	51.8	48.7			
	Thallium (Tl)-Dissolved (mg/L)	DLA <0.000020	<0.000010			
	Tin (Sn)-Dissolved (mg/L)	DLA <0.00020	<0.00010			
	Titanium (Ti)-Dissolved (mg/L)	DLA <0.00060	0.00039			
	Uranium (U)-Dissolved (mg/L)	0.00562	0.00406			
	Vanadium (V)-Dissolved (mg/L)	DLA <0.0010	<0.00050			
	Zinc (Zn)-Dissolved (mg/L)	0.0151	0.0152			
	Zirconium (Zr)-Dissolved (mg/L)	DLA <0.00060	<0.00030			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Reference Information

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA Water Dissolved Sulfur in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA Water TDS (Calculated) APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR Water Total Suspended Solids by Gravimetric APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-05-16 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1769267-COFC

COC Number: 2016-05-16 B

Page of

Report To	Contact and company name below will appear on the final report	
Company:	Minto Explorations Ltd.	
Contact:	Minto Environment - Coordinator	
Phone:	1-604-759-4659	
Company address below will appear on the final report		
Street:	2100-510 West Georgia St.	
City/Province:	Vancouver, British Columbia	
Postal Code:	V6B 0M3	
Invoice To	Same as Report To	☐ YES ☑ NO
	Copy of Invoice with Report	☐ YES ☑ NO
Company:	Minto Explorations Ltd.	
Contact:	Ruth Cayetano	

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below — ...firm all E&P TATs with your AM - surcharges will apply

Regular [R] ☐ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ | 3 day [P3] ☐ | 2 day [P2] ☑

EMERGENCY: 1 Business day [E1] ☐ | Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: 220404 (GW)

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#

Major/Minor Code: | Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact:

Sampler: SR/CP

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions							Number of Containers
	MW12-07-01	13-May-16	16:35	Water		R		R	R		R							4
	MW12-07-02	13-May-16	17:10			R		R	R		R							4
	MW12-05-01	14-May-16	7:40			R		R	R		R							4
	MW12-05-02	14-May-16	8:15			R		R	R		R							4
	MW12-05-03	14-May-16	8:40			R		R	R		R							4
	MW12-05-04	14-May-16	9:00			R		R	R		R							4
	MW12-05-05	14-May-16	9:20			R		R	R		R							4
	MW12-05-06	14-May-16	10:05			R		R	R		R							4
	MW12-05-07	14-May-16	10:20			R		R	R		R							4
	MW12-06-02	14-May-16	13:30			R		R	R		R							4
	MW12-06-04	14-May-16	16:20			R		R	R		R							4
	MW12-06-06	14-May-16	16:50			R		R	R		R							4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ | SIF Observations Yes ☐ No ☐

Ice Packs ☑ | Ice Cubes ☐ | Custody seal intact Yes ☐ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C: 7.0C | 8.8

FINAL COOLER TEMPERATURES °C: 2/2/3/1C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016/05/16	Time: 10:00	Received by: EHF	Date: 16 May 2016	Time: 2:25	Received by: lady	Date: May 17	Time: 1:30pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 18-MAY-16
Report Date: 01-JUN-16 16:57 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1770901
Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-05-18 B
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1770901-1				
	Description	Water				
	Sampled Date	17-MAY-16				
	Sampled Time	16:10				
	Client ID	MW11-04				
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	183				
Dissolved Metals	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	1.32				
	Antimony (Sb)-Dissolved (mg/L)	0.00149				
	Arsenic (As)-Dissolved (mg/L)	0.00337				
	Barium (Ba)-Dissolved (mg/L)	0.188				
	Beryllium (Be)-Dissolved (mg/L)	<0.000020				
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050				
	Boron (B)-Dissolved (mg/L)	<0.010				
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050				
	Calcium (Ca)-Dissolved (mg/L)	73.3				
	Chromium (Cr)-Dissolved (mg/L)	0.00331				
	Cobalt (Co)-Dissolved (mg/L)	<0.00010				
	Copper (Cu)-Dissolved (mg/L)	0.0937				
	Iron (Fe)-Dissolved (mg/L)	<0.010				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	0.0174				
	Magnesium (Mg)-Dissolved (mg/L)	<0.10				
	Manganese (Mn)-Dissolved (mg/L)	0.00046				
	Molybdenum (Mo)-Dissolved (mg/L)	0.00317				
	Nickel (Ni)-Dissolved (mg/L)	0.00051				
	Phosphorus (P)-Dissolved (mg/L)	<0.050				
	Potassium (K)-Dissolved (mg/L)	4.45				
	Selenium (Se)-Dissolved (mg/L)	0.00271				
	Silicon (Si)-Dissolved (mg/L)	4.98				
	Silver (Ag)-Dissolved (mg/L)	0.000011				
	Sodium (Na)-Dissolved (mg/L)	4.64				
	Strontium (Sr)-Dissolved (mg/L)	0.292				
	Sulfur (S)-Dissolved (mg/L)	2.25				
	Thallium (Tl)-Dissolved (mg/L)	<0.000010				
	Tin (Sn)-Dissolved (mg/L)	0.00043				
	Titanium (Ti)-Dissolved (mg/L)	<0.00030				
	Uranium (U)-Dissolved (mg/L)	<0.000010				
	Vanadium (V)-Dissolved (mg/L)	0.0181				
	Zinc (Zn)-Dissolved (mg/L)	0.0021				
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Aluminum (Al)-Dissolved	DLA	L1770901-1
Duplicate	Antimony (Sb)-Dissolved	DLA	L1770901-1
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1770901-1
Duplicate	Chromium (Cr)-Dissolved	DLA	L1770901-1
Duplicate	Cobalt (Co)-Dissolved	DLA	L1770901-1
Duplicate	Lead (Pb)-Dissolved	DLA	L1770901-1
Duplicate	Silver (Ag)-Dissolved	DLA	L1770901-1
Duplicate	Thallium (Tl)-Dissolved	DLA	L1770901-1
Duplicate	Tin (Sn)-Dissolved	DLA	L1770901-1
Duplicate	Titanium (Ti)-Dissolved	DLA	L1770901-1
Duplicate	Vanadium (V)-Dissolved	DLA	L1770901-1
Duplicate	Zirconium (Zr)-Dissolved	DLA	L1770901-1
Duplicate	Antimony (Sb)-Dissolved	DLA	L1770901-1
Duplicate	Arsenic (As)-Dissolved	DLA	L1770901-1
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1770901-1
Duplicate	Chromium (Cr)-Dissolved	DLA	L1770901-1
Duplicate	Cobalt (Co)-Dissolved	DLA	L1770901-1
Duplicate	Lead (Pb)-Dissolved	DLA	L1770901-1
Duplicate	Lithium (Li)-Dissolved	DLA	L1770901-1
Duplicate	Silver (Ag)-Dissolved	DLA	L1770901-1
Duplicate	Thallium (Tl)-Dissolved	DLA	L1770901-1
Duplicate	Tin (Sn)-Dissolved	DLA	L1770901-1
Duplicate	Titanium (Ti)-Dissolved	DLA	L1770901-1
Duplicate	Vanadium (V)-Dissolved	DLA	L1770901-1
Duplicate	Zirconium (Zr)-Dissolved	DLA	L1770901-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1770901-1
Matrix Spike	Boron (B)-Dissolved	MS-B	L1770901-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1770901-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1770901-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1770901-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1770901-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1770901-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1770901-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1770901-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1770901-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1770901-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1770901-1
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1770901-1

Reference Information

	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1770901-1
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1770901-1
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1770901-1
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1770901-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1770901-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-DIS-LOW-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

ALS Test Code	Matrix	Test Description	Method Reference**
S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location

Chain of Custody Numbers:

2016-05-18 B

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1770901-COFC

COC Number: 2016-05-18 B

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☑ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax minto_environment@mintomine.com
Email 2
Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax ap@mintomine.com
Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:
Job #:
PO / AFE: 220404 (GW)
LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#
Major/Minor Code: | Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only)
ALS Contact:
Sampler: SR

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions							Number of Containers
	MW11-04	17-May-16	16:10	Water		R												1

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human drinking water use?
☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
6.8			5	5	5

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-05-18	Time: 8:00	Received by: [signature]	Date: 18-May-16	Time: 4:00	Received by: JC	Date: MAY 19 2016	Time: 14:30

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION   WHITE - LABORATORY COPY   YELLOW - CLIENT COPY   OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 24-MAY-16
Report Date: 06-JUN-16 17:44 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1772574

Project P.O. #: 220404(GW)

Job Reference:

C of C Numbers: 2016-05-23C

Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1772574-1	L1772574-2	L1772574-3	L1772574-4
	Description	Water	Water	Water	Water
	Sampled Date	21-MAY-16	21-MAY-16	22-MAY-16	22-MAY-16
	Sampled Time	15:35	16:25	15:10	15:30
	Client ID	MW09-03-01	MW09-03-02	MW09-07-01	MW09-07-02
Grouping	**Analyte**				
WATER					
Physical Tests	Conductivity (uS/cm)	439	588	1360	1450
	Hardness (as CaCO3) (mg/L)	150	303	631	685
	pH (pH)	8.86	7.69	8.04	8.07
	Total Suspended Solids (mg/L)	4.7	34.0	5.3	4.7
	Total Dissolved Solids (mg/L)	264	351	866	748
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	139	327	503	110
	Alkalinity, Carbonate (as CaCO3) (mg/L)	46.8	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	186	327	503	110
	Ammonia, Total (as N) (mg/L)	0.124	0.149	0.902	0.0310
	Chloride (Cl) (mg/L)	0.51	2.20	DLDS <2.5	DLDS <2.5
	Nitrate and Nitrite (as N) (mg/L)	9.31	0.152	0.558	0.271
	Nitrate (as N) (mg/L)	0.0455	<0.0050	0.167	0.080
	Nitrite (as N) (mg/L)	HTD 9.27	0.152	0.390	0.191
	Sulfate (SO4) (mg/L)	21.9	4.40	234	356
	Anion Sum (meq/L)	4.85	6.70	15.0	9.63
	Cation Sum (meq/L)	4.95	7.62	16.5	16.8
	Cation - Anion Balance (%)	1.0	6.4	4.8	27.2
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0067	0.0026	0.0039	0.0021
	Antimony (Sb)-Dissolved (mg/L)	0.00169	0.00035	<0.00010	DLA <0.00020
	Arsenic (As)-Dissolved (mg/L)	0.00090	0.00058	0.00096	0.00193
	Barium (Ba)-Dissolved (mg/L)	0.0583	0.341	0.0738	0.0142
	Beryllium (Be)-Dissolved (mg/L)	<0.000040	<0.000020	0.000043	DLA <0.000040
	Bismuth (Bi)-Dissolved (mg/L)	<0.00010	<0.000050	<0.000050	DLA <0.00010
	Boron (B)-Dissolved (mg/L)	6.94	0.869	0.724	0.352
	Cadmium (Cd)-Dissolved (mg/L)	0.000029	0.0000056	<0.0000050	DLA <0.000010
	Calcium (Ca)-Dissolved (mg/L)	43.0	96.3	213	217
	Chromium (Cr)-Dissolved (mg/L)	DLA <0.00020	<0.00010	0.00041	DLA <0.00020
	Cobalt (Co)-Dissolved (mg/L)	DLA <0.00020	0.00068	<0.00010	DLA <0.00020
	Copper (Cu)-Dissolved (mg/L)	0.00155	0.00138	0.00027	DLA <0.00040
	Iron (Fe)-Dissolved (mg/L)	0.160	10.8	0.064	0.168
	Lead (Pb)-Dissolved (mg/L)	DLA <0.00010	<0.000050	<0.000050	DLA <0.00010
	Lithium (Li)-Dissolved (mg/L)	0.0035	<0.0010	0.0260	0.0283
	Magnesium (Mg)-Dissolved (mg/L)	10.3	15.1	23.7	34.7
	Manganese (Mn)-Dissolved (mg/L)	0.109	7.96	0.218	0.112

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1772574-1	L1772574-2	L1772574-3	L1772574-4
	Description	Water	Water	Water	Water
	Sampled Date	21-MAY-16	21-MAY-16	22-MAY-16	22-MAY-16
	Sampled Time	15:35	16:25	15:10	15:30
	Client ID	MW09-03-01	MW09-03-02	MW09-07-01	MW09-07-02
Grouping	**Analyte**				
WATER					
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.0275	0.0192	0.000995	0.0191
	Nickel (Ni)-Dissolved (mg/L)	0.0020	<0.00050	<0.00050	DLA <0.0010
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	2.84	3.02	3.13	2.78
	Selenium (Se)-Dissolved (mg/L)	0.00077	0.000233	0.00388	0.00037
	Silicon (Si)-Dissolved (mg/L)	7.60	10.4	9.32	6.04
	Silver (Ag)-Dissolved (mg/L)	DLA <0.000020	<0.000010	<0.000010	DLA <0.000020
	Sodium (Na)-Dissolved (mg/L)	42.8	14.2	85.7	70.2
	Strontium (Sr)-Dissolved (mg/L)	0.811	0.873	8.47	10.4
	Sulfur (S)-Dissolved (mg/L)	7.50	1.83	235	236
	Thallium (Tl)-Dissolved (mg/L)	DLA <0.000020	<0.000010	<0.000010	DLA <0.000020
	Tin (Sn)-Dissolved (mg/L)	0.00033	<0.00010	<0.00010	DLA <0.00020
	Titanium (Ti)-Dissolved (mg/L)	DLA <0.00060	<0.00030	<0.00030	DLA <0.00060
	Uranium (U)-Dissolved (mg/L)	0.000955	0.000274	0.000124	0.00163
	Vanadium (V)-Dissolved (mg/L)	DLA <0.0010	<0.00050	0.00157	DLA <0.0010
	Zinc (Zn)-Dissolved (mg/L)	0.0268	0.0158	0.0055	0.0049
	Zirconium (Zr)-Dissolved (mg/L)	0.00066	<0.00030	<0.00030	DLA <0.00060

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Alkalinity, Total (as CaCO3)	B	L1772574-1, -2, -3, -4
Duplicate	Cadmium (Cd)-Dissolved	DLM	L1772574-1, -2, -3, -4
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1772574-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1772574-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1772574-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLA	Detection Limit adjusted for required dilution
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
HTD	Hold time exceeded for re-analysis or dilution, but initial testing was conducted within hold time.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the

Reference Information

American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR	Water	Total Suspended Solids by Gravimetric	APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-05-23C

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1772574-COFC

COC Number: 2016-05-23 C

Report To — Contact and company name below will appear on the final report

Company: Minto Explorations Ltd.
Contact: Minto Environment - Coordinator
Phone: 1-604-759-4659

Company address below will appear on the final report

Street: 2100-510 West Georgia St.
City/Province: Vancouver, British Columbia
Postal Code: V6B 0M3

Invoice To
Same as Report To ☐ YES ☑ NO
Copy of Invoice with Report ☐ YES ☑ NO
Company: Minto Explorations Ltd.
Contact: Ruth Cayetano

Report Format
Select Report Format: ☑ PDF
Quality Control (QC) Report with Report ☑ YES ☐ NO
☑ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax minto_environment@mintomine.com
Email 2
Email 3

Invoice Distribution
Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax ap@mintomine.com
Email 2

Oil and Gas Required Fields (client use)
AFE/Cost Center: | PO#
Major/Minor Code: | Routing Code:
Requisitioner:
Location:

...firm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information
ALS Account # / Quote #:
Job #:
PO / AFE: 220404 (GW)
LSD:

ALS Lab Work Order # (lab use only)

ALS Contact:
Sampler: CH

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals (TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	MW09-03-01	21-May-16	15:35	Water		P2		P2	P2		P2	4
	MW09-03-02	21-May-16	16:25	Water		P2		P2	P2		P2	4
	MW12-07-01	22-May-16	15:10	Water		P2		P2	P2		P2	4
	MW12-07-02	22-May-16	15:30	Water		P2		P2	P2		P2	4

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System? ☐ YES ☑ NO
Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑
INITIAL COOLER TEMPERATURES °C: 7.1
FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Chris Harry	Date: 2016-05-23 9:00	Time:	Received by: [signature]	Date: 24 May 16	Time: 1:30	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 15-JUN-16
Report Date: 24-JUN-16 17:14 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1783590

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-06-14 C
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1783590-1	L1783590-2			
	Description	Water	Water			
	Sampled Date	11-JUN-16	11-JUN-16			
	Sampled Time	15:15	15:40			
	Client ID	MW09-03-01	MW09-03-02			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	353	575			
	Hardness (as CaCO3) (mg/L)	158	302			
	pH (pH)	8.51	7.64			
	Total Suspended Solids (mg/L)	<3.0	25.3			
	Total Dissolved Solids (mg/L)	189	350			
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	142	321			
	Alkalinity, Carbonate (as CaCO3) (mg/L)	13.6	<1.0			
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0			
	Alkalinity, Total (as CaCO3) (mg/L)	156	321			
	Ammonia, Total (as N) (mg/L)	0.0630	0.142			
	Chloride (Cl) (mg/L)	<0.50	4.5			
	Nitrate and Nitrite (as N) (mg/L)	1.58	0.776			
	Nitrate (as N) (mg/L)	0.0140	<0.010 DLDS			
	Nitrite (as N) (mg/L)	1.57	0.776			
	Sulfate (SO4) (mg/L)	11.3	9.08			
	Anion Sum (meq/L)	3.46	6.79			
	Cation Sum (meq/L)	4.10	7.30			
	Cation - Anion Balance (%)	8.5	3.6			
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD			
	Dissolved Metals Filtration Location	FIELD	FIELD			
	Aluminum (Al)-Dissolved (mg/L)	0.0035	0.0026			
	Antimony (Sb)-Dissolved (mg/L)	0.00059	0.00019			
	Arsenic (As)-Dissolved (mg/L)	0.00097	0.00043			
	Barium (Ba)-Dissolved (mg/L)	0.0630	0.323			
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020			
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050			
	Boron (B)-Dissolved (mg/L)	2.21	0.546			
	Cadmium (Cd)-Dissolved (mg/L)	0.0000258	0.0000175			
	Calcium (Ca)-Dissolved (mg/L)	44.9	96.0			
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010			
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	0.00063			
	Copper (Cu)-Dissolved (mg/L)	0.00033	0.00056			
	Iron (Fe)-Dissolved (mg/L)	0.110	6.66			
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050			
	Lithium (Li)-Dissolved (mg/L)	0.0037	0.0013			
	Magnesium (Mg)-Dissolved (mg/L)	11.1	15.1			
	Manganese (Mn)-Dissolved (mg/L)	0.109	7.49			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1783590-1	L1783590-2			
	Description	Water	Water			
	Sampled Date	11-JUN-16	11-JUN-16			
	Sampled Time	15:15	15:40			
	Client ID	MW09-03-01	MW09-03-02			
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050			
	Molybdenum (Mo)-Dissolved (mg/L)	0.0121	0.0165			
	Nickel (Ni)-Dissolved (mg/L)	0.00181	<0.00050			
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050			
	Potassium (K)-Dissolved (mg/L)	2.79	3.30			
	Selenium (Se)-Dissolved (mg/L)	0.000225	0.000130			
	Silicon (Si)-Dissolved (mg/L)	6.06	9.92			
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010			
	Sodium (Na)-Dissolved (mg/L)	19.8	12.5			
	Strontium (Sr)-Dissolved (mg/L)	0.885	0.857			
	Sulfur (S)-Dissolved (mg/L)	7.85	1.83			
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010			
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010			
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030			
	Uranium (U)-Dissolved (mg/L)	0.000972	0.000270			
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050			
	Zinc (Zn)-Dissolved (mg/L)	0.0132	0.0112			
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Alkalinity, Total (as CaCO3)	B	L1783590-1, -2
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1783590-1, -2
Duplicate	Cadmium (Cd)-Dissolved	DLA	L1783590-1, -2
Duplicate	Chromium (Cr)-Dissolved	DLA	L1783590-1, -2
Duplicate	Cobalt (Co)-Dissolved	DLA	L1783590-1, -2
Duplicate	Copper (Cu)-Dissolved	DLA	L1783590-1, -2
Duplicate	Nickel (Ni)-Dissolved	DLA	L1783590-1, -2
Duplicate	Selenium (Se)-Dissolved	DLA	L1783590-1, -2
Duplicate	Silver (Ag)-Dissolved	DLA	L1783590-1, -2
Duplicate	Thallium (Tl)-Dissolved	DLA	L1783590-1, -2
Duplicate	Tin (Sn)-Dissolved	DLA	L1783590-1, -2
Duplicate	Titanium (Ti)-Dissolved	DLA	L1783590-1, -2
Duplicate	Vanadium (V)-Dissolved	DLA	L1783590-1, -2
Duplicate	Zinc (Zn)-Dissolved	DLA	L1783590-1, -2
Duplicate	Zirconium (Zr)-Dissolved	DLA	L1783590-1, -2
Matrix Spike	Nitrate (as N)	MS-B	L1783590-1, -2
Matrix Spike	Sulfate (SO4)	MS-B	L1783590-1, -2
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1783590-1, -2
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1783590-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLA	Detection Limit adjusted for required dilution
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

Reference Information

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

Reference Information

SO4-IC-N-WR	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR	Water	Total Suspended Solids by Gravimetric	APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WR	ALS ENVIRONMENTAL - WHITEHORSE, YUKON, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-06-14 C

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

L1783590-COFC

COC Number: 2016-06-14 C

Page of

Report To	Contact and company name below will appear on the final report	**Report Format / Distribution**	
Company:	Minto Explorations Ltd.	Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)	
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report ☑ YES ☐ NO	
Phone:	1-604-759-4659	☑ Compare Results to Criteria on Report - provide details below if box checked	
	Company address below will appear on the final report	Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Street:	2100-510 West Georgia St.	Email 1 or Fax	minto_environment@mintomine.com
City/Province:	Vancouver, British Columbia	Email 2	
Postal Code:	V6B 0M3	Email 3	
Invoice To	Same as Report To ☐ YES ☑ NO	**Invoice Distribution**	
	Copy of Invoice with Report ☐ YES ☑ NO	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:	Minto Explorations Ltd.	Email 1 or Fax	ap@mintomine.com
Contact:	Ruth Cayetano	Email 2	
Project Information		**Oil and Gas Required Fields (client use)**	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:	220404 (GW)	Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		**ALS Contact:**	**Sampler:** SR/CP

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R]	☑ Standard TAT if received by 3 pm - business days - no surcharges apply		
PRIORITY (Business Days)	4 day [P4] ☐	EMERGENCY	1 Business day [E1] ☐
	3 day [P3] ☐		Same Day, Weekend or Statutory holiday [E0] ☐
	2 day [P2] ☐		

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions							Number of Containers
	MW09-03-01	11-Jun-16	15:15	Water		R		R	R		R							4
	MW09-03-02	11-Jun-16	15:40	Water		R		R	R		R							4

Short Holding Time

Rush Processing

Drinking Water (DW) Samples[1] (client use)	**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**
Are samples taken from a Regulated DW System? ☐ YES ☑ NO	
Are samples for human drinking water use? ☐ YES ☑ NO	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐		SIF Observations	Yes ☐ No ☐
Ice Packs ☐	Ice Cubes ☐	Custody seal intact	Yes ☐ No ☐
Cooling Initiated ☑			
INITIAL COOLER TEMPERATURES °C	6.5	FINAL COOLER TEMPERATURES °C	9/9/11/15

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-06-14	Time: 11:00	Received by: [signature]	Date: 15-Jun-16	Time: 8:45	Received by: Shelley	Date: June 16	Time: 1:30

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2016 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 08-JUL-16
Report Date: 19-JUL-16 17:01 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1795474
Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-07-07 C
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte					
	Sample ID	L1795474-1	L1795474-2	L1795474-3	L1795474-4	L1795474-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	06-JUL-16	06-JUL-16	06-JUL-16	06-JUL-16	06-JUL-16
	Sampled Time	08:50	09:20	09:50	10:05	10:50
	Client ID	MW12-05-01	MW12-05-02	MW12-05-03	MW12-05-04	MW12-05-06
WATER						
Physical Tests	Conductivity (uS/cm)	2000	801	1800	509	484
	Hardness (as CaCO3) (mg/L)	889	422	827	246	225
	pH (pH)	8.08	8.43	8.16	8.21	8.20
	Total Suspended Solids (mg/L)	3.3	<3.0	<3.0	<3.0	<3.0
	Total Dissolved Solids (mg/L)	1570	548	1340	289	271
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	149	282	265	232	215
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	14.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	149	296	265	232	215
	Ammonia, Total (as N) (mg/L)	0.0751	0.0248	0.0189	0.0173	<0.0050
	Chloride (Cl) (mg/L)	11.3	5.67	9.2	5.47	5.82
	Nitrate and Nitrite (as N) (mg/L)	0.069	0.167	0.241	0.261	0.305
	Nitrate (as N) (mg/L)	<0.025 DLDS	<0.0050	<0.025 DLDS	0.0569	0.271
	Nitrite (as N) (mg/L)	0.0690	0.167	0.241	0.204	0.0346
	Sulfate (SO4) (mg/L)	992	151	776	43.7	43.0
	Anion Sum (meq/L)	23.9	9.24	21.7	5.71	5.39
	Cation Sum (meq/L)	24.2	11.2	21.3	5.79	5.26
	Cation - Anion Balance (%)	0.5	9.7	-1.0	0.7	-1.2
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0036	0.0059	0.0016	0.0025	0.0023
	Antimony (Sb)-Dissolved (mg/L)	0.00014	0.00028	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00084	0.00047	0.00020	0.00012	0.00013
	Barium (Ba)-Dissolved (mg/L)	0.0480	0.702	0.0629	0.0577	0.0609
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.172	0.112	0.111	0.085	0.079
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000076
	Calcium (Ca)-Dissolved (mg/L)	293	115	209	49.0	47.9
	Chromium (Cr)-Dissolved (mg/L)	0.00037	0.00065	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	0.00021	0.00121
	Iron (Fe)-Dissolved (mg/L)	0.026	0.028	0.253	0.019	<0.010
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0080	0.0079	0.0055	0.0035	0.0038
	Magnesium (Mg)-Dissolved (mg/L)	38.2	32.5	74.0	29.9	25.7
	Manganese (Mn)-Dissolved (mg/L)	0.139	0.365	2.41	0.216	0.0631

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1795474-6				
	Description	Water				
	Sampled Date	06-JUL-16				
	Sampled Time	11:10				
	Client ID	MW12-05-07				
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	507				
	Hardness (as CaCO3) (mg/L)	248				
	pH (pH)	8.32				
	Total Suspended Solids (mg/L)	<3.0				
	Total Dissolved Solids (mg/L)	284				
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	248				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	5.4				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Total (as CaCO3) (mg/L)	254				
	Ammonia, Total (as N) (mg/L)	0.0161				
	Chloride (Cl) (mg/L)	5.56				
	Nitrate and Nitrite (as N) (mg/L)	0.0212				
	Nitrate (as N) (mg/L)	<0.0050				
	Nitrite (as N) (mg/L)	0.0212				
	Sulfate (SO4) (mg/L)	25.6				
	Anion Sum (meq/L)	5.76				
	Cation Sum (meq/L)	5.74				
	Cation - Anion Balance (%)	-0.2				
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD				
	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	0.0034				
	Antimony (Sb)-Dissolved (mg/L)	<0.00010				
	Arsenic (As)-Dissolved (mg/L)	0.00026				
	Barium (Ba)-Dissolved (mg/L)	0.677				
	Beryllium (Be)-Dissolved (mg/L)	<0.000020				
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050				
	Boron (B)-Dissolved (mg/L)	0.034				
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050				
	Calcium (Ca)-Dissolved (mg/L)	54.8				
	Chromium (Cr)-Dissolved (mg/L)	0.00020				
	Cobalt (Co)-Dissolved (mg/L)	<0.00010				
	Copper (Cu)-Dissolved (mg/L)	<0.00020				
	Iron (Fe)-Dissolved (mg/L)	0.124				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	0.0032				
	Magnesium (Mg)-Dissolved (mg/L)	26.9				
	Manganese (Mn)-Dissolved (mg/L)	0.739				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1795474-1	L1795474-2	L1795474-3	L1795474-4	L1795474-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	06-JUL-16	06-JUL-16	06-JUL-16	06-JUL-16	06-JUL-16
	Sampled Time	08:50	09:20	09:50	10:05	10:50
	Client ID	MW12-05-01	MW12-05-02	MW12-05-03	MW12-05-04	MW12-05-06
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.000349	0.00112	0.000679	0.00480	0.00359
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	0.00073
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	3.50	3.03	3.86	2.14	1.97
	Selenium (Se)-Dissolved (mg/L)	0.000347	0.000155	0.000102	0.000105	0.000176
	Silicon (Si)-Dissolved (mg/L)	7.48	6.93	7.82	6.34	6.08
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	145	62.0	105	18.8	16.1
	Strontium (Sr)-Dissolved (mg/L)	8.29	4.01	8.31	0.959	0.778
	Sulfur (S)-Dissolved (mg/L)	356	91.8	255	15.4	14.5
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	0.00037	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.00101	0.000378	0.00104	0.00236	0.00296
	Vanadium (V)-Dissolved (mg/L)	<0.00050	0.00126	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0014	0.0029	0.0018	0.0013	0.0624
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	0.00040	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1795474-6				
	Description	Water				
	Sampled Date	06-JUL-16				
	Sampled Time	11:10				
	Client ID	MW12-05-07				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050				
	Molybdenum (Mo)-Dissolved (mg/L)	0.00223				
	Nickel (Ni)-Dissolved (mg/L)	<0.00050				
	Phosphorus (P)-Dissolved (mg/L)	0.072				
	Potassium (K)-Dissolved (mg/L)	1.90				
	Selenium (Se)-Dissolved (mg/L)	0.000558				
	Silicon (Si)-Dissolved (mg/L)	6.78				
	Silver (Ag)-Dissolved (mg/L)	<0.000010				
	Sodium (Na)-Dissolved (mg/L)	16.2				
	Strontium (Sr)-Dissolved (mg/L)	0.773				
	Sulfur (S)-Dissolved (mg/L)	43.4				
	Thallium (Tl)-Dissolved (mg/L)	<0.000010				
	Tin (Sn)-Dissolved (mg/L)	<0.00010				
	Titanium (Ti)-Dissolved (mg/L)	<0.00030				
	Uranium (U)-Dissolved (mg/L)	0.00195				
	Vanadium (V)-Dissolved (mg/L)	<0.00050				
	Zinc (Zn)-Dissolved (mg/L)	0.0019				
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Sulfate (SO4)	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1795474-1, -2, -3, -4, -5, -6

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Reference Information

MET-DIS-LOW-ICP-VA Water Dissolved Metals in Water by ICPOES EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA Water Dissolved Sulfur in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA Water TDS (Calculated) APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR Water Total Suspended Solids by Gravimetric APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WR	ALS ENVIRONMENTAL - WHITEHORSE, YUKON, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-07-07 C

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1795474-COFC

COC Number: 2016-07-07 C

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: 220404 (GW)

LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#

Major/Minor Code: | Routing Code:

Requisitioner:

Location:

ALS Contact:

Sampler: SR/CP

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions						Number of Containers
	MW12-05-01 ✓	6-Jul-16	8:50	Water		R		R	R		R						4
	MW12-05-02 ✓	6-Jul-16	9:20	Water		R		R	R		R						4
	MW12-05-03 ✓	6-Jul-16	9:50	Water		R		R	R		R						4
	MW12-05-04 ✓	6-Jul-16	10:05	Water		R		R	R		R						4
	MW12-05-06 ✓	6-Jul-16	10:50	Water		R		R	R		R						4
	MW12-05-07 ✓	6-Jul-16	11:10	Water		R		R	R		R						4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C: 8.0 7.5 5.0

FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-07-07	Time: 9:00	Received by:	Date: 8-Jul-16	Time: 12:00	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 20-SEP-16
Report Date: 29-SEP-16 17:56 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1831163

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-09-19 C
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1831163-1				
	Description	Water				
	Sampled Date	18-SEP-16				
	Sampled Time	15:18				
	Client ID	MW11-04A				
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	250				
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0604				
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD				
	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	1.12				
	Antimony (Sb)-Dissolved (mg/L)	0.00030				
	Arsenic (As)-Dissolved (mg/L)	0.00277				
	Barium (Ba)-Dissolved (mg/L)	0.273				
	Beryllium (Be)-Dissolved (mg/L)	<0.000020				
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050				
	Boron (B)-Dissolved (mg/L)	<0.010				
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050				
	Calcium (Ca)-Dissolved (mg/L)	100				
	Chromium (Cr)-Dissolved (mg/L)	0.00289				
	Cobalt (Co)-Dissolved (mg/L)	<0.00010				
	Copper (Cu)-Dissolved (mg/L)	0.0633				
	Iron (Fe)-Dissolved (mg/L)	<0.010				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	0.0158				
	Magnesium (Mg)-Dissolved (mg/L)	<0.10				
	Manganese (Mn)-Dissolved (mg/L)	0.00036				
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050				
	Molybdenum (Mo)-Dissolved (mg/L)	0.00255				
	Nickel (Ni)-Dissolved (mg/L)	<0.00050				
	Phosphorus (P)-Dissolved (mg/L)	<0.050				
	Potassium (K)-Dissolved (mg/L)	4.70				
	Selenium (Se)-Dissolved (mg/L)	0.00262				
	Silicon (Si)-Dissolved (mg/L)	4.66				
	Silver (Ag)-Dissolved (mg/L)	<0.000010				
	Sodium (Na)-Dissolved (mg/L)	4.89				
	Strontium (Sr)-Dissolved (mg/L)	0.397				
	Sulfur (S)-Dissolved (mg/L)	1.98				
	Thallium (Tl)-Dissolved (mg/L)	<0.000010				
	Tin (Sn)-Dissolved (mg/L)	0.00021				
	Titanium (Ti)-Dissolved (mg/L)	<0.00030				
	Uranium (U)-Dissolved (mg/L)	<0.000010				
	Vanadium (V)-Dissolved (mg/L)	0.0137				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1831163-1					
	Description	Water					
	Sampled Date	18-SEP-16					
	Sampled Time	15:18					
	Client ID	MW11-04A					
Grouping	**Analyte**						
WATER							
Dissolved Metals	Zinc (Zn)-Dissolved (mg/L)	0.0038					
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Aluminum (Al)-Dissolved	MS-B	L1831163-1
Matrix Spike	Arsenic (As)-Dissolved	MS-B	L1831163-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1831163-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1831163-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1831163-1
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1831163-1
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1831163-1
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1831163-1
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1831163-1
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1831163-1
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1831163-1
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1831163-1
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1831163-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1831163-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1831163-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1831163-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1831163-1
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1831163-1
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1831163-1
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1831163-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1831163-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1831163-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1831163-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1831163-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1831163-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1831163-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1831163-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1831163-1
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1831163-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society

Reference Information

of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-09-19 C

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1831163-COFC

COC Number: 2016-09-19 C

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
Company address below will appear on the final report	
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information	
ALS Account # / Quote #:	
Job #:	
PO / AFE:	220404 (GW)
LSD:	
ALS Lab Work Order # (lab use only)	

Oil and Gas Required Fields (client use)

AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	
ALS Contact:	Sampler: CH/CB

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	MW11-04A	18-Sep-16	15:18	Water		R		R	R			3

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C: 4.0

FINAL COOLER TEMPERATURES °C: 4, 5

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: EHF	Date: 20 Sep 2016	Time: 9:00	Received by: JC	Date: 21/9/16	Time: 14:30

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION   WHITE - LABORATORY COPY   YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 07-SEP-16
Report Date: 20-SEP-16 16:31 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1825918

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-09-07 A
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825918-1	L1825918-2	L1825918-3	L1825918-4	L1825918-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	01-SEP-16	01-SEP-16	02-SEP-16	02-SEP-16	02-SEP-16
	Sampled Time	15:45	17:15	11:00	11:45	16:15
	Client ID	MW12-07-01	MW12-07-02	MW09-03-01	MW09-03-02	MW12-06-02
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	1280	1410	331	487	983
	Hardness (as CaCO3) (mg/L)	614	691	155	242	494
	pH (pH)	8.13	8.07	8.25	7.98	8.06
	Total Suspended Solids (mg/L)	<3.0	<3.0	<3.0	24.6	46.4
	TDS (Calculated) (mg/L)	825	1110	187	280	660
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	551	115	154	261	368
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	551	115	154	261	368
	Ammonia, Total (as N) (mg/L)	0.472	0.0427	0.0473	0.105	0.0235
	Chloride (Cl) (mg/L)	1.2	DLDS <1.0	<0.50	1.79	DLDS <1.0
	Nitrate and Nitrite (as N) (mg/L)	0.675	0.529	1.56	0.0873	1.39
	Nitrate (as N) (mg/L)	0.203	0.149	<0.0050	<0.0050	0.264
	Nitrite (as N) (mg/L)	0.472	0.380	1.56	0.0873	1.13
	Sulfate (SO4) (mg/L)	166	710	22.4	2.08	216
	Anion Sum (meq/L)	14.6	17.1	3.65	5.32	12.0
	Cation Sum (meq/L)	16.3	16.9	3.58	6.16	11.7
	Cation - Anion Balance (%)	5.6	-0.5	-0.9	7.3	-1.0
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0028	0.0022	0.0030	0.0026	0.0014
	Antimony (Sb)-Dissolved (mg/L)	0.00012	DLA <0.00020	0.00011	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00092	0.00093	0.00062	0.00022	0.00438
	Barium (Ba)-Dissolved (mg/L)	0.0705	0.0121	0.0656	0.293	0.0237
	Beryllium (Be)-Dissolved (mg/L)	0.000041	DLA <0.000040	<0.000020	<0.000020	0.000049
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	DLA <0.00010	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.773	0.300	0.310	0.306	0.162
	Cadmium (Cd)-Dissolved (mg/L)	0.0000282	DLA <0.000010	<0.0000050	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	208	219	43.5	77.3	137
	Chromium (Cr)-Dissolved (mg/L)	0.00042	DLA <0.00020	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	DLA <0.00020	<0.00010	0.00020	<0.00010
	Copper (Cu)-Dissolved (mg/L)	0.00040	DLA <0.00040	<0.00020	0.00245	<0.00020
	Iron (Fe)-Dissolved (mg/L)	0.039	0.181	0.324	10.7	1.11
	Lead (Pb)-Dissolved (mg/L)	<0.000050	DLA <0.00010	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0275	0.0300	0.0035	<0.0010	0.0095
	Magnesium (Mg)-Dissolved (mg/L)	23.3	35.1	11.3	11.9	37.2
	Manganese (Mn)-Dissolved (mg/L)	0.152	0.152	0.0977	6.48	0.0277

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825918-6	L1825918-7	L1825918-8	L1825918-9	L1825918-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	02-SEP-16	02-SEP-16	02-SEP-16	02-SEP-16	05-SEP-16
	Sampled Time	16:50	17:50	18:40	19:20	11:10
	Client ID	MW12-06-03	MW12-06-04	MW12-06-05	MW12-06-06	MW12-05-01
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	941		977	829	1980
	Hardness (as CaCO3) (mg/L)	502	526	535	426	929
	pH (pH)	8.20		8.14	8.23	7.82
	Total Suspended Solids (mg/L)	5.2		9.0	<3.0	3.4
	TDS (Calculated) (mg/L)	615		641	531	1660
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	381		412	325	143
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0		<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0		<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	381		412	325	143
	Ammonia, Total (as N) (mg/L)	0.0307		<0.0050	<0.0050	0.0597
	Chloride (Cl) (mg/L)	<0.50		DLDS <1.0	5.70	11.5
	Nitrate and Nitrite (as N) (mg/L)	1.26		0.192	1.25	0.076
	Nitrate (as N) (mg/L)	0.234		0.038	1.15	DLDS <0.025
	Nitrite (as N) (mg/L)	1.02		0.154	0.0971	0.0764
	Sulfate (SO4) (mg/L)	175		181	154	1070
	Anion Sum (meq/L)	11.3		12.0	9.94	25.4
	Cation Sum (meq/L)	11.8		12.3	9.98	25.1
	Cation - Anion Balance (%)	2.1		1.4	0.2	-0.5
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD		FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0018	0.0018	0.0029	0.0024	0.0031
	Antimony (Sb)-Dissolved (mg/L)	0.00013	<0.00010	<0.00010	<0.00010	DLA <0.00020
	Arsenic (As)-Dissolved (mg/L)	0.00079	0.00224	0.00087	<0.00010	0.00077
	Barium (Ba)-Dissolved (mg/L)	0.0261	0.0174	0.0427	0.0144	0.0450
	Beryllium (Be)-Dissolved (mg/L)	0.000026	0.000021	<0.000020	<0.000020	DLA <0.000040
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	DLA <0.00010
	Boron (B)-Dissolved (mg/L)	0.327	0.527	0.096	0.074	0.114
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	0.0000169	DLA <0.000010
	Calcium (Ca)-Dissolved (mg/L)	110	108	108	82.8	309
	Chromium (Cr)-Dissolved (mg/L)	0.00039	<0.00010	<0.00010	<0.00010	0.00040
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	0.00115	<0.00010	DLA <0.00020
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	0.00041	<0.00020	DLA <0.00040
	Iron (Fe)-Dissolved (mg/L)	1.19	<0.010	0.014	<0.010	0.037
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	DLA <0.00010
	Lithium (Li)-Dissolved (mg/L)	0.0083	0.0070	0.0069	0.0052	0.0070
	Magnesium (Mg)-Dissolved (mg/L)	55.3	62.2	64.6	53.2	38.0
	Manganese (Mn)-Dissolved (mg/L)	0.0153	0.0464	0.340	0.0192	0.135

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825918-11	L1825918-12			
	Description	Water	Water			
	Sampled Date	05-SEP-16	05-SEP-16			
	Sampled Time	11:45	14:15			
	Client ID	MW12-05-02	MW12-05-03			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	1660				
	Hardness (as CaCO3) (mg/L)	931	873			
	pH (pH)	8.07				
	Total Suspended Solids (mg/L)	<3.0				
	TDS (Calculated) (mg/L)	1410				
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	209				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Total (as CaCO3) (mg/L)	209				
	Ammonia, Total (as N) (mg/L)	0.0634	0.0205			
	Chloride (Cl) (mg/L)	9.3				
	Nitrate and Nitrite (as N) (mg/L)	0.047				
	Nitrate (as N) (mg/L)	<0.025 DLDS				
	Nitrite (as N) (mg/L)	0.0470				
	Sulfate (SO4) (mg/L)	802				
	Anion Sum (meq/L)	21.1				
	Cation Sum (meq/L)	24.4				
	Cation - Anion Balance (%)	7.2				
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD			
	Dissolved Metals Filtration Location	FIELD	FIELD			
	Aluminum (Al)-Dissolved (mg/L)	0.0045	0.0030			
	Antimony (Sb)-Dissolved (mg/L)	0.00012	<0.00010			
	Arsenic (As)-Dissolved (mg/L)	0.00063	0.00020			
	Barium (Ba)-Dissolved (mg/L)	0.219	0.0468			
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020			
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050			
	Boron (B)-Dissolved (mg/L)	0.114	0.100			
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050			
	Calcium (Ca)-Dissolved (mg/L)	282	228			
	Chromium (Cr)-Dissolved (mg/L)	0.00025	0.00012			
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010			
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020			
	Iron (Fe)-Dissolved (mg/L)	0.176	0.290			
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050			
	Lithium (Li)-Dissolved (mg/L)	0.0062	0.0056			
	Magnesium (Mg)-Dissolved (mg/L)	54.9	73.8			
	Manganese (Mn)-Dissolved (mg/L)	0.927	2.41			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825918-1	L1825918-2	L1825918-3	L1825918-4	L1825918-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	01-SEP-16	01-SEP-16	02-SEP-16	02-SEP-16	02-SEP-16
	Sampled Time	15:45	17:15	11:00	11:45	16:15
	Client ID	MW12-07-01	MW12-07-02	MW09-03-01	MW09-03-02	MW12-06-02
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	0.0000051	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.000755	0.0181	0.00498	0.00917	0.00666
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	DLA <0.0010	0.00106	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	3.23	2.94	2.25	2.60	3.60
	Selenium (Se)-Dissolved (mg/L)	0.00206	0.00013	0.000065	0.000060	<0.000050
	Silicon (Si)-Dissolved (mg/L)	9.41	6.03	5.62	9.10	10.6
	Silver (Ag)-Dissolved (mg/L)	<0.000010	DLA <0.000020	<0.000010	0.000019	<0.000010
	Sodium (Na)-Dissolved (mg/L)	89.6	70.2	9.19	9.99	39.2
	Strontium (Sr)-Dissolved (mg/L)	8.16	10.1	0.917	0.731	9.95
	Sulfur (S)-Dissolved (mg/L)	269	234	7.74	1.20	70.3
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	DLA <0.000020	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	DLA <0.00020	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	DLA <0.00060	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.000144	0.00157	0.000944	0.000039	0.00240
	Vanadium (V)-Dissolved (mg/L)	0.00168	DLA <0.0010	<0.00050	0.00058	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0058	0.0066	0.0051	0.0066	0.0046
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	DLA <0.00060	<0.00030	<0.00030	<0.00030

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825918-6	L1825918-7	L1825918-8	L1825918-9	L1825918-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	02-SEP-16	02-SEP-16	02-SEP-16	02-SEP-16	05-SEP-16
	Sampled Time	16:50	17:50	18:40	19:20	11:10
	Client ID	MW12-06-03	MW12-06-04	MW12-06-05	MW12-06-06	MW12-05-01
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050		<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00189	0.00854	0.00863	0.00554	0.00033
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	0.00067	<0.00050	DLA <0.0010
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	3.95	3.85	3.77	3.36	3.72
	Selenium (Se)-Dissolved (mg/L)	0.000078	0.000119	<0.000050	0.000266	0.00030
	Silicon (Si)-Dissolved (mg/L)	9.13	8.98	8.50	6.96	7.56
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	DLA <0.000020
	Sodium (Na)-Dissolved (mg/L)	37.2	39.5	35.4	31.8	148
	Strontium (Sr)-Dissolved (mg/L)	4.22	2.98	2.69	1.53	7.95
	Sulfur (S)-Dissolved (mg/L)	61.4	59.2	59.9	50.4	375
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	DLA <0.000020
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	DLA <0.00020
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	DLA <0.00060
	Uranium (U)-Dissolved (mg/L)	0.00190	0.00564	0.00587	0.00412	0.00102
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	DLA <0.0010
	Zinc (Zn)-Dissolved (mg/L)	0.0083	0.0686	0.0637	0.0827	DLA <0.0020
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	DLA <0.00060

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825918-11	L1825918-12
	Description	Water	Water
	Sampled Date	05-SEP-16	05-SEP-16
	Sampled Time	11:45	14:15
	Client ID	MW12-05-02	MW12-05-03
Grouping	**Analyte**		
WATER			
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00105	0.000456
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	4.10	4.25
	Selenium (Se)-Dissolved (mg/L)	0.000070	0.000075
	Silicon (Si)-Dissolved (mg/L)	7.12	8.16
	Silver (Ag)-Dissolved (mg/L)	0.000011	<0.000010
	Sodium (Na)-Dissolved (mg/L)	130	108
	Strontium (Sr)-Dissolved (mg/L)	9.65	7.94
	Sulfur (S)-Dissolved (mg/L)	325	272
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.000790	0.00105
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0037	0.0023
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Boron (B)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Cobalt (Co)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Nickel (Ni)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1825918-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sulfate (SO4)	MS-B	L1825918-1, -10, -11, -2, -3, -4, -5, -6, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

Reference Information

IONBALANCE-VA Water Ion Balance Calculation APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA Water Dissolved Metals in Water by ICPOES EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA Water Dissolved Sulfur in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA Water TDS (Calculated) APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".
The Total Dissolved Solids result is calculated from measured concentrations of anions and cations in the sample.

TSS-VA Water Total Suspended Solids by Gravimetric APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended

Reference Information

Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WR	ALS ENVIRONMENTAL - WHITEHORSE, YUKON, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-09-07 A

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Short Holding Time — *Rush Processing*

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1825918-COFC

COC Number: 2016-09-07 A

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: 220404 (GW)

LSD:

ALS Lab Work Order # (lab use only) L1825918

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Contact: Sampler: SR/CP

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	MW12-07-01	1-Sep-16	15:45	Water		R		R	R		R	4
	MW12-07-02	1-Sep-16	17:15	Water		R		R	R		R	4
	MW09-03-01	2-Sep-16	11:00	Water		R		R	R		R	4
	MW09-03-02	2-Sep-16	11:45	Water		R		R	R		R	4
	MW12-06-02	2-Sep-16	16:15	Water		R		R	R		R	4
	MW12-06-03	2-Sep-16	16:50	Water		R		R	R		R	4
	MW12-06-04	2-Sep-16	17:50	Water		R						1
	MW12-06-05	2-Sep-16	18:40	Water		R		R	R		R	4
	MW12-06-06	2-Sep-16	19:20	Water		R		R	R		R	4
	MW12-05-01	5-Sep-16	11:10	Water		R		R	R		R	4
	MW12-05-02	5-Sep-16	11:45	Water		R		R	R		R	4
	MW12-05-03	5-Sep-16	14:15	Water		R		R	R			3

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☒ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 9.0c

FINAL COOLER TEMPERATURES °C: 1.5, 3 | 4.4 | 9.1

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-09-07	Time: 10:30	Received by: [signature]	Date: Sept-7-16	Time: 3:20	Received by: JC	Date: SEP - 8 2016	Time: 12:40

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 28-OCT-16
Report Date: 07-NOV-16 13:27 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1850474

Project P.O. #: 220404 (GW)

Job Reference:

C of C Numbers: 2016-10-26 B

Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1850474-1	L1850474-2	L1850474-3	L1850474-4	L1850474-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	25-OCT-16	25-OCT-16	25-OCT-16	25-OCT-16	25-OCT-16
	Sampled Time	11:40	13:30	13:55	14:40	15:20
	Client ID	MW12-06-01	MW12-06-02	MW12-06-03	MW12-06-05	MW12-06-06
WATER						
Physical Tests	Conductivity (uS/cm)	720	982	981	978	839
	Hardness (as CaCO3) (mg/L)	288	455	469	480	411
	pH (pH)	7.95	7.94	8.09	8.08	8.10
	Total Suspended Solids (mg/L)	<3.0	15.6	5.3	4.8	<3.0
	TDS (Calculated) (mg/L)	401	643	652	624	529
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	378	377	394	420	326
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	378	377	394	420	326
	Ammonia, Total (as N) (mg/L)	0.0542	0.0142	0.0076	0.0070	<0.0050
	Chloride (Cl) (mg/L)	5.3	<2.5 DLDS	<2.5 DLDS	<2.5 DLDS	5.9
	Nitrate and Nitrite (as N) (mg/L)	1.20	0.700	0.967	0.165	1.22
	Nitrate (as N) (mg/L)	0.252	0.143	0.198	0.040	1.15
	Nitrite (as N) (mg/L)	0.952	0.557	0.769	0.125	0.0692
	Sulfate (SO4) (mg/L)	2.3	209	214	176	156
	Anion Sum (meq/L)	7.84	11.9	12.4	12.1	10.0
	Cation Sum (meq/L)	8.25	10.9	11.1	11.2	9.66
	Cation - Anion Balance (%)	2.5	-4.3	-5.4	-3.6	-1.8
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0148	<0.0010	<0.0010	<0.0010	<0.0010
	Antimony (Sb)-Dissolved (mg/L)	0.00038	<0.00010	0.00012	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00640	0.00286	0.00060	0.00085	<0.00010
	Barium (Ba)-Dissolved (mg/L)	0.239	0.0237	0.0258	0.0417	0.0137
	Beryllium (Be)-Dissolved (mg/L)	0.000113	0.000025	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.590	0.298	0.360	0.101	0.087
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	85.2	129	106	102	81.1
	Chromium (Cr)-Dissolved (mg/L)	0.00333	<0.00010	0.00011	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	0.00109	<0.00010
	Copper (Cu)-Dissolved (mg/L)	0.00038	<0.00020	<0.00020	<0.00020	<0.00020
	Iron (Fe)-Dissolved (mg/L)	0.239	0.012	0.020	0.012	<0.010
	Lead (Pb)-Dissolved (mg/L)	0.000056	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0099	0.0081	0.0075	0.0061	0.0055
	Magnesium (Mg)-Dissolved (mg/L)	18.2	32.1	49.7	54.8	50.6
	Manganese (Mn)-Dissolved (mg/L)	0.0922	0.0264	0.0151	0.333	0.0266

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1850474-1	L1850474-2	L1850474-3	L1850474-4	L1850474-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	25-OCT-16	25-OCT-16	25-OCT-16	25-OCT-16	25-OCT-16
	Sampled Time	11:40	13:30	13:55	14:40	15:20
	Client ID	MW12-06-01	MW12-06-02	MW12-06-03	MW12-06-05	MW12-06-06
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00172	0.00646	0.00238	0.00880	0.00562
	Nickel (Ni)-Dissolved (mg/L)	0.00060	<0.00050	<0.00050	0.00057	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	2.56	3.54	3.95	3.77	3.43
	Selenium (Se)-Dissolved (mg/L)	0.000327	<0.000050	0.000052	<0.000050	0.000259
	Silicon (Si)-Dissolved (mg/L)	7.68	9.21	9.63	8.60	6.92
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	55.4	40.3	38.0	35.1	31.3
	Strontium (Sr)-Dissolved (mg/L)	3.48	9.73	4.36	2.70	1.53
	Sulfur (S)-Dissolved (mg/L)	3.48	59.9	67.8	60.6	50.8
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	0.00016	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	0.00229	<0.00030	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.000815	0.00231	0.00201	0.00575	0.00401
	Vanadium (V)-Dissolved (mg/L)	0.0116	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0044	0.0034	0.0065	0.0406	0.0504
	Zirconium (Zr)-Dissolved (mg/L)	0.00103	<0.00030	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Aluminum (Al)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Boron (B)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Cobalt (Co)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Copper (Cu)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Iron (Fe)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Nickel (Ni)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1850474-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description

Reference Information

DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-VA	Water	Nitrite & Nitrate in Water (Calculation)	EPA 300.0

Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

Reference Information

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".
The Total Dissolved Solids result is calculated from measured concentrations of anions and cations in the sample.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	**Laboratory Location**
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-10-26 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1850474-COFC

COC Number: 2016-10-26 B

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

[redacted] Date and Time Required for all E&P TATs: [redacted]

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: 220404 (GW)

LSD:

ALS Lab Work Order # (lab use only)

[redacted] Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Contact:

Sampler: SR/CP

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	MW12-06-01	25-Oct-16	11:40	Water		R		R	R		R	4
	MW12-06-02	25-Oct-16	13:30	Water		R		R	R		R	4
	MW12-06-03	25-Oct-16	13:55	Water		R		R	R		R	4
	MW12-06-05	25-Oct-16	14:40	Water		R		R	R		R	4
	MW12-06-06	25-Oct-16	15:20	Water		R		R	R		R	4

Short Holding Time

Rush Processing

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☑ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C: 4.0°

FINAL COOLER TEMPERATURES °C: 3.6, 5.1 C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-10-26	Time: 11:00	Received by: EHF	Date: 27 Oct 2016	Time: 09:44	Received by: MMC	Date: Oct 28/16	Time: 11:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 26-OCT-16
Report Date: 04-NOV-16 15:51 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1849162

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-10-25 B
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1849162-1	L1849162-2	L1849162-3	L1849162-4	L1849162-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	21-OCT-16	21-OCT-16	21-OCT-16	21-OCT-16	21-OCT-16
	Sampled Time	11:35	13:10	13:45	14:20	14:50
	Client ID	MW12-05-01	MW12-05-02	MW12-05-03	MW12-05-04	MW12-05-05
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	2010	2000	1780	494	485
	Hardness (as CaCO3) (mg/L)	901	967	852	231	224
	pH (pH)	7.96	8.09	8.15	8.19	8.14
	Total Suspended Solids (mg/L)	3.1	3.1	4.8	<3.0	<3.0
	TDS (Calculated) (mg/L)	1670	1640	1390	285	275
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	143	190	242	228	219
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	143	190	242	228	219
	Ammonia, Total (as N) (mg/L)	0.0117	0.0095	<0.0050	<0.0050	<0.0050
	Chloride (Cl) (mg/L)	11.9	10.9	9.1	5.76	5.72
	Nitrate and Nitrite (as N) (mg/L)	0.053	<0.051	0.054	0.0659	0.414
	Nitrate (as N) (mg/L)	<0.050 DLDS	<0.050 DLDS	<0.050 DLDS	0.0350	0.248
	Nitrite (as N) (mg/L)	0.053	0.020	0.054	0.0309	0.167
	Sulfate (SO4) (mg/L)	1080	1030	828	47.3	43.8
	Anion Sum (meq/L)	25.7	25.6	22.3	5.71	5.48
	Cation Sum (meq/L)	24.5	25.0	21.9	5.45	5.29
	Cation - Anion Balance (%)	-2.4	-1.2	-1.1	-2.4	-1.7
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0033	0.0036	0.0011	0.0021	0.0024
	Antimony (Sb)-Dissolved (mg/L)	0.00022	0.00032	0.00017	0.00016	0.00038
	Arsenic (As)-Dissolved (mg/L)	0.00064	0.00024	0.00017	0.00011	0.00017
	Barium (Ba)-Dissolved (mg/L)	0.0438	0.157	0.0436	0.0439	0.0688
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.097	0.121	0.104	0.069	0.162
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	302	297	221	47.8	46.9
	Chromium (Cr)-Dissolved (mg/L)	0.00037	0.00027	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	0.00021	0.00039
	Iron (Fe)-Dissolved (mg/L)	0.018	0.020	0.021	<0.010	<0.010
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0078	0.0062	0.0051	0.0035	0.0036
	Magnesium (Mg)-Dissolved (mg/L)	36.0	54.7	72.7	27.1	26.0
	Manganese (Mn)-Dissolved (mg/L)	0.138	0.869	2.36	0.122	0.124

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1849162-6	L1849162-7	L1849162-8	L1849162-9	L1849162-10
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	21-OCT-16	21-OCT-16	22-OCT-16	22-OCT-16	22-OCT-16
	Sampled Time	15:15	15:50	11:30	14:00	16:00
	Client ID	MW12-05-06	MW12-05-07	MW09-03-01	MW09-03-02	MW12-07-01
WATER						
Physical Tests	Conductivity (uS/cm)	473	487	326	414	1240
	Hardness (as CaCO3) (mg/L)	222	237	146	211	578
	pH (pH)	8.10	8.26	8.24	8.18	8.13
	Total Suspended Solids (mg/L)	<3.0	<3.0	<3.0	<3.0	<3.0
	TDS (Calculated) (mg/L)	268	279	180	236	769
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	213	250	151	215	529
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	213	250	151	215	529
	Ammonia, Total (as N) (mg/L)	<0.0050	0.0092	0.0396	0.0267	0.315
	Chloride (Cl) (mg/L)	5.62	5.37	<0.50	<0.50	DLDS <2.5
	Nitrate and Nitrite (as N) (mg/L)	0.384	<0.0051	0.824	1.96	0.841
	Nitrate (as N) (mg/L)	0.361	<0.0050	0.0089	1.77	0.263
	Nitrite (as N) (mg/L)	0.0230	<0.0010	0.816	0.198	0.578
	Sulfate (SO4) (mg/L)	42.5	26.8	21.8	9.82	138
	Anion Sum (meq/L)	5.32	5.70	3.53	4.65	13.5
	Cation Sum (meq/L)	5.18	5.51	3.46	4.58	15.5
	Cation - Anion Balance (%)	-1.3	-1.7	-1.1	-0.8	7.0
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0024	0.0022	0.0014	0.0011	0.0031
	Antimony (Sb)-Dissolved (mg/L)	0.00013	<0.00010	0.00045	0.00039	0.00041
	Arsenic (As)-Dissolved (mg/L)	0.00012	0.00022	0.00060	0.00029	0.00078
	Barium (Ba)-Dissolved (mg/L)	0.0627	0.558	0.0688	0.119	0.0818
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	0.000043
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.044	0.032	0.659	0.221	0.616
	Cadmium (Cd)-Dissolved (mg/L)	0.0000179	<0.0000050	<0.0000050	0.0000267	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	47.4	52.2	40.4	70.5	198
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	0.00011	<0.00010	<0.00010	0.00045
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	0.00577	<0.00010
	Copper (Cu)-Dissolved (mg/L)	0.00087	<0.00020	<0.00020	0.00115	0.00024
	Iron (Fe)-Dissolved (mg/L)	<0.010	0.041	<0.010	<0.010	0.055
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0036	0.0031	0.0037	0.0012	0.0265
	Magnesium (Mg)-Dissolved (mg/L)	25.2	25.9	10.9	8.53	20.6
	Manganese (Mn)-Dissolved (mg/L)	0.0607	0.712	0.0888	0.449	0.146

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1849162-11				
	Description	WATER				
	Sampled Date	22-OCT-16				
	Sampled Time	17:02				
	Client ID	MW12-07-02				
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	1420				
	Hardness (as CaCO3) (mg/L)	672				
	pH (pH)	7.98				
	Total Suspended Solids (mg/L)	3.5				
	TDS (Calculated) (mg/L)	1120				
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	108				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Total (as CaCO3) (mg/L)	108				
	Ammonia, Total (as N) (mg/L)	<0.0050				
	Chloride (Cl) (mg/L)	DLDS <2.5				
	Nitrate and Nitrite (as N) (mg/L)	0.406				
	Nitrate (as N) (mg/L)	0.122				
	Nitrite (as N) (mg/L)	0.285				
	Sulfate (SO4) (mg/L)	733				
	Anion Sum (meq/L)	17.4				
	Cation Sum (meq/L)	16.6				
	Cation - Anion Balance (%)	-2.4				
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD				
	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	0.0038				
	Antimony (Sb)-Dissolved (mg/L)	0.00024				
	Arsenic (As)-Dissolved (mg/L)	0.00132				
	Barium (Ba)-Dissolved (mg/L)	0.0117				
	Beryllium (Be)-Dissolved (mg/L)	<0.000020				
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050				
	Boron (B)-Dissolved (mg/L)	0.274				
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050				
	Calcium (Ca)-Dissolved (mg/L)	218				
	Chromium (Cr)-Dissolved (mg/L)	<0.00010				
	Cobalt (Co)-Dissolved (mg/L)	<0.00010				
	Copper (Cu)-Dissolved (mg/L)	0.00022				
	Iron (Fe)-Dissolved (mg/L)	0.021				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	0.0274				
	Magnesium (Mg)-Dissolved (mg/L)	31.2				
	Manganese (Mn)-Dissolved (mg/L)	0.109				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1849162-1	L1849162-2	L1849162-3	L1849162-4	L1849162-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	21-OCT-16	21-OCT-16	21-OCT-16	21-OCT-16	21-OCT-16
	Sampled Time	11:35	13:10	13:45	14:20	14:50
	Client ID	MW12-05-01	MW12-05-02	MW12-05-03	MW12-05-04	MW12-05-05
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.000281	0.000558	0.000566	0.00439	0.00368
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	0.00058
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	3.53	3.98	4.07	2.20	2.18
	Selenium (Se)-Dissolved (mg/L)	0.000083	<0.000050	0.000059	<0.000050	0.000099
	Silicon (Si)-Dissolved (mg/L)	7.23	7.07	7.83	6.37	6.21
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	148	127	107	17.8	17.3
	Strontium (Sr)-Dissolved (mg/L)	8.09	10.1	8.14	0.890	0.732
	Sulfur (S)-Dissolved (mg/L)	383	374	301	16.1	14.8
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.000986	0.000375	0.00123	0.00264	0.00272
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	<0.0010	0.0217	0.0069	0.0141	0.0760
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1849162-6	L1849162-7	L1849162-8	L1849162-9	L1849162-10
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	21-OCT-16	21-OCT-16	22-OCT-16	22-OCT-16	22-OCT-16
	Sampled Time	15:15	15:50	11:30	14:00	16:00
	Client ID	MW12-05-06	MW12-05-07	MW09-03-01	MW09-03-02	MW12-07-01
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00346	0.00236	0.00617	0.0356	0.000904
	Nickel (Ni)-Dissolved (mg/L)	0.00060	<0.00050	0.00128	0.00308	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	2.09	1.93	2.26	2.83	3.03
	Selenium (Se)-Dissolved (mg/L)	0.000102	0.000075	<0.000050	0.000279	0.000444
	Silicon (Si)-Dissolved (mg/L)	6.18	6.72	5.50	5.41	9.39
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	15.8	16.0	11.1	6.11	89.0
	Strontium (Sr)-Dissolved (mg/L)	0.713	0.725	0.935	0.453	8.11
	Sulfur (S)-Dissolved (mg/L)	14.6	9.78	7.09	3.46	52.1
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.00286	0.00214	0.000967	0.00448	0.000168
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	0.00177
	Zinc (Zn)-Dissolved (mg/L)	0.0521	0.0136	0.0182	0.0348	<0.0010
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1849162-11					
	Description	WATER					
	Sampled Date	22-OCT-16					
	Sampled Time	17:02					
	Client ID	MW12-07-02					
Grouping	**Analyte**						
WATER							
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050					
	Molybdenum (Mo)-Dissolved (mg/L)	0.0197					
	Nickel (Ni)-Dissolved (mg/L)	<0.00050					
	Phosphorus (P)-Dissolved (mg/L)	<0.050					
	Potassium (K)-Dissolved (mg/L)	2.84					
	Selenium (Se)-Dissolved (mg/L)	0.000055					
	Silicon (Si)-Dissolved (mg/L)	5.92					
	Silver (Ag)-Dissolved (mg/L)	<0.000010					
	Sodium (Na)-Dissolved (mg/L)	71.1					
	Strontium (Sr)-Dissolved (mg/L)	10.7					
	Sulfur (S)-Dissolved (mg/L)	255					
	Thallium (Tl)-Dissolved (mg/L)	<0.000010					
	Tin (Sn)-Dissolved (mg/L)	<0.00010					
	Titanium (Ti)-Dissolved (mg/L)	0.00035					
	Uranium (U)-Dissolved (mg/L)	0.00176					
	Vanadium (V)-Dissolved (mg/L)	<0.00050					
	Zinc (Zn)-Dissolved (mg/L)	0.0659					
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Aluminum (Al)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Antimony (Sb)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Arsenic (As)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Boron (B)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Copper (Cu)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Iron (Fe)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Lithium (Li)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Nitrate (as N)	MS-B	L1849162-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-VA	Water	Nitrite & Nitrate in Water (Calculation)	EPA 300.0

Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents.

Reference Information

Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".
The Total Dissolved Solids result is calculated from measured concentrations of anions and cations in the sample.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Reference Information

Chain of Custody Numbers:

2016-10-25 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

RUSH

dy (COC) / Analytical
uest Form

Free: 1 800 668 9878

L1849162-COFC

COC Number: 2016-10-25 B

Page of

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	
Company:	Minto Explorations Ltd.	Select Report Format:	☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report	☑ YES ☐ NO
Phone:	1-604-759-4659	☑ Compare Results to Criteria on Report - provide details below if box checked	
Company address below will appear on the final report		Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Street:	2100-510 West Georgia St.	Email 1 or Fax	minto_environment@mintomine.com
City/Province:	Vancouver, British Columbia	Email 2	
Postal Code:	V6B 0M3	Email 3	
Invoice To	Same as Report To ☐ YES ☑ NO	Invoice Distribution	
	Copy of Invoice with Report ☐ YES ☑ NO	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Company:	Minto Explorations Ltd.	Email 1 or Fax	ap@mintomine.com
Contact:	Ruth Cayetano	Email 2	

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R]	☑ Standard TAT if received by 3 pm - business days - no surcharges apply		
PRIORITY (Business Days)	4 day [P4] ☐	EMERGENCY	1 Business day [E1] ☐
	3 day [P3] ☐		Same Day, Weekend or Statutory holiday [E0] ☐
	2 day [P2] ☐		

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:	220404 (GW)	Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact:	Sampler: SR/CP

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM)	Dissolved Metals (DM)	Total Mercury, Hardness	Dissolved Mercury	Ammonia (Total Nutrients)	Dissolved Organic Carbon (DOC)	pH, Cond., TSS, TDS, Alkalinity, Anions							Number of Containers
					P	F/P	P	F/P	P	F/P								
	MW12-05-01	21-Oct-16	11:35	Water		R		R	R		R							4
	MW12-05-02	21-Oct-16	13:10	Water		R		R	R		R							4
	MW12-05-03	21-Oct-16	13:45	Water		R		R	R		R							4
	MW12-05-04	21-Oct-16	14:20	Water		R		R	R		R							4
	MW12-05-05	21-Oct-16	14:50	Water		R		R	R		R							4
	MW12-05-06	21-Oct-16	15:15	Water		R		R	R		R							4
	MW12-05-07	21-Oct-16	15:50	Water		R		R	R		R							4
	MW09-03-01	22-Oct-16	11:30	Water		R		R	R		R							4
	MW09-03-02	22-Oct-16	14:00	Water		R		R	R		R							4
	MW12-07-01	22-Oct-16	16:00	Water		R		R	R		R							4
	MW12-07-02	22-Oct-16	17:02	Water		R		R	R		R							4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐		SIF Observations	Yes ☐ No ☐
Ice Packs ☑	Ice Cubes ☐	Custody seal intact	Yes ☐ No ☐
Cooling Initiated ☐			

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
1.7			10	12	7

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-10-25	Time: 9:30	Received by: [illegible signature]	Date: Oct-26-16	Time: 1:30pm	Received by: RJ	Date: 10/27	Time: 15:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 21-DEC-16
Report Date: 04-JAN-17 16:16 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1873526

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-12-21 B
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1873526-1	L1873526-2	L1873526-3	L1873526-4	L1873526-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	19-DEC-16	19-DEC-16	20-DEC-16	20-DEC-16	20-DEC-16
	Sampled Time	14:20	15:35	15:45	17:10	17:40
	Client ID	MW09-03-01	MW09-03-02	MW12-07-01	MW12-07-02	MW12-07-03
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	320	347	1250	1190	1290
	Hardness (as CaCO3) (mg/L)	152	175	576	702	635
	pH (pH)	8.19	8.18	7.98	8.01	7.89
	Total Suspended Solids (mg/L)	<3.0	7.4	<3.0	70.6	27.7
	TDS (Calculated) (mg/L)	179	199	763	1140	979
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	154	178	573	112	138
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	154	178	573	112	138
	Ammonia, Total (as N) (mg/L)	0.0392	0.0116	0.351	0.0220	0.0761
	Chloride (Cl) (mg/L)	<0.50	<0.50	DLDS <2.5	DLDS <2.5	DLDS <2.5
	Nitrate and Nitrite (as N) (mg/L)	0.155	2.07	0.742	1.37	0.474
	Nitrate (as N) (mg/L)	<0.0050	1.73	0.225	0.399	0.143
	Nitrite (as N) (mg/L)	0.155	0.344	0.518	0.969	0.331
	Sulfate (SO4) (mg/L)	20.9	9.08	105	724	604
	Anion Sum (meq/L)	3.51	3.89	13.7	17.4	15.4
	Cation Sum (meq/L)	3.49	3.84	15.5	17.5	15.4
	Cation - Anion Balance (%)	-0.3	-0.7	6.3	0.3	0.0
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0026	0.0021	0.0044	DLA <0.0020	0.0056
	Antimony (Sb)-Dissolved (mg/L)	0.00019	0.00047	0.00022	0.00028	0.00016
	Arsenic (As)-Dissolved (mg/L)	0.00069	0.00029	0.00087	0.00162	<0.00010
	Barium (Ba)-Dissolved (mg/L)	0.0678	0.0309	0.0802	0.0120	0.0243
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	0.000040	DLA <0.000040	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	DLA <0.00010	<0.000050
	Boron (B)-Dissolved (mg/L)	0.171	0.382	0.612	0.645	0.283
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	0.0000210	<0.0000050	DLA <0.000010	0.0000058
	Calcium (Ca)-Dissolved (mg/L)	42.8	59.1	198	227	184
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	0.00046	DLA <0.00020	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	0.00051	<0.00010	DLA <0.00020	<0.00010
	Copper (Cu)-Dissolved (mg/L)	0.00070	0.00158	<0.00020	DLA <0.00040	0.00258
	Iron (Fe)-Dissolved (mg/L)	0.175	0.011	0.037	DLA <0.020	1.56
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	DLA <0.00010	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0047	0.0016	0.0264	0.0277	0.0176
	Magnesium (Mg)-Dissolved (mg/L)	10.9	6.62	19.9	32.8	42.9
	Manganese (Mn)-Dissolved (mg/L)	0.0929	0.0567	0.134	0.111	1.77

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1873526-1	L1873526-2	L1873526-3	L1873526-4	L1873526-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	19-DEC-16	19-DEC-16	20-DEC-16	20-DEC-16	20-DEC-16
	Sampled Time	14:20	15:35	15:45	17:10	17:40
	Client ID	MW09-03-01	MW09-03-02	MW12-07-01	MW12-07-02	MW12-07-03
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00479	0.00715	0.000582	0.0195	0.0322
	Nickel (Ni)-Dissolved (mg/L)	0.00111	<0.00050	<0.00050	DLA <0.0010	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	DLA <0.10	<0.050
	Potassium (K)-Dissolved (mg/L)	2.28	2.35	3.02	2.89	3.72
	Selenium (Se)-Dissolved (mg/L)	<0.000050	0.000222	0.000405	0.00019	0.000101
	Silicon (Si)-Dissolved (mg/L)	5.36	5.09	9.32	6.01	4.13
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	DLA <0.000020	<0.000010
	Sodium (Na)-Dissolved (mg/L)	8.79	6.44	89.8	78.7	56.2
	Strontium (Sr)-Dissolved (mg/L)	0.974	0.347	7.92	10.8	3.57
	Sulfur (S)-Dissolved (mg/L)	9.49	3.42	43.3	257	223
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	DLA <0.000020	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	DLA <0.00020	0.00023
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	DLA <0.00060	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.00106	0.00305	0.000212	0.00167	0.000205
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	0.00166	DLA <0.0010	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0106	0.0563	0.0023	0.178	0.0810
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	DLA <0.00060	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Aluminum (Al)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Copper (Cu)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Iron (Fe)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1873526-1, -2, -3, -4, -5
Matrix Spike	Nitrate (as N)	MS-B	L1873526-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-VA	Water	Nitrite & Nitrate in Water (Calculation)	EPA 300.0

Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Reference Information

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".
The Total Dissolved Solids result is calculated from measured concentrations of anions and cations in the sample.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

Reference Information

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-12-21 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Whitehorse Receive

:al

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1873526-COFC

COC Number: 2016-12-21 B

Page of

Report To	Contact and company name below will appear on the final report	**Report Format / Distribution**	
Company:	Minto Explorations Ltd.	Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)	
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report ☑ YES ☐ NO	
Phone:	1-604-759-4659	☑ Compare Results to Criteria on Report - provide details below if box checked	
	Company address below will appear on the final report	Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Street:	2100-510 West Georgia St.	Email 1 or Fax	minto_environment@mintomine.com
City/Province:	Vancouver, British Columbia	Email 2	
Postal Code:	V6B 0M3	Email 3	
Invoice To	Same as Report To ☐ YES ☑ NO	**Invoice Distribution**	
	Copy of Invoice with Report ☐ YES ☑ NO	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:	Minto Explorations Ltd.	Email 1 or Fax	ap@mintomine.com
Contact:	Ruth Cayetano	Email 2	
Project Information		**Oil and Gas Required Fields (client use)**	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:	220404 (GW)	Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		**ALS Contact:**	**Sampler:** SR/SB

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)		EMERGENCY	
4 day [P4]	☐	**1 Business day [E1]**	☐
3 day [P3]	☐	**Same Day, Weekend or Statutory holiday [E0]**	☐
2 day [P2]	☐		

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions							Number of Containers
	MW09-03-01 ✓	19-Dec-16	14:20	Water		R		R	R		R							4
	MW09-03-02 ✓	19-Dec-16	15:35	Water		R		R	R		R							4
	MW12-07-01 ✓	20-Dec-16	15:45	Water		R		R	R		R							4
	MW12-07-02 ✓	20-Dec-16	17:10	Water		R		R	R		R							4
	MW12-07-03 ✓	20-Dec-16	17:40	Water		R		R	R		R							4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
4.0			2.5		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-12-21	Time: 12:00	Received by: EHF	Date: 21 Dec 2016	Time: 14:54	Received by: DJ	Date: Dec 22/16	Time: 16:55

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 28-DEC-16
Report Date: 11-JAN-17 10:46 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1874662
Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-12-27A
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1874662-1	L1874662-2	L1874662-3	L1874662-4	L1874662-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	23-DEC-16	23-DEC-16	23-DEC-16	23-DEC-16	23-DEC-16
	Sampled Time	11:15	11:35	13:30	13:45	14:45
	Client ID	MW12-05-01	MW12-05-02	MW12-05-03	MW12-05-04	MW12-05-05
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	2100	2080	1770	520	486
	Hardness (as CaCO3) (mg/L)	951	1060	847	245	236
	pH (pH)	7.69	7.90	7.72	7.87	7.82
	Total Suspended Solids (mg/L)	<3.0	<3.0	<3.0	<3.0	<3.0
	TDS (Calculated) (mg/L)	1700	1750	1360	289	278
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	147	191	268	236	218
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	147	191	268	236	218
	Ammonia, Total (as N) (mg/L)	0.0260	0.0162	0.0150	0.0164	0.0050
	Chloride (Cl) (mg/L)	12.0	11.3	8.9	5.50	5.33
	Nitrate and Nitrite (as N) (mg/L)	0.086	0.065	0.075	0.0610	0.450
	Nitrate (as N) (mg/L)	<0.050 DLDS	<0.050 DLDS	<0.050 DLDS	<0.0050	0.317
	Nitrite (as N) (mg/L)	0.086	0.065	0.075	0.0610	0.133
	Sulfate (SO4) (mg/L)	1090	1090	786	39.3	43.7
	Anion Sum (meq/L)	26.0	26.8	22.0	5.69	5.45
	Cation Sum (meq/L)	25.6	27.7	21.7	5.88	5.57
	Cation - Anion Balance (%)	-0.7	1.6	-0.6	1.7	1.1
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0041	0.0045	0.0013	0.0027	0.0034
	Antimony (Sb)-Dissolved (mg/L)	0.00022	0.00026	0.00023	0.00016	0.00024
	Arsenic (As)-Dissolved (mg/L)	0.00059	0.00023	0.00025	<0.00010	0.00013
	Barium (Ba)-Dissolved (mg/L)	0.0423	0.138	0.0462	0.0648	0.0734
	Beryllium (Be)-Dissolved (mg/L)	<0.000040 DLA	<0.000040 DLA	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.00010 DLA	<0.00010 DLA	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.133	0.139	0.125	0.085	0.125
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010 DLA	<0.000010 DLA	<0.0000050	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	318	324	220	48.9	47.9
	Chromium (Cr)-Dissolved (mg/L)	0.00042	0.00026	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00020 DLA	<0.00020 DLA	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	0.00836	<0.00040 DLA	<0.00020	<0.00020	0.00360
	Iron (Fe)-Dissolved (mg/L)	0.046	0.025	0.031	0.032	<0.010
	Lead (Pb)-Dissolved (mg/L)	<0.00010 DLA	<0.00010 DLA	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0083	0.0061	0.0052	0.0033	0.0035
	Magnesium (Mg)-Dissolved (mg/L)	37.9	62.0	72.4	29.8	28.4
	Manganese (Mn)-Dissolved (mg/L)	0.137	0.897	2.24	0.552	0.134

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1874662-6	L1874662-7	L1874662-8	L1874662-9	
	Description	WATER	WATER	WATER	WATER	
	Sampled Date	23-DEC-16	23-DEC-16	24-DEC-16	23-DEC-16	
	Sampled Time	15:00	15:50	14:15		
	Client ID	MW12-05-06	MW12-05-07	MW11-04A	DUP	
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	516	483	550	503	
	Hardness (as CaCO3) (mg/L)	227	257	193	239	
	pH (pH)	7.98	7.76	11.46	7.88	
	Total Suspended Solids (mg/L)	<3.0	<3.0	552	<3.0	
	TDS (Calculated) (mg/L)	302	252	203	280	
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	266	212	<1.0	237	
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	177	<1.0	
	Alkalinity, Total (as CaCO3) (mg/L)	266	212	177	237	
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	0.0265	0.0164	
	Chloride (Cl) (mg/L)	5.23	5.06	DLDS <2.5	5.40	
	Nitrate and Nitrite (as N) (mg/L)	0.472	<0.0051	1.25	0.0781	
	Nitrate (as N) (mg/L)	0.433	<0.0050	1.24	<0.0050	
	Nitrite (as N) (mg/L)	0.0394	0.0021	0.0121	0.0781	
	Sulfate (SO4) (mg/L)	43.2	16.7	5.0	33.2	
	Anion Sum (meq/L)	6.39	4.72	3.73	5.59	
	Cation Sum (meq/L)	5.30	5.94	4.24	5.71	
	Cation - Anion Balance (%)	-9.4	11.5	6.5	1.1	
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Aluminum (Al)-Dissolved (mg/L)	0.0022	0.0028	0.809	0.0028	
	Antimony (Sb)-Dissolved (mg/L)	0.00014	0.00015	0.00081	0.00018	
	Arsenic (As)-Dissolved (mg/L)	0.00012	0.00028	0.00307	0.00012	
	Barium (Ba)-Dissolved (mg/L)	0.0642	0.822	0.247	0.0634	
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Boron (B)-Dissolved (mg/L)	0.043	0.034	<0.010	0.092	
	Cadmium (Cd)-Dissolved (mg/L)	0.0000122	<0.0000050	<0.0000050	<0.0000050	
	Calcium (Ca)-Dissolved (mg/L)	45.6	54.8	77.2	47.4	
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	0.00019	0.00241	<0.00010	
	Cobalt (Co)-Dissolved (mg/L)	0.00010	<0.00010	<0.00010	<0.00010	
	Copper (Cu)-Dissolved (mg/L)	0.00095	0.00021	0.0431	<0.00020	
	Iron (Fe)-Dissolved (mg/L)	<0.010	0.022	<0.010	0.048	
	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000095	<0.000050	<0.000050	
	Lithium (Li)-Dissolved (mg/L)	0.0031	0.0029	0.0181	0.0030	
	Magnesium (Mg)-Dissolved (mg/L)	27.4	29.2	<0.10	29.3	
	Manganese (Mn)-Dissolved (mg/L)	0.0672	0.662	0.00016	0.530	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1874662-1	L1874662-2	L1874662-3	L1874662-4	L1874662-5
	Sample ID	L1874662-1	L1874662-2	L1874662-3	L1874662-4	L1874662-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	23-DEC-16	23-DEC-16	23-DEC-16	23-DEC-16	23-DEC-16
	Sampled Time	11:15	11:35	13:30	13:45	14:45
	Client ID	MW12-05-01	MW12-05-02	MW12-05-03	MW12-05-04	MW12-05-05
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00031	0.00041	0.000430	0.00444	0.00379
	Nickel (Ni)-Dissolved (mg/L)	DLA <0.0010	DLA <0.0010	<0.00050	<0.00050	0.00068
	Phosphorus (P)-Dissolved (mg/L)	DLA <0.10	DLA <0.10	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	3.68	4.50	4.36	2.38	2.29
	Selenium (Se)-Dissolved (mg/L)	DLA <0.00010	DLA <0.00010	0.000057	<0.000050	0.000072
	Silicon (Si)-Dissolved (mg/L)	7.28	7.25	7.55	6.25	6.10
	Silver (Ag)-Dissolved (mg/L)	DLA <0.000020	DLA <0.000020	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	150	144	106	20.8	17.9
	Strontium (Sr)-Dissolved (mg/L)	8.32	10.8	7.76	0.912	0.734
	Sulfur (S)-Dissolved (mg/L)	388	400	268	12.4	14.6
	Thallium (Tl)-Dissolved (mg/L)	DLA <0.000020	DLA <0.000020	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	0.00051	DLA <0.00020	<0.00010	<0.00010	0.00012
	Titanium (Ti)-Dissolved (mg/L)	DLA <0.00060	DLA <0.00060	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.000944	0.000373	0.00155	0.00135	0.00250
	Vanadium (V)-Dissolved (mg/L)	DLA <0.0010	DLA <0.0010	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	DLA <0.0020	0.0261	0.0103	0.0069	0.118
	Zirconium (Zr)-Dissolved (mg/L)	DLA <0.00060	DLA <0.00060	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1874662-6	L1874662-7	L1874662-8	L1874662-9
	Description	WATER	WATER	WATER	WATER
	Sampled Date	23-DEC-16	23-DEC-16	24-DEC-16	23-DEC-16
	Sampled Time	15:00	15:50	14:15	
	Client ID	MW12-05-06	MW12-05-07	MW11-04A	DUP
Grouping	**Analyte**				
WATER					
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00339	0.00152	0.00250	0.00508
	Nickel (Ni)-Dissolved (mg/L)	0.00068	0.00051	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	0.061	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	2.16	2.11	4.21	2.25
	Selenium (Se)-Dissolved (mg/L)	0.000100	<0.000050	0.00261	<0.000050
	Silicon (Si)-Dissolved (mg/L)	5.92	6.65	5.25	6.35
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	16.3	16.7	4.34	19.8
	Strontium (Sr)-Dissolved (mg/L)	0.669	0.752	0.292	0.825
	Sulfur (S)-Dissolved (mg/L)	14.2	6.91	2.02	11.2
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.00247	0.00178	<0.000010	0.00137
	Vanadium (V)-Dissolved (mg/L)	<0.00050	0.00054	0.0139	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.115	0.0015	0.0016	0.0132
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Aluminum (Al)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Aluminum (Al)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Copper (Cu)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Copper (Cu)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Iron (Fe)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1874662-1, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-VA	Water	Nitrite & Nitrate in Water (Calculation)	EPA 300.0

Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Reference Information

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".
The Total Dissolved Solids result is calculated from measured concentrations of anions and cations in the sample.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-12-27A

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Whitehorse Receive

Short Holding Time

Rush Processing

alytical

378

L1874662-COFC

COC Number: 2016-12-27 A

Page of

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	
Company:	Minto Explorations Ltd.	Select Report Format:	☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report	☑ YES ☐ NO
Phone:	1-604-759-4659	☑ Compare Results to Criteria on Report - provide details below if box checked	
	Company address below will appear on the final report	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Street:	2100-510 West Georgia St.	Email 1 or Fax	minto_environment@mintomine.com
City/Province:	Vancouver, British Columbia	Email 2	
Postal Code:	V6B 0M3	Email 3	
Invoice To	Same as Report To ☐ YES ☑ NO	**Invoice Distribution**	
	Copy of Invoice with Report ☐ YES ☑ NO	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Company:	Minto Explorations Ltd.	Email 1 or Fax	ap@mintomine.com
Contact:	Ruth Cayetano	Email 2	

all E&P TATs with your AM - surcharges will apply	
Regular [R]	☑ Standard TAT if received by 3 pm - business days - no surcharges apply
PRIORITY (Business Days) 4 day [P4]	☐
3 day [P3]	☐
2 day [P2]	☐
EMERGENCY 1 Business day [E1]	☐
Same Day, Weekend or Statutory holiday [E0]	☐
Date and Time Required for all E&P TATs:	

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:	220404 (GW)	Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		**ALS Contact:**	**Sampler:** SR/SB

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions						Number of Containers
✓	MW12-05-01	23-Dec-16	11:15	Water		R		R	R		R						4
✓	MW12-05-02	23-Dec-16	11:35	Water		R		R	R		R						4
✓	MW12-05-03	23-Dec-16	13:30	Water		R		R	R		R						4
✓	MW12-05-04	23-Dec-16	13:45	Water		R		R	R		R						4
✓	MW12-05-05	23-Dec-16	14:45	Water		R		R	R		R						4
✓	MW12-05-06	23-Dec-16	15:00	Water		R		R	R		R						4
✓	MW12-05-07	23-Dec-16	15:50	Water		R		R	R		R						4
✓	MW11-04A	24-Dec-16	14:15	Water		R		R	R		R						4
	Dup	23-Dec-16		Water		R		R	R		R						4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐		SIF Observations	Yes ☐ No ☐
Ice Packs ☑	Ice Cubes ☐	Custody seal intact	Yes ☐ No ☒
Cooling Initiated ☑			

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
1.5			4	2	

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-12-27	Time: 8:00	Received by: BHF	Date: 28 Dec 2016	Time: 12:57	Received by: JC	Date: DEC 2 9 2016	Time: 1325

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 04-JAN-17
Report Date: 13-JAN-17 15:22 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1875871

Project P.O. #: 220404 (GW)
Job Reference:
C of C Numbers: 2016-12-30 A
Legal Site Desc:

Selam Worku
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1875871-1	L1875871-2			
	Description	Water	Water			
	Sampled Date	29-DEC-16	29-DEC-16			
	Sampled Time	15:00	16:15			
	Client ID	MW12-06-01	MW12-06-02			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	734	995			
	Hardness (as CaCO3) (mg/L)	285	468			
	pH (pH)	7.93	7.65			
	Total Suspended Solids (mg/L)	6.1	43.1			
	TDS (Calculated) (mg/L)	418	644			
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	382	362			
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0			
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0			
	Alkalinity, Total (as CaCO3) (mg/L)	382	362			
	Ammonia, Total (as N) (mg/L)	0.955	0.0303			
	Bromide (Br) (mg/L)	DLDS <0.25	DLDS <0.25			
	Chloride (Cl) (mg/L)	4.8	DLDS <2.5			
	Fluoride (F) (mg/L)	0.85	1.44			
	Nitrate (as N) (mg/L)	0.820	0.153			
	Nitrite (as N) (mg/L)	3.31	0.642			
	Sulfate (SO4) (mg/L)	4.3	209			
	Anion Sum (meq/L)	8.20	11.7			
	Cation Sum (meq/L)	8.35	11.4			
	Cation - Anion Balance (%)	0.9	-1.4			
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD			
	Dissolved Metals Filtration Location	FIELD	FIELD			
	Aluminum (Al)-Dissolved (mg/L)	0.0169	0.0023			
	Antimony (Sb)-Dissolved (mg/L)	0.00040	0.00027			
	Arsenic (As)-Dissolved (mg/L)	0.00759	0.00458			
	Barium (Ba)-Dissolved (mg/L)	0.255	0.0301			
	Beryllium (Be)-Dissolved (mg/L)	0.000116	0.000045			
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050			
	Boron (B)-Dissolved (mg/L)	0.898	0.787			
	Cadmium (Cd)-Dissolved (mg/L)	0.0000085	<0.0000050			
	Calcium (Ca)-Dissolved (mg/L)	83.4	131			
	Chromium (Cr)-Dissolved (mg/L)	0.00318	<0.00010			
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010			
	Copper (Cu)-Dissolved (mg/L)	0.00034	0.00049			
	Iron (Fe)-Dissolved (mg/L)	0.058	0.936			
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050			
	Lithium (Li)-Dissolved (mg/L)	0.0089	0.0082			
	Magnesium (Mg)-Dissolved (mg/L)	18.6	33.9			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1875871-1	L1875871-2			
	Description	Water	Water			
	Sampled Date	29-DEC-16	29-DEC-16			
	Sampled Time	15:00	16:15			
	Client ID	MW12-06-01	MW12-06-02			
Grouping	**Analyte**					
WATER						
Dissolved Metals	Manganese (Mn)-Dissolved (mg/L)	0.0872	0.0268			
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050			
	Molybdenum (Mo)-Dissolved (mg/L)	0.000867	0.00628			
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050			
	Phosphorus (P)-Dissolved (mg/L)	0.052	<0.050			
	Potassium (K)-Dissolved (mg/L)	2.54	3.49			
	Selenium (Se)-Dissolved (mg/L)	0.00189	0.00022			
	Silicon (Si)-Dissolved (mg/L)	7.67	10.2			
	Silver (Ag)-Dissolved (mg/L)	<0.000010	DLM <0.000020			
	Sodium (Na)-Dissolved (mg/L)	57.9	43.9			
	Strontium (Sr)-Dissolved (mg/L)	3.53	9.94			
	Sulfur (S)-Dissolved (mg/L)	11.1	69.0			
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010			
	Tin (Sn)-Dissolved (mg/L)	0.00030	<0.00010			
	Titanium (Ti)-Dissolved (mg/L)	0.00255	<0.00030			
	Uranium (U)-Dissolved (mg/L)	0.000808	0.00237			
	Vanadium (V)-Dissolved (mg/L)	0.0116	<0.00050			
	Zinc (Zn)-Dissolved (mg/L)	0.0027	0.0061			
	Zirconium (Zr)-Dissolved (mg/L)	0.00100	<0.00030			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Boron (B)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1875871-1, -2
Matrix Spike	Sulfate (SO4)	MS-B	L1875871-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions)

Reference Information

should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".
The Total Dissolved Solids result is calculated from measured concentrations of anions and cations in the sample.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	**Laboratory Location**
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-12-30 A

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Whitehorse Receive

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here (lab use only)

COC Number: 2016-12-30 A

Report To	(will appear on the final report)
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☑ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax minto_environment@mintomine.com
Email 2
Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax ap@mintomine.com
Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:
Job #:
PO / AFE: 220404 (GW)
LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#
Major/Minor Code: | Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only) | ALS Contact: | Sampler: CH/DP

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	MW12-06-01	29-Dec-16	15:00	Water		R		R	R		R	4
	MW12-06-02	29-Dec-16	16:15	Water		R		R	R		R	4

L1875871-COFC

Short Holding Time
Rush Processing

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO
Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C: 3.0
FINAL COOLER TEMPERATURES °C: 6 °C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Chris Harry	Date: 2016-12-30 9:00	Time:	Received by: EHF	Date: 30 Dec 2016	Time: 18:12	Received by: SF	Date: Jan 4	Time: 8°C

12:30pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 05-JAN-17
Report Date: 13-JAN-17 15:05 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1876396
Project P.O. #: 224161 (GW)
Job Reference:
C of C Numbers: 2017-01-04 B
Legal Site Desc:

Selam Worku
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1876396-1	L1876396-2	L1876396-3	L1876396-4	
	Description	WATER	WATER	WATER	WATER	
	Sampled Date	30-DEC-16	30-DEC-16	30-DEC-16	30-DEC-16	
	Sampled Time	11:15	11:45	14:00	14:40	
	Client ID	MW12-06-03	MW12-06-04	MW12-06-05	MW12-06-06	
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	1000	993	1000	853	
	Hardness (as CaCO3) (mg/L)	493	505	505	415	
	pH (pH)	7.77	7.76	7.73	7.75	
	Total Suspended Solids (mg/L)	5.5	3.7	6.1	<3.0	
	TDS (Calculated) (mg/L)	661	651	646	537	
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	389	418	418	327	
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	
	Alkalinity, Total (as CaCO3) (mg/L)	389	418	418	327	
	Ammonia, Total (as N) (mg/L)	0.0367	<0.0050	<0.0050	<0.0050	
	Chloride (Cl) (mg/L)	DLDS <2.5	DLDS <2.5	DLDS <2.5	5.8	
	Nitrate and Nitrite (as N) (mg/L)	1.34	2.78	1.26	1.22	
	Nitrate (as N) (mg/L)	0.269	0.552	0.255	1.13	
	Nitrite (as N) (mg/L)	1.07	2.23	1.00	0.0889	
	Sulfate (SO4) (mg/L)	214	179	185	159	
	Anion Sum (meq/L)	12.3	12.3	12.3	10.1	
	Cation Sum (meq/L)	11.8	12.1	11.8	9.84	
	Cation - Anion Balance (%)	-2.1	-0.7	-1.9	-1.3	
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Aluminum (Al)-Dissolved (mg/L)	0.0013	0.0019	0.0014	<0.0010	
	Antimony (Sb)-Dissolved (mg/L)	0.00039	0.00062	0.00028	0.00033	
	Arsenic (As)-Dissolved (mg/L)	0.00092	0.00329	0.00110	<0.00010	
	Barium (Ba)-Dissolved (mg/L)	0.0320	0.0196	0.0442	0.0154	
	Beryllium (Be)-Dissolved (mg/L)	0.000025	0.000030	<0.000020	<0.000020	
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Boron (B)-Dissolved (mg/L)	0.570	0.762	0.123	0.066	
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	0.0000070	0.0000130	
	Calcium (Ca)-Dissolved (mg/L)	110	106	106	81.4	
	Chromium (Cr)-Dissolved (mg/L)	0.00030	<0.00010	<0.00010	<0.00010	
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	0.00121	<0.00010	
	Copper (Cu)-Dissolved (mg/L)	<0.00020	0.00076	<0.00020	<0.00020	
	Iron (Fe)-Dissolved (mg/L)	1.17	0.708	0.162	<0.010	
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Lithium (Li)-Dissolved (mg/L)	0.0076	0.0064	0.0063	0.0048	
	Magnesium (Mg)-Dissolved (mg/L)	52.8	58.3	58.5	51.4	
	Manganese (Mn)-Dissolved (mg/L)	0.0199	0.0480	0.367	0.0388	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L1876396-1	L1876396-2	L1876396-3	L1876396-4	
		Description	WATER	WATER	WATER	WATER	
		Sampled Date	30-DEC-16	30-DEC-16	30-DEC-16	30-DEC-16	
		Sampled Time	11:15	11:45	14:00	14:40	
		Client ID	MW12-06-03	MW12-06-04	MW12-06-05	MW12-06-06	
Grouping	**Analyte**						
WATER							
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)		<0.0000050	<0.0000050	<0.0000050	<0.0000050	
	Molybdenum (Mo)-Dissolved (mg/L)		0.00201	0.00761	0.00833	0.00521	
	Nickel (Ni)-Dissolved (mg/L)		<0.00050	<0.00050	0.00059	<0.00050	
	Phosphorus (P)-Dissolved (mg/L)		<0.050	<0.050	<0.050	<0.050	
	Potassium (K)-Dissolved (mg/L)		4.13	4.04	4.05	3.74	
	Selenium (Se)-Dissolved (mg/L)		0.000447	0.00084	0.000183	0.000346	
	Silicon (Si)-Dissolved (mg/L)		9.66	9.13	8.68	7.29	
	Silver (Ag)-Dissolved (mg/L)		<0.000010	<0.000020 DLM	<0.000010	<0.000010	
	Sodium (Na)-Dissolved (mg/L)		41.3	43.0	37.6	33.4	
	Strontium (Sr)-Dissolved (mg/L)		4.22	2.85	2.61	1.47	
	Sulfur (S)-Dissolved (mg/L)		68.9	60.5	60.6	53.1	
	Thallium (Tl)-Dissolved (mg/L)		<0.000010	<0.000010	<0.000010	<0.000010	
	Tin (Sn)-Dissolved (mg/L)		0.00010	<0.00010	<0.00010	<0.00010	
	Titanium (Ti)-Dissolved (mg/L)		<0.00030	<0.00030	<0.00030	<0.00030	
	Uranium (U)-Dissolved (mg/L)		0.00212	0.00560	0.00577	0.00402	
	Vanadium (V)-Dissolved (mg/L)		<0.00050	<0.00050	<0.00050	<0.00050	
	Zinc (Zn)-Dissolved (mg/L)		0.0035	0.0266	0.0145	0.0208	
	Zirconium (Zr)-Dissolved (mg/L)		<0.00030	<0.00030	<0.00030	<0.00030	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Boron (B)-Dissolved	MS-B	L1876396-1, -2, -3, -4
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1876396-1, -2, -3, -4
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1876396-1, -2, -3, -4
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1876396-1, -2, -3, -4
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1876396-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1876396-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1876396-1, -2, -3, -4
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1876396-1, -2, -3, -4
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1876396-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-VA	Water	Nitrite & Nitrate in Water (Calculation)	EPA 300.0

Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Reference Information

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".
The Total Dissolved Solids result is calculated from measured concentrations of anions and cations in the sample.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2017-01-04 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Whitehorse Receive

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1876396-COFC

COC Number: 2017-01-04 B

Page 1 of 1

www.alsglobal.com

Report To	Contact and company name below will appear on the final report	**Report Format / Distribution**	
Company:	Minto Explorations Ltd.	Select Report Format:	☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report	☑ YES ☐ NO
Phone:	1-604-759-4659	☑ Compare Results to Criteria on Report - provide details below if box checked	
	Company address below will appear on the final report	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Street:	2100-510 West Georgia St.	Email 1 or Fax	minto_environment@mintomine.com
City/Province:	Vancouver, British Columbia	Email 2	
Postal Code:	V6B 0M3	Email 3	
Invoice To	Same as Report To ☐ YES ☑ NO	**Invoice Distribution**	
	Copy of Invoice with Report ☐ YES ☑ NO	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Company:	Minto Explorations Ltd.	Email 1 or Fax	ap@mintomine.com
Contact:	Ruth Cayetano	Email 2	

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): **4 day [P4]** ☐ **3 day [P3]** ☐ **2 day [P2]** ☐

EMERGENCY: **1 Business day [E1]** ☐ **Same Day, Weekend or Statutory holiday [E0]** ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information		**Oil and Gas Required Fields (client use)**	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:	220404 (GW)	Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		**ALS Contact:**	**Sampler:** CH / DP

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions							Number of Containers
	MW12-06-03	30-Dec-16	11:15	Water		R		R	R		R							4
	MW12-06-04	30-Dec-16	11:45	Water		R		R	R		R							4
	MW12-06-05	30-Dec-16	14:00	Water		R		R	R		R							4
	MW12-06-06	30-Dec-16	14:40	Water		R		R	R		R							4

Short Holding Time

Rush Processing

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
-3.0			5	2	

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Chris Harry	Date: 2017-01-04 8:00	Time:	Received by: VFD	Date: 4 JAN 2017	Time: 14:41	Received by: JC	Date: JAN - 5 2017	Time: 15:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

OCTOBER 2015 FRONT

Appendix E – Seepage Monitoring Program Laboratory Results

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 15-JUN-16
Report Date: 24-JUN-16 15:27 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1783503
Project P.O. #: TBD (Seepage)
Job Reference:
C of C Numbers: 2016-06-14 A
Legal Site Desc:

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1783503-1	L1783503-2	L1783503-3	L1783503-4	L1783503-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	08-JUN-16	12-JUN-15	12-JUN-16	12-JUN-16	12-JUN-16
	Sampled Time	14:05	13:55	14:20	14:30	14:40
	Client ID	SS32	W38	SS55	SS29	SS30
WATER						
Physical Tests	Conductivity (uS/cm)	199	1040	1330	1320	1140
	Hardness (as CaCO3) (mg/L)	103	547	696	689	627
	pH (pH)	7.90	8.16	7.79	7.81	8.18
	Total Suspended Solids (mg/L)	<3.0	<3.0	18.7	91.3	<3.0
	Total Dissolved Solids (mg/L)	110	699	957	945	765
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	100	273	266	269	367
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	100	273	266	269	367
	Ammonia, Total (as N) (mg/L)	<0.0050	0.0072	0.0053	0.0161	0.0056
	Chloride (Cl) (mg/L)	<0.50	6.3	3.2	3.4	3.7
	Nitrate and Nitrite (as N) (mg/L)	0.308	33.8	40.6	32.9	32.7
	Nitrate (as N) (mg/L)	0.308	33.8	40.6	32.9	32.7
	Nitrite (as N) (mg/L)	<0.0010	0.0055	0.0054	0.0109	0.0089
	Sulfate (SO4) (mg/L)	5.66	163	330	353	150
	Anion Sum (meq/L)	2.14	11.4	15.2	15.2	12.9
	Cation Sum (meq/L)	2.25	11.8	15.5	15.4	13.3
	Cation - Anion Balance (%)	2.6	1.5	1.0	0.7	1.5
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0023	0.0022	0.0066	0.0020	0.0024
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00014	0.00027	0.00019	0.00027	0.00022
	Barium (Ba)-Dissolved (mg/L)	0.0166	0.145	0.0794	0.0947	0.107
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	<0.010	0.020	0.033	0.047	0.023
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	0.0000426	0.0000091	<0.0000050	0.0000427
	Calcium (Ca)-Dissolved (mg/L)	32.7	156	196	192	189
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	0.00013	<0.00010	<0.00010	0.00014
	Copper (Cu)-Dissolved (mg/L)	0.00045	0.0574	0.00208	0.00397	0.0690
	Iron (Fe)-Dissolved (mg/L)	<0.010	0.027	<0.010	<0.010	0.029
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	<0.0010	0.0029	0.0031	0.0042	0.0029
	Magnesium (Mg)-Dissolved (mg/L)	5.23	38.0	50.1	51.1	37.8
	Manganese (Mn)-Dissolved (mg/L)	<0.00010	0.0811	0.00151	0.00323	0.370

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1783503-6	L1783503-7	L1783503-8	L1783503-9	L1783503-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	12-JUN-16	12-JUN-16	12-JUN-16	13-JUN-16	13-JUN-16
	Sampled Time	15:05	15:45	16:10	14:50	14:55
	Client ID	SS31	SS51	SS44	SS58	SS47
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	1030	1250	460	1290	1400
	Hardness (as CaCO3) (mg/L)	548	520	203	665	715
	pH (pH)	8.14	7.84	7.59	7.84	8.26
	Total Suspended Solids (mg/L)	<3.0	199	272	132	73.3
	Total Dissolved Solids (mg/L)	701	841	283	854	973
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	349	223	92.3	393	322
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	349	223	92.3	393	322
	Ammonia, Total (as N) (mg/L)	0.0597	0.160	0.224	0.250	0.376
	Chloride (Cl) (mg/L)	3.2	2.8	1.41	5.4	4.5
	Nitrate and Nitrite (as N) (mg/L)	0.383	30.5	0.991	54.8	87.9
	Nitrate (as N) (mg/L)	0.376	30.5	0.973	54.7	87.7
	Nitrite (as N) (mg/L)	0.0073	0.0475	0.0178	0.0818	0.259
	Sulfate (SO4) (mg/L)	248	358	131	106	111
	Anion Sum (meq/L)	12.3	14.2	4.68	14.1	15.1
	Cation Sum (meq/L)	12.6	11.6	4.90	14.8	15.7
	Cation - Anion Balance (%)	1.2	-10.1	2.4	2.3	1.8
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0079	0.0050	0.0215	0.0099	0.0111
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00066	0.00033	0.00025	0.00257	0.00218
	Barium (Ba)-Dissolved (mg/L)	0.171	0.120	0.0609	0.215	0.137
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.011	<0.010	<0.010	0.055	0.093
	Cadmium (Cd)-Dissolved (mg/L)	0.0000160	0.0000078	0.0000079	0.0000361	0.0000343
	Calcium (Ca)-Dissolved (mg/L)	163	140	51.2	171	168
	Chromium (Cr)-Dissolved (mg/L)	0.00011	<0.00010	<0.00010	0.00025	0.00021
	Cobalt (Co)-Dissolved (mg/L)	0.00054	<0.00010	0.00014	0.00262	0.00061
	Copper (Cu)-Dissolved (mg/L)	0.0219	0.00373	0.00421	0.102	0.110
	Iron (Fe)-Dissolved (mg/L)	0.143	0.013	0.038	4.73	0.076
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0040	0.0033	0.0018	0.0033	0.0050
	Magnesium (Mg)-Dissolved (mg/L)	34.1	41.6	18.2	57.8	71.6
	Manganese (Mn)-Dissolved (mg/L)	1.41	0.0189	0.332	1.32	0.566

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1783503-11	L1783503-12	L1783503-13	L1783503-14	L1783503-15
	Description	Water	Water	Water	Water	Water
	Sampled Date	13-JUN-16	13-JUN-16	13-JUN-16	13-JUN-16	13-JUN-16
	Sampled Time	15:05	15:30	15:40	16:10	
	Client ID	SS46	SS50	SS49	SS39	DUP
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	2780	2160	580	1040	1030
	Hardness (as CaCO3) (mg/L)	1310	1070	241	542	542
	pH (pH)	8.14	7.95	8.19	8.12	7.83
	Total Suspended Solids (mg/L)	32.7	22.7	4.0	<3.0	<3.0
	Total Dissolved Solids (mg/L)	2090	1710	366	691	696
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	261	133	116	284	281
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	261	133	116	284	281
	Ammonia, Total (as N) (mg/L)	0.0319	0.132	0.0343	0.0832	0.0815
	Chloride (Cl) (mg/L)	6.2	12.2	3.41	3.8	3.8
	Nitrate and Nitrite (as N) (mg/L)	290	136	16.5	32.1	32.9
	Nitrate (as N) (mg/L)	290	136	16.4	32.1	32.8
	Nitrite (as N) (mg/L)	0.356	0.247	0.104	0.0466	0.0457
	Sulfate (SO4) (mg/L)	144	572	108	160	164
	Anion Sum (meq/L)	29.1	24.6	5.82	11.4	11.5
	Cation Sum (meq/L)	29.1	24.6	6.00	11.8	11.9
	Cation - Anion Balance (%)	-0.1	0.0	1.5	1.9	1.6
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0141	0.0021	0.0025	0.0032	0.0057
	Antimony (Sb)-Dissolved (mg/L)	0.00012	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00085	0.00096	0.00041	0.00040	0.00037
	Barium (Ba)-Dissolved (mg/L)	0.205	0.0755	0.0689	0.164	0.162
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.027	0.214	0.129	0.027	0.026
	Cadmium (Cd)-Dissolved (mg/L)	0.0000335	0.0000437	0.0000085	0.0000423	0.0000517
	Calcium (Ca)-Dissolved (mg/L)	288	262	58.0	146	146
	Chromium (Cr)-Dissolved (mg/L)	0.00018	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00032	0.00032	<0.00010	0.00016	0.00017
	Copper (Cu)-Dissolved (mg/L)	0.142	0.0280	0.0180	0.0484	0.0483
	Iron (Fe)-Dissolved (mg/L)	0.024	<0.010	<0.010	0.041	0.038
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0046	0.0144	0.0062	0.0032	0.0030
	Magnesium (Mg)-Dissolved (mg/L)	144	102	23.3	43.1	42.9
	Manganese (Mn)-Dissolved (mg/L)	0.189	0.165	0.00356	0.299	0.298

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1783503-1	L1783503-2	L1783503-3	L1783503-4	L1783503-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	08-JUN-16	12-JUN-15	12-JUN-16	12-JUN-16	12-JUN-16
	Sampled Time	14:05	13:55	14:20	14:30	14:40
	Client ID	SS32	W38	SS55	SS29	SS30
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00296	0.00492	0.00775	0.00944	0.00413
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	0.00053	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	1.43	5.39	5.61	6.38	5.93
	Selenium (Se)-Dissolved (mg/L)	0.000120	0.0113	0.00699	0.0106	0.0135
	Silicon (Si)-Dissolved (mg/L)	6.46	6.41	5.91	5.18	7.71
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000012
	Sodium (Na)-Dissolved (mg/L)	3.48	16.9	32.8	33.4	13.7
	Strontium (Sr)-Dissolved (mg/L)	0.155	2.08	3.05	3.80	1.25
	Sulfur (S)-Dissolved (mg/L)	2.17	56.1	116	124	51.4
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.000377	0.00429	0.00387	0.00383	0.00702
	Vanadium (V)-Dissolved (mg/L)	0.00064	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	<0.0010	<0.0010	0.0022	<0.0010	0.0018
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1783503-6	L1783503-7	L1783503-8	L1783503-9	L1783503-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	12-JUN-16	12-JUN-16	12-JUN-16	13-JUN-16	13-JUN-16
	Sampled Time	15:05	15:45	16:10	14:50	14:55
	Client ID	SS31	SS51	SS44	SS58	SS47
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00516	0.00136	0.000432	0.0103	0.00707
	Nickel (Ni)-Dissolved (mg/L)	0.00088	<0.00050	<0.00050	0.00138	0.00117
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	0.083	<0.050	0.106
	Potassium (K)-Dissolved (mg/L)	11.6	8.00	5.23	6.55	9.18
	Selenium (Se)-Dissolved (mg/L)	0.00103	0.00211	0.00119	0.00492	0.00507
	Silicon (Si)-Dissolved (mg/L)	6.13	3.00	2.76	6.71	8.06
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	0.000021	0.000019
	Sodium (Na)-Dissolved (mg/L)	28.5	22.1	15.8	23.1	25.4
	Strontium (Sr)-Dissolved (mg/L)	0.860	2.15	0.388	2.19	3.84
	Sulfur (S)-Dissolved (mg/L)	84.4	99.0	46.4	38.9	39.0
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	0.00040	<0.00030	0.00032	0.00068	0.00100
	Uranium (U)-Dissolved (mg/L)	0.00157	0.000506	<0.000010	0.00692	0.00367
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	0.00097	0.00092
	Zinc (Zn)-Dissolved (mg/L)	0.0020	0.0016	0.0032	<0.0010	0.0052
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	0.00046	0.00035

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1783503-11	L1783503-12	L1783503-13	L1783503-14	L1783503-15
	Description	Water	Water	Water	Water	Water
	Sampled Date	13-JUN-16	13-JUN-16	13-JUN-16	13-JUN-16	13-JUN-16
	Sampled Time	15:05	15:30	15:40	16:10	
	Client ID	SS46	SS50	SS49	SS39	DUP
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.00613	0.0362	0.00957	0.00846	0.00820
	Nickel (Ni)-Dissolved (mg/L)	0.00205	<0.00050	<0.00050	0.00055	0.00057
	Phosphorus (P)-Dissolved (mg/L)	<0.050	0.058	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	16.7	16.1	8.80	5.16	5.20
	Selenium (Se)-Dissolved (mg/L)	0.00521	0.105	0.00404	0.0133	0.0135
	Silicon (Si)-Dissolved (mg/L)	4.56	4.22	0.243	5.75	5.76
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	55.9	62.7	22.2	19.9	19.9
	Strontium (Sr)-Dissolved (mg/L)	4.07	7.21	1.41	2.60	2.55
	Sulfur (S)-Dissolved (mg/L)	52.1	201	37.9	56.0	55.5
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	0.00102	<0.00030	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.00333	0.0100	0.00141	0.00574	0.00560
	Vanadium (V)-Dissolved (mg/L)	0.00071	0.00075	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0022	0.0014	<0.0010	0.0025	0.0020
	Zirconium (Zr)-Dissolved (mg/L)	0.00049	<0.00030	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Alkalinity, Total (as CaCO3)	B	L1783503-15
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Cadmium (Cd)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Chromium (Cr)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Cobalt (Co)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Copper (Cu)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Nickel (Ni)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Selenium (Se)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Silver (Ag)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Thallium (Tl)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Tin (Sn)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Titanium (Ti)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Vanadium (V)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Zinc (Zn)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Zirconium (Zr)-Dissolved	DLA	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Nitrate (as N)	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sulfate (SO4)	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1783503-1, -10, -11, -12, -13, -14, -15, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLA	Detection Limit adjusted for required dilution
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

Reference Information

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

Reference Information

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR	Water	Total Suspended Solids by Gravimetric	APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WR	ALS ENVIRONMENTAL - WHITEHORSE, YUKON, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-06-14 A

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1783503-COFC

COC Number: 2016-06-14 A

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☑ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax minto_environment@mintomine.com
Email 2
Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax ap@mintomine.com
Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐
EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:
Job #:
PO / AFE: TDB (Seepage)
LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#
Major/Minor Code: | Routing Code:
Requisitioner:
Location:

ALS Contact: | Sampler: SR/SC

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	SS32	8-Jun-16	14:05	Water		R		R	R		R	4
	W38	12-Jun-16	13:55	Water		R		R	R		R	4
	SS55	12-Jun-16	14:20	Water		R		R	R		R	4
	SS29	12-Jun-16	14:30	Water		R		R	R		R	4
	SS30	12-Jun-16	14:40	Water		R		R	R		R	4
	SS31	12-Jun-16	15:05	Water		R		R	R		R	4
	SS51	12-Jun-16	15:45	Water		R		R	R		R	4
	SS44	12-Jun-16	16:10	Water		R		R	R		R	4
	SS58	13-Jun-16	14:50	Water		R		R	R		R	4
	SS47	13-Jun-16	14:55	Water		R		R	R		R	4
	SS46	13-Jun-16	15:05	Water		R		R	R		R	4
	SS50	13-Jun-16	15:30	Water		R		R	R		R	4

Short Holding Time

Rush Processing

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO
Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C: 6.5 | 4.5
FINAL COOLER TEMPERATURES °C: 9 | 9 | 11 | 15

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-06-14	Time: 11:00	Received by:	Date: 15-Jun-16	Time: 8:45	Received by: Shelby	Date: June 16	Time: 1:30

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1783503-COFC

COC Number: 2016-06-14 A

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☑ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax minto_environment@mintomine.com
Email 2
Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax ap@mintomine.com
Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:
Job #:
PO / AFE: TDB (Seepage)
LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#
Major/Minor Code: Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only)
ALS Contact:
Sampler: SR/SC

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	SS49	13-Jun-16	15:40	Water		R		R	R		R	4
	SS39	13-Jun-16	16:10	Water		R		R	R		R	4
	Dup	13-Jun-16		Water		R		R	R		R	4

Short Holding Time
Rush Processing

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO
Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C: 6.5 4.5
FINAL COOLER TEMPERATURES °C: 9/9/11/16

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-06-14	Time: 11:00	Received by:	Date: 15-Jun-16	Time: 8:45	Received by: Shillay	Date: June 16	Time: 1:?

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY — OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 16-JUN-16
Report Date: 29-JUN-16 17:44 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1784698

Project P.O. #: 220824 (Seepage)
Job Reference:
C of C Numbers: 2016-06-16 B
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1784698-1				
	Description	Water				
	Sampled Date	15-JUN-16				
	Sampled Time	17:10				
	Client ID	SS33				
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	1760				
	Hardness (as CaCO3) (mg/L)	876				
	pH (pH)	7.90				
	Total Suspended Solids (mg/L)	92.0				
	Total Dissolved Solids (mg/L)	1280				
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	359				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Total (as CaCO3) (mg/L)	359				
	Ammonia, Total (as N) (mg/L)	0.117				
	Chloride (Cl) (mg/L)	12.6				
	Nitrate and Nitrite (as N) (mg/L)	83.5				
	Nitrate (as N) (mg/L)	82.6				
	Nitrite (as N) (mg/L)	0.997				
	Sulfate (SO4) (mg/L)	323				
	Anion Sum (meq/L)	20.2				
	Cation Sum (meq/L)	19.8				
	Cation - Anion Balance (%)	-1.0				
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD				
	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	0.0109				
	Antimony (Sb)-Dissolved (mg/L)	<0.00010				
	Arsenic (As)-Dissolved (mg/L)	0.00042				
	Barium (Ba)-Dissolved (mg/L)	0.119				
	Beryllium (Be)-Dissolved (mg/L)	<0.000020				
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050				
	Boron (B)-Dissolved (mg/L)	0.069				
	Cadmium (Cd)-Dissolved (mg/L)	0.000363				
	Calcium (Ca)-Dissolved (mg/L)	248				
	Chromium (Cr)-Dissolved (mg/L)	<0.00010				
	Cobalt (Co)-Dissolved (mg/L)	0.00031				
	Copper (Cu)-Dissolved (mg/L)	0.146				
	Iron (Fe)-Dissolved (mg/L)	0.019				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	0.0056				
	Magnesium (Mg)-Dissolved (mg/L)	62.5				
	Manganese (Mn)-Dissolved (mg/L)	0.627				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1784698-1				
	Description	Water				
	Sampled Date	15-JUN-16				
	Sampled Time	17:10				
	Client ID	SS33				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050				
	Molybdenum (Mo)-Dissolved (mg/L)	0.0114				
	Nickel (Ni)-Dissolved (mg/L)	0.00052				
	Phosphorus (P)-Dissolved (mg/L)	<0.050				
	Potassium (K)-Dissolved (mg/L)	7.51				
	Selenium (Se)-Dissolved (mg/L)	0.0328				
	Silicon (Si)-Dissolved (mg/L)	6.79				
	Silver (Ag)-Dissolved (mg/L)	0.000035				
	Sodium (Na)-Dissolved (mg/L)	47.3				
	Strontium (Sr)-Dissolved (mg/L)	5.74				
	Sulfur (S)-Dissolved (mg/L)	101				
	Thallium (Tl)-Dissolved (mg/L)	<0.000010				
	Tin (Sn)-Dissolved (mg/L)	<0.00010				
	Titanium (Ti)-Dissolved (mg/L)	0.00097				
	Uranium (U)-Dissolved (mg/L)	0.00711				
	Vanadium (V)-Dissolved (mg/L)	0.00082				
	Zinc (Zn)-Dissolved (mg/L)	0.0026				
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Alkalinity, Total (as CaCO3)	B	L1784698-1
Duplicate	Beryllium (Be)-Dissolved	DLA	L1784698-1
Duplicate	Aluminum (Al)-Dissolved	DLA	L1784698-1
Duplicate	Antimony (Sb)-Dissolved	DLA	L1784698-1
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1784698-1
Duplicate	Cadmium (Cd)-Dissolved	DLA	L1784698-1
Duplicate	Copper (Cu)-Dissolved	DLA	L1784698-1
Duplicate	Lead (Pb)-Dissolved	DLA	L1784698-1
Duplicate	Silver (Ag)-Dissolved	DLA	L1784698-1
Duplicate	Tin (Sn)-Dissolved	DLA	L1784698-1
Duplicate	Titanium (Ti)-Dissolved	DLA	L1784698-1
Duplicate	Vanadium (V)-Dissolved	DLA	L1784698-1
Duplicate	Zirconium (Zr)-Dissolved	DLA	L1784698-1
Duplicate	Beryllium (Be)-Dissolved	DLA	L1784698-1
Duplicate	Antimony (Sb)-Dissolved	DLA	L1784698-1
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1784698-1
Duplicate	Cadmium (Cd)-Dissolved	DLA	L1784698-1
Duplicate	Chromium (Cr)-Dissolved	DLA	L1784698-1
Duplicate	Lead (Pb)-Dissolved	DLA	L1784698-1
Duplicate	Selenium (Se)-Dissolved	DLA	L1784698-1
Duplicate	Silver (Ag)-Dissolved	DLA	L1784698-1
Duplicate	Thallium (Tl)-Dissolved	DLA	L1784698-1
Duplicate	Titanium (Ti)-Dissolved	DLA	L1784698-1
Duplicate	Vanadium (V)-Dissolved	DLA	L1784698-1
Duplicate	Zirconium (Zr)-Dissolved	DLA	L1784698-1
Duplicate	Beryllium (Be)-Dissolved	DLA	L1784698-1
Duplicate	Antimony (Sb)-Dissolved	DLA	L1784698-1
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1784698-1
Duplicate	Chromium (Cr)-Dissolved	DLA	L1784698-1
Duplicate	Silver (Ag)-Dissolved	DLA	L1784698-1
Duplicate	Tin (Sn)-Dissolved	DLA	L1784698-1
Duplicate	Titanium (Ti)-Dissolved	DLA	L1784698-1
Duplicate	Vanadium (V)-Dissolved	DLA	L1784698-1
Duplicate	Zirconium (Zr)-Dissolved	DLA	L1784698-1
Duplicate	Selenium (Se)-Dissolved	DLA	L1784698-1
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1784698-1
Duplicate	Chromium (Cr)-Dissolved	DLA	L1784698-1
Duplicate	Copper (Cu)-Dissolved	DLA	L1784698-1
Duplicate	Lead (Pb)-Dissolved	DLA	L1784698-1
Duplicate	Selenium (Se)-Dissolved	DLA	L1784698-1
Duplicate	Silver (Ag)-Dissolved	DLA	L1784698-1
Duplicate	Tin (Sn)-Dissolved	DLA	L1784698-1
Duplicate	Titanium (Ti)-Dissolved	DLA	L1784698-1
Duplicate	Vanadium (V)-Dissolved	DLA	L1784698-1
Duplicate	Zinc (Zn)-Dissolved	DLA	L1784698-1
Duplicate	Zirconium (Zr)-Dissolved	DLA	L1784698-1
Duplicate	Aluminum (Al)-Dissolved	DLA	L1784698-1
Duplicate	Selenium (Se)-Dissolved	DLA	L1784698-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1784698-1
Matrix Spike	Boron (B)-Dissolved	MS-B	L1784698-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1784698-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1784698-1

Reference Information

	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1784698-1
Matrix Spike	Sulfate (SO4)	MS-B	L1784698-1
Matrix Spike	Sulfate (SO4)	MS-B	L1784698-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1784698-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1784698-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1784698-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1784698-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1784698-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1784698-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1784698-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1784698-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1784698-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1784698-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1784698-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1784698-1
Matrix Spike	Arsenic (As)-Dissolved	MS-B	L1784698-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1784698-1
Matrix Spike	Cadmium (Cd)-Dissolved	MS-B	L1784698-1
Matrix Spike	Cobalt (Co)-Dissolved	MS-B	L1784698-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1784698-1
Matrix Spike	Nickel (Ni)-Dissolved	MS-B	L1784698-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1784698-1
Matrix Spike	Zinc (Zn)-Dissolved	MS-B	L1784698-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1784698-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1784698-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1784698-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLA	Detection Limit adjusted for required dilution
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Reference Information

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA Water Diss. Mercury in Water by CVAAS or CVAFS APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA Water Ion Balance Calculation APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA Water Dissolved Metals in Water by ICPOES EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA Water Dissolved Sulfur in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Reference Information

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR	Water	Total Suspended Solids by Gravimetric	APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WR	ALS ENVIRONMENTAL - WHITEHORSE, YUKON, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-06-16 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1784698-COFC

COC Number: 2016-06-16 B

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☑ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax minto_environment@mintomine.com
Email 2
Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax ap@mintomine.com
Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:
Job #:
PO / AFE: ~~TBD~~ (Seepage) → 220824
LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#
Major/Minor Code: Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only)

ALS Contact:

Sampler: CH

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	SS33	15-Jun-16	17:10	Water		R		R	R		R	4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human drinking water use?
☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C: 9.0
FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Chris Harry	Date: 2016-06-16 9:30	Time:	Received by:	Date: 16-JUN-16	Time: 3:40	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 20-JUN-16
Report Date: 30-JUN-16 18:26 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1785996

Project P.O. #: 220824 (Seepage)
Job Reference:
C of C Numbers: 2016-06-20 B
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1785996-1	L1785996-2	L1785996-3		
	Description	Water	Water	Water		
	Sampled Date	16-JUN-16	16-JUN-16	16-JUN-16		
	Sampled Time	13:15	13:40	13:45		
	Client ID	SS7	SS8	SS59		
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	1710	1760	1800		
	Hardness (as CaCO3) (mg/L)	908	935	950		
	pH (pH)	7.85	7.77	7.77		
	Total Suspended Solids (mg/L)	240	485	16.7		
	Total Dissolved Solids (mg/L)	1230	1290	1310		
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	344	346	369		
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0		
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0		
	Alkalinity, Total (as CaCO3) (mg/L)	344	346	369		
	Ammonia, Total (as N) (mg/L)	0.0299	0.0146	0.233		
	Chloride (Cl) (mg/L)	11.8	12.0	11.5		
	Nitrate and Nitrite (as N) (mg/L)	76.7	81.9	79.4		
	Nitrate (as N) (mg/L)	76.3	81.6	78.2		
	Nitrite (as N) (mg/L)	0.440	0.400	1.19		
	Sulfate (SO4) (mg/L)	293	314	328		
	Anion Sum (meq/L)	18.8	19.6	20.2		
	Cation Sum (meq/L)	20.4	21.0	21.4		
	Cation - Anion Balance (%)	4.1	3.3	2.9		
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD		
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD		
	Aluminum (Al)-Dissolved (mg/L)	0.0039	0.0035	0.0024		
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010		
	Arsenic (As)-Dissolved (mg/L)	0.00043	0.00027	0.00035		
	Barium (Ba)-Dissolved (mg/L)	0.0481	0.0434	0.119		
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020		
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Dissolved (mg/L)	0.068	0.071	0.068		
	Cadmium (Cd)-Dissolved (mg/L)	0.0000452	0.0000202	0.000533		
	Calcium (Ca)-Dissolved (mg/L)	258	281	270		
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010		
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	0.00030		
	Copper (Cu)-Dissolved (mg/L)	0.0914	0.0738	0.105		
	Iron (Fe)-Dissolved (mg/L)	<0.010	<0.010	<0.010		
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050		
	Lithium (Li)-Dissolved (mg/L)	0.0059	0.0070	0.0058		
	Magnesium (Mg)-Dissolved (mg/L)	64.3	56.3	66.7		
	Manganese (Mn)-Dissolved (mg/L)	0.154	0.0407	0.765		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1785996-1	L1785996-2	L1785996-3
	Description	Water	Water	Water
	Sampled Date	16-JUN-16	16-JUN-16	16-JUN-16
	Sampled Time	13:15	13:40	13:45
	Client ID	SS7	SS8	SS59
Grouping	**Analyte**			
WATER				
Dissolved Metals	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.0100	0.00468	0.0114
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	7.61	6.92	7.92
	Selenium (Se)-Dissolved (mg/L)	0.0304	0.0283	0.0324
	Silicon (Si)-Dissolved (mg/L)	7.00	7.67	6.91
	Silver (Ag)-Dissolved (mg/L)	0.000052	0.000054	0.000050
	Sodium (Na)-Dissolved (mg/L)	47.3	48.8	49.5
	Strontium (Sr)-Dissolved (mg/L)	5.66	2.78	5.95
	Sulfur (S)-Dissolved (mg/L)	101	105	110
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	0.00034	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.00751	0.00889	0.00731
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	0.00077
	Zinc (Zn)-Dissolved (mg/L)	0.0019	0.0017	0.0028
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Sulfate (SO4)	MS-B	L1785996-1, -2, -3

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Reference Information

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-MAN-WR	Water	Total Suspended Solids by Gravimetric	APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WR	ALS ENVIRONMENTAL - WHITEHORSE, YUKON, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-06-20 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1785996-COFC

COC Number: 2016-06-20 B

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	
Company:	Minto Explorations Ltd.	Select Report Format:	☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report	☑ YES ☐ NO
Phone:	1-604-759-4659	☑ Compare Results to Criteria on Report - provide details below if box checked	
Company address below will appear on the final report		Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Street:	2100-510 West Georgia St.	Email 1 or Fax	minto_environment@mintomine.com
City/Province:	Vancouver, British Columbia	Email 2	
Postal Code:	V6B 0M3	Email 3	
Invoice To	Same as Report To ☐ YES ☑ NO	Invoice Distribution	
	Copy of Invoice with Report ☐ YES ☑ NO	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Company:	Minto Explorations Ltd.	Email 1 or Fax	ap@mintomine.com
Contact:	Ruth Cayetano	Email 2	
Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO#
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:	220824 (Seepage)	Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact:	Sampler: CH/CB/SC

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)		EMERGENCY	
4 day [P4]	☐	1 Business day [E1]	☐
3 day [P3]	☐	Same Day, Weekend or Statutory holiday [E0]	☐
2 day [P2]	☐		

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Total Mercury, Hardness (P)	Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)	Dissolved Organic Carbon (DOC) (F/P)	pH, Cond., TSS, TDS, Alkalinity, Anions							Number of Containers
	SS7	16-Jun-16	13:15	Water		R		R	R		R							4
	SS8	16-Jun-16	13:40	Water		R		R	R		R							4
	SS59	16-Jun-16	13:45	Water		R		R	R		R							4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
4.5	0.1		5,4,8	8,4,5	10°c

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Chris Harry	Date: 2016-06-20 9:00	Time:	Received by:	Date: 20 JUN-16	Time: 2:15	Received by: JC	Date: 21 JUN	Time: 13:25

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION   WHITE - LABORATORY COPY   YELLOW - CLIENT COPY   OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 12-SEP-16
Report Date: 23-SEP-16 17:16 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1827082
Project P.O. #: 220824
Job Reference:
C of C Numbers: 2016-09-12 A
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1827082-1	L1827082-2	L1827082-3		
	Description	WATER	WATER	WATER		
	Sampled Date	10-SEP-16	11-SEP-16	11-SEP-16		
	Sampled Time	16:30	13:57	15:20		
	Client ID	SS32	W39	W38		
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	194	960	1010		
	Hardness (as CaCO3) (mg/L)	101	519	558		
	pH (pH)	7.72	8.01	8.07		
	Total Suspended Solids (mg/L)	<3.0	4.0	21.3		
	TDS (Calculated) (mg/L)	111	670	657		
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	103	241	379		
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0		
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0		
	Alkalinity, Total (as CaCO3) (mg/L)	103	241	379		
	Ammonia, Total (as N) (mg/L)	<0.0050	0.0201	0.0051		
	Chloride (Cl) (mg/L)	<0.50	5.49	40.2		
	Nitrate and Nitrite (as N) (mg/L)	0.316	33.2	14.1		
	Nitrate (as N) (mg/L)	0.316	33.2	14.1		
	Nitrite (as N) (mg/L)	<0.0010	0.0472	<0.0010		
	Sulfate (SO4) (mg/L)	5.74	166	106		
	Anion Sum (meq/L)	2.20	10.8	11.9		
	Cation Sum (meq/L)	2.21	11.2	11.8		
	Cation - Anion Balance (%)	0.4	1.9	-0.4		
Total Metals	Aluminum (Al)-Total (mg/L)	<0.0030	0.0322	0.451		
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Arsenic (As)-Total (mg/L)	0.00013	0.00024	0.00044		
	Barium (Ba)-Total (mg/L)	0.0173	0.129	0.207		
	Beryllium (Be)-Total (mg/L)	<0.000020	<0.000020	0.000023		
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Total (mg/L)	<0.010	0.023	<0.010		
	Cadmium (Cd)-Total (mg/L)	0.0000061	0.0000390	0.0000476		
	Calcium (Ca)-Total (mg/L)	32.1	150	173		
	Chromium (Cr)-Total (mg/L)	<0.00010	0.00013	0.00022		
	Cobalt (Co)-Total (mg/L)	<0.00010	0.00017	0.00029		
	Copper (Cu)-Total (mg/L)	0.00063	0.0340	0.105		
	Iron (Fe)-Total (mg/L)	<0.010	0.129	0.612		
	Lead (Pb)-Total (mg/L)	<0.000050	<0.000050	0.000263		
	Lithium (Li)-Total (mg/L)	<0.0010	0.0016	0.0031		
	Magnesium (Mg)-Total (mg/L)	5.20	32.9	31.9		
	Manganese (Mn)-Total (mg/L)	0.00012	0.0876	0.0336		
	Mercury (Hg)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050		
	Molybdenum (Mo)-Total (mg/L)	0.00307	0.00439	0.00183		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1827082-1	L1827082-2	L1827082-3		
	Description	WATER	WATER	WATER		
	Sampled Date	10-SEP-16	11-SEP-16	11-SEP-16		
	Sampled Time	16:30	13:57	15:20		
	Client ID	SS32	W39	W38		
Grouping	**Analyte**					
WATER						
Total Metals	Nickel (Ni)-Total (mg/L)	<0.00050	0.00053	0.00060		
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050		
	Potassium (K)-Total (mg/L)	1.33	5.21	5.01		
	Selenium (Se)-Total (mg/L)	0.000138	0.00891	0.00188		
	Silicon (Si)-Total (mg/L)	6.42	6.23	9.33		
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	0.000019		
	Sodium (Na)-Total (mg/L)	3.71	16.5	13.3		
	Strontium (Sr)-Total (mg/L)	0.162	2.03	1.22		
	Sulfur (S)-Total (mg/L)	2.00	55.9	36.2		
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	<0.00030	0.00131	0.0205		
	Uranium (U)-Total (mg/L)	0.000390	0.00359	0.00411		
	Vanadium (V)-Total (mg/L)	0.00069	<0.00050	0.00174		
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	0.0039		
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030		
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD		
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD		
	Aluminum (Al)-Dissolved (mg/L)	0.0023	0.0022	0.0078		
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010		
	Arsenic (As)-Dissolved (mg/L)	0.00012	0.00021	0.00034		
	Barium (Ba)-Dissolved (mg/L)	0.0178	0.126	0.195		
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020		
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050		
	Boron (B)-Dissolved (mg/L)	<0.010	0.022	<0.010		
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	0.0000248	0.0000396		
	Calcium (Ca)-Dissolved (mg/L)	31.9	153	173		
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010		
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	0.00011	<0.00010		
	Copper (Cu)-Dissolved (mg/L)	0.00058	0.0230	0.0631		
	Iron (Fe)-Dissolved (mg/L)	<0.010	0.024	<0.010		
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050		
	Lithium (Li)-Dissolved (mg/L)	<0.0010	0.0018	0.0029		
	Magnesium (Mg)-Dissolved (mg/L)	5.24	33.3	30.7		
	Manganese (Mn)-Dissolved (mg/L)	<0.00010	0.0692	0.00861		
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050		
	Molybdenum (Mo)-Dissolved (mg/L)	0.00285	0.00465	0.00171		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1827082-1	L1827082-2	L1827082-3		
	Description	WATER	WATER	WATER		
	Sampled Date	10-SEP-16	11-SEP-16	11-SEP-16		
	Sampled Time	16:30	13:57	15:20		
	Client ID	SS32	W39	W38		
Grouping	**Analyte**					
WATER						
Dissolved Metals	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050		
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050		
	Potassium (K)-Dissolved (mg/L)	1.28	5.00	4.36		
	Selenium (Se)-Dissolved (mg/L)	0.000131	0.00997	0.00229		
	Silicon (Si)-Dissolved (mg/L)	6.48	6.11	8.38		
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010		
	Sodium (Na)-Dissolved (mg/L)	3.69	16.2	13.1		
	Strontium (Sr)-Dissolved (mg/L)	0.157	1.98	1.16		
	Sulfur (S)-Dissolved (mg/L)	2.11	56.3	34.9		
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010		
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	0.00042		
	Uranium (U)-Dissolved (mg/L)	0.000367	0.00357	0.00384		
	Vanadium (V)-Dissolved (mg/L)	0.00066	<0.00050	<0.00050		
	Zinc (Zn)-Dissolved (mg/L)	<0.0010	<0.0010	0.0019		
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
WSMD	Water sample(s) for dissolved mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
WSMT	Water sample(s) for total mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1827082-1, -2, -3
Matrix Spike	Sulfate (SO4)	MS-B	L1827082-1, -2, -3

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-WR	Water	Nitrite & Nitrate Nitrogen	EPA 300.1

Nitrate and Nitrite Nitrogen is determined by calculation from the individual Nitrate and Nitrite Nitrogen analyses by Ion Chromatography with UV absorbance.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

BE-T-L-CCMS-VA	Water	Total Be (Low) in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Reference Information

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

HG-T-CVAA-VA Water Total Mercury in Water by CVAAS or CVAFS EPA 1631E (mod)

Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA Water Ion Balance Calculation APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA Water Dissolved Metals in Water by ICPOES EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA Water Total Metals in Water by CRC ICPMS EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-TOT-LOW-ICP-VA Water Total Metals in Water by ICPOES EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA Water Dissolved Sulfur in Water by ICPOES EPA SW-846 3005A/6010B

Reference Information

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

S-TOT-ICP-VA	Water	Total Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-WR	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".
The Total Dissolved Solids result is calculated from measured concentrations of anions and cations in the sample.

TSS-MAN-WR	Water	Total Suspended Solids by Gravimetric	APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WR	ALS ENVIRONMENTAL - WHITEHORSE, YUKON, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-09-12 A

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1827082-COFC

COC Number: 2016-09-12 A

Page of

Report To	Contact and company name below will appear on the final report	Report Format / Distribution	
Company:	Minto Explorations Ltd.	Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)	
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report ☑ YES ☐ NO	
Phone:	1-604-759-4659	☑ Compare Results to Criteria on Report - provide details below if box checked	
	Company address below will appear on the final report	Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Street:	2100-510 West Georgia St.	Email 1 or Fax	minto_environment@mintomine.com
City/Province:	Vancouver, British Columbia	Email 2	
Postal Code:	V6B 0M3	Email 3	
Invoice To	Same as Report To ☐ YES ☑ NO	Invoice Distribution	
	Copy of Invoice with Report ☐ YES ☑ NO	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:	Minto Explorations Ltd.	Email 1 or Fax	ap@mintomine.com
Contact:	Ruth Cayetano	Email 2	

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)		EMERGENCY	
4 day [P4]	☐	1 Business day [E1]	☐
3 day [P3]	☐	Same Day, Weekend or Statutory holiday [E0]	☐
2 day [P2]	☐		

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information		Oil and Gas Required Fields (client use)	
ALS Account # / Quote #:		AFE/Cost Center:	PO# 220824
Job #:		Major/Minor Code:	Routing Code:
PO / AFE:	220824 (Seepage)	Requisitioner:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact: Ariel McDonnell	Sampler: CP/CB

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Disolved Metals (DM) (F/P)	Ammonia (Total Nutrients) (P)	pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	SS32	10-Sep-16	16:30	Water	R	R	R	R	4
	W39	11-Sep-16	13:57	Water	R	R	R	R	4
	W38	11-Sep-16	1520	Water	R	R	R	R	4
				Water					
				Water					
				Water					
				Water					
				Water					
				Water					
				Water					
				Water					
				Water					

Short Holding Time

Rush Processing

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☑ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 6.9°C

FINAL COOLER TEMPERATURES °C: 5°C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Colin Prentice	Date: 2016-09-12	Time:	Received by: [signature]	Date: Sept-12-16	Time: 12:30PM	Received by: HMC	Date: SEP 13 2016	Time: 10:55

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

OCTOBER 2015 FRONT

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 15-SEP-16
Report Date: 27-SEP-16 16:23 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1829558

Project P.O. #: 220824 (seepage)
Job Reference:
C of C Numbers: 2016-09-13 B
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1829558-1	L1829558-2	L1829558-3	L1829558-4
	Sample ID	L1829558-1	L1829558-2	L1829558-3	L1829558-4
	Description	Water	Water	Water	Water
	Sampled Date	12-SEP-16	12-SEP-16	12-SEP-16	12-SEP-16
	Sampled Time	11:59	12:30	12:18	12:11
	Client ID	SS7	SS8	SS33	SS6
Grouping	**Analyte**				
WATER					
Physical Tests	Conductivity (uS/cm)	1780	1860	1600	1720
	Hardness (as CaCO3) (mg/L)	946	956	851	896
	pH (pH)	8.14	7.81	8.16	8.11
	Total Suspended Solids (mg/L)	<3.0	214	<3.0	12.1
	TDS (Calculated) (mg/L)	1410	1450	1200	1330
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	305	285	344	295
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	305	285	344	295
	Ammonia, Total (as N) (mg/L)	0.0515	0.159	0.0695	<0.0050
	Chloride (Cl) (mg/L)	12.7	11.7	13.8	13.0
	Nitrate and Nitrite (as N) (mg/L)	82.3	89.1	61.8	77.1
	Nitrate (as N) (mg/L)	82.1	88.6	61.6	77.1
	Nitrite (as N) (mg/L)	0.225	0.511	0.191	<0.010 DLDS
	Sulfate (SO4) (mg/L)	454	475	352	427
	Anion Sum (meq/L)	21.8	22.3	19.0	20.6
	Cation Sum (meq/L)	21.4	21.7	19.3	20.3
	Cation - Anion Balance (%)	-0.9	-1.4	0.8	-0.9
Total Metals	Aluminum (Al)-Total (mg/L)	0.0042	1.64	0.0041	0.0517
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00040	0.00079	0.00044	0.00038
	Barium (Ba)-Total (mg/L)	0.0481	0.0637	0.132	0.0607
	Beryllium (Be)-Total (mg/L)	<0.000020	0.000056	<0.000020	<0.000020
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.075	0.074	0.075	0.070
	Cadmium (Cd)-Total (mg/L)	0.0000529	0.0000570	0.000367	0.0000577
	Calcium (Ca)-Total (mg/L)	283	289	243	262
	Chromium (Cr)-Total (mg/L)	<0.00010	0.00058	<0.00010	<0.00010
	Cobalt (Co)-Total (mg/L)	<0.00010	0.00071	0.00025	<0.00010
	Copper (Cu)-Total (mg/L)	0.0652	0.240	0.193	0.115
	Iron (Fe)-Total (mg/L)	<0.010	1.80	0.021	0.078
	Lead (Pb)-Total (mg/L)	<0.000050	0.000555	<0.000050	0.000071
	Lithium (Li)-Total (mg/L)	0.0066	0.0077	0.0052	0.0067
	Magnesium (Mg)-Total (mg/L)	66.5	65.8	59.2	62.4
	Manganese (Mn)-Total (mg/L)	0.118	0.270	0.429	0.00681
	Molybdenum (Mo)-Total (mg/L)	0.00654	0.00458	0.0112	0.00657
	Nickel (Ni)-Total (mg/L)	<0.00050	0.00080	0.00069	<0.00050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1829558-1	L1829558-2	L1829558-3	L1829558-4	
	Description	Water	Water	Water	Water	
	Sampled Date	12-SEP-16	12-SEP-16	12-SEP-16	12-SEP-16	
	Sampled Time	11:59	12:30	12:18	12:11	
	Client ID	SS7	SS8	SS33	SS6	
Grouping	**Analyte**					
WATER						
Total Metals	Phosphorus (P)-Total (mg/L)	<0.050	0.054	<0.050	<0.050	
	Potassium (K)-Total (mg/L)	7.59	7.65	7.03	7.11	
	Selenium (Se)-Total (mg/L)	0.0587	0.0637	0.0455	0.0536	
	Silicon (Si)-Total (mg/L)	7.21	9.51	6.65	6.91	
	Silver (Ag)-Total (mg/L)	0.000036	0.000111	0.000047	0.000032	
	Sodium (Na)-Total (mg/L)	52.1	51.3	46.0	46.0	
	Strontium (Sr)-Total (mg/L)	5.07	4.43	5.93	4.60	
	Sulfur (S)-Total (mg/L)	152	158	123	141	
	Thallium (Tl)-Total (mg/L)	<0.000010	0.000013	<0.000010	<0.000010	
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Titanium (Ti)-Total (mg/L)	<0.00030	0.0940	<0.00030	0.00299	
	Uranium (U)-Total (mg/L)	0.00824	0.00925	0.00664	0.00949	
	Vanadium (V)-Total (mg/L)	<0.00050	0.00558	0.00081	0.00094	
	Zinc (Zn)-Total (mg/L)	<0.0030	0.0103	0.0033	<0.0030	
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Aluminum (Al)-Dissolved (mg/L)	0.0012	0.0013	0.0021	0.0012	
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Arsenic (As)-Dissolved (mg/L)	0.00036	0.00038	0.00040	0.00033	
	Barium (Ba)-Dissolved (mg/L)	0.0498	0.0436	0.137	0.0652	
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Boron (B)-Dissolved (mg/L)	0.072	0.069	0.070	0.065	
	Cadmium (Cd)-Dissolved (mg/L)	0.0000457	0.0000340	0.000387	0.0000522	
	Calcium (Ca)-Dissolved (mg/L)	270	276	241	257	
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	0.00025	<0.00010	
	Copper (Cu)-Dissolved (mg/L)	0.0634	0.0812	0.194	0.104	
	Iron (Fe)-Dissolved (mg/L)	<0.010	<0.010	0.013	<0.010	
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Lithium (Li)-Dissolved (mg/L)	0.0064	0.0067	0.0049	0.0064	
	Magnesium (Mg)-Dissolved (mg/L)	66.2	64.5	60.7	61.8	
	Manganese (Mn)-Dissolved (mg/L)	0.116	0.216	0.439	0.00359	
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	
	Molybdenum (Mo)-Dissolved (mg/L)	0.00611	0.00447	0.0103	0.00622	
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	0.00069	<0.00050	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1829558-1	L1829558-2	L1829558-3	L1829558-4
	Description	Water	Water	Water	Water
	Sampled Date	12-SEP-16	12-SEP-16	12-SEP-16	12-SEP-16
	Sampled Time	11:59	12:30	12:18	12:11
	Client ID	SS7	SS8	SS33	SS6
Grouping	**Analyte**				
WATER					
Dissolved Metals	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	7.19	6.96	7.03	6.92
	Selenium (Se)-Dissolved (mg/L)	0.0617	0.0589	0.0498	0.0565
	Silicon (Si)-Dissolved (mg/L)	6.86	6.96	6.49	6.71
	Silver (Ag)-Dissolved (mg/L)	0.000031	0.000029	0.000030	0.000029
	Sodium (Na)-Dissolved (mg/L)	52.5	54.4	47.9	50.4
	Strontium (Sr)-Dissolved (mg/L)	5.04	4.34	5.77	4.54
	Sulfur (S)-Dissolved (mg/L)	142	149	121	132
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.00793	0.00884	0.00630	0.00913
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	0.00065	0.00064
	Zinc (Zn)-Dissolved (mg/L)	0.0021	0.0025	0.0035	0.0018
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Alkalinity, Total (as CaCO3)	B	L1829558-1, -2, -3, -4
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Boron (B)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Barium (Ba)-Total	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Manganese (Mn)-Total	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Total	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Total	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Silicon (Si)-Total	MS-B	L1829558-1, -2, -3, -4
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1829558-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-N+N-CALC-VA	Water	Nitrite & Nitrate in Water (Calculation)	EPA 300.0

Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

BE-T-L-CCMS-VA	Water	Total Be (Low) in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

Reference Information

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA | Water | Hardness | APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA | Water | Diss. Mercury in Water by CVAAS or CVAFS | APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

IONBALANCE-VA | Water | Ion Balance Calculation | APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

MET-D-CCMS-VA | Water | Dissolved Metals in Water by CRC ICPMS | APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-LOW-ICP-VA | Water | Dissolved Metals in Water by ICPOES | EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-TOT-LOW-ICP-VA | Water | Total Metals in Water by ICPOES | EPA 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA | Water | Ammonia in Water by Fluorescence | APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA | Water | Ammonia in Water by Fluorescence | J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA | Water | Nitrite in Water by IC (Low Level) | EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA | Water | Nitrate in Water by IC (Low Level) | EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA | Water | pH by Meter (Automated) | APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA | Water | pH by Meter (Automated) | APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

Reference Information

It is recommended that this analysis be conducted in the field.

S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

S-TOT-ICP-VA	Water	Total Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA	Water	TDS (Calculated)	APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".
The Total Dissolved Solids result is calculated from measured concentrations of anions and cations in the sample.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

2016-09-13 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1829558-COFC

COC Number: 2016-09-13 B

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☑ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax minto_environment@mintomine.com
Email 2
Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax ap@mintomine.com
Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐
EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:
Job #:
PO / AFE: 220824 (Seepage)
LSD:

ALS Lab Work Order # (lab use only) 558

Oil and Gas Required Fields (client use)

AFE/Cost Center:	PO# 220824
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Contact: Ariel McDonnell Sampler: CP

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals(TM) (P)	Dissolved Metals (DM) (F/P)		Dissolved Mercury (F/P)	Ammonia (Total Nutrients) (P)		pH, Cond., TSS, TDS, Alkalinity, Anions	Number of Containers
	SS7	12-Sep-16	11:59	Water	R	R		R	R		R	5
	SS8	12-Sep-16	12:30	Water	R	R		R	R		R	5
	SS33	12-Sep-16	12:18	Water	R	R		R	R		R	5
	SS6	12-Sep-16	12:11	Water	R	R		R	R		R	5

Short Holding Time
Rush Processing

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO
Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
3.0	2.0	5.0	4	4	3

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Colin Prentice	Date: 2016-09-13	Time:	Received by: EHF	Date: 14-Sep-2016	Time: 13:19	Received by: JC	Date: SEP 15 2016	Time: 12:45

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Appendix F – 2016 Water Balance and Water Quality Model Summary for the Minto Mine

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Memo

To:	Deborah Flemming, Ryan Herbert	**Client:**	Minto Explorations Ltd.
From:	Soren Jensen, Kaitlyn Kooy	**Project No:**	1CM002.024
Cc:	Dylan MacGregor (SRK)	**Date:**	March 28, 2017
Subject:	2016 Water Balance and Water Quality Model Summary for the Minto Mine Site		

1 Introduction and Background

This memorandum provides a summary of the 2016 water balance and water quality model updates for the Minto Mine site. The update covers the period January 1, 2016 through December 31, 2016.

The water balance update includes a review and summary of precipitation, flow and water inventory data for the Mine site. The water quality update includes a comparison of water quality data collected in 2016 to updated water quality model predictions for Phase V/VI of the Mine development. Updated water quality predictions for the Main Pit Tailings Management Facility (MPTMF) and the Water Storage Pond (WSP) are provided for the 2018 and for the post-closure period when predicted concentrations are the same from year to year (steady state concentrations).

2 Water Balance Update

2.1 Precipitation

Table 1 shows a summary of monthly precipitation measured at the Mine site between October 2015 and December 2016 along with precipitation data from the regional station at Carmacks, YT (Climate ID: 2100301)[1], which is located 77 km Southwest of the Minto Mine. In the past, the meteorological station at Pelly Ranch (Climate ID 2100880)[1] located 25 km north of Minto was used as a regional reference station. However, the published data record from Pelly Ranch ends in March 2015 so the Carmacks Station was used instead.

Approximately 242 mm of precipitation was collected at the Mine site in the 2016 hydrological year, which was nearly identical to the annual precipitation of 243 mm measured in 2015. A 242 mm annual total precipitation roughly corresponds to a 1 in 15 dry year.

[1] Pelly Ranch Data: obtained from Meteorological Service of Canada, Environment Canada.

Table 1: Precipitation Records for the Minto Mine Site and Pelly Ranch

		Campbell Scientific Station (Minto Mine)		
Year	**Month**	**Tipping Bucket Gauge**	**Geonor Gauge[A]**	**Carmacks Ranch[B] (Climate ID 2100301)**
		mm/month	mm/month	mm/month
2015	Oct	14.7	27.7	n/a
2015	Nov	14.3	7.1	n/a
2015	Dec	9.5	11.5	n/a
2016	Jan	9.1	11.7	7.5
2016	Feb	6.9	7.8	12.2
2016	Mar	2.6	3.3	5.0
2016	Apr	14.7	14.7	13.1
2016	May	39.3	31.5	28.5
2016	Jun	30.2	22.2	17.1
2016	Jul	74.7	68.2	94.9
2016	Aug	46.0	35.9	26.1
2016	Sept	18.5	17.8	9.6
2016	Oct	6.7	9.8	8.4
2016	Nov	24.2	13.6	14.4
2016	Dec	7.4	14.1	17.5
SUM Hydrological Year, Nov. 2015 to Oct. 2016		273	242	256

Source: Minto Site Data: X:\01_SITES\Minto\1CM002.024_Water_Balance_Support\2015_Water_Balance_Update\Minto Water Balance\2016 Met Station Data Summary.xlsx

Notes:

A: Tipping bucket measurement used for month of November.
B: Data obtained from Meteorological Service of Canada, Environment Canada.
n/a: Not available at time of publication.

Minto's Campbell Scientific meteorological station measures total precipitation using a Geonor and a tipping bucket rain gauge. From October through May, the tipping bucket is equipped with a snowfall conversion adaptor, which allows it to measure snowfall as snow water equivalent. The Geonor precipitation gauge collects precipitation in a bucket and records precipitation by measuring the weight of the bucket. In the winter months, the bucket is partially filled with an antifreeze solution that melts any snow collected. Figure 1 shows monthly precipitation recorded by the two gauges as well as total precipitation recorded at Carmacks.

The total annual precipitation measured by the two gauges at Minto differ by 12%. Both gauges at Minto are within 6% of the total precipitation measured at Carmacks on an annual basis. The precipitation measured by the Geonor gauge at Minto was considered more reliable than the tipping bucket gauge and was therefore used for the hydrological analysis.

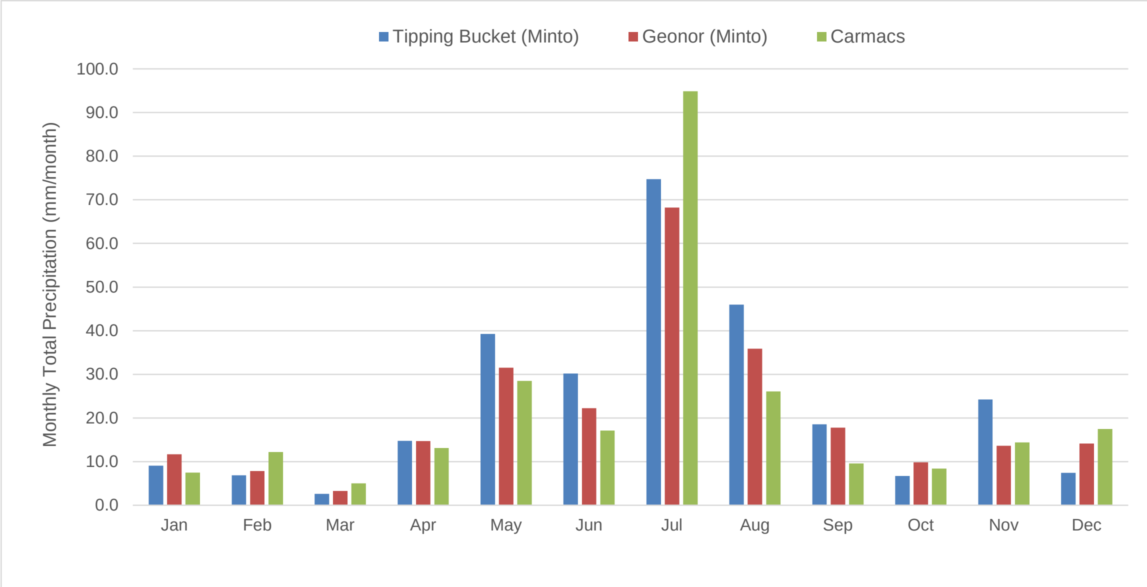

Figure 1: 2015 Monthly Total Precipitation Measurements at Minto and at Carmacks in 2016

2.2 Snow Course Data

Snow course surveys were completed at the three established snow survey stations at the Mine site in 2016. Table 2 shows a summary of the snow survey data (i.e. an average of the results from the three stations) from 2009 to 2016. The depth and water equivalent of the snow pack provides an indication of the volume of surface runoff that must be managed the following freshet. In April and May 2016, approximately 260,000 m^3 of surface runoff was collected from catchments at the Mine site upstream of the Water Storage Dam. This volume corresponds to roughly 25 mm of runoff, which was slightly greater than the estimated 22 mm of runoff observed in 2015.

Table 2: Summary of Snow Survey Data for the Minto Mine Site

Year	February			March			April		
	Snow Depth (cm)	Snow Density (%)	Water Equivalent (mm)	Snow Depth (cm)	Snow Density (%)	Water Equivalent (mm)	Snow Depth (cm)	Snow Density (%)	Water Equivalent (mm)
2009	55.6	16.6	92.7	70.2	15.7	110.0	67.4	22.3	150.7
2010	60.5	17.8	107.7	58.1	20.7	120.7	40.4	[A]13.9	56.0
2011	57.2	18.7	106.0	70.3	20.1	141.7	52.3	22.8	111.7
2012	54.7	20.3	111.0	64.6	19.6	127.0	61.3	21.5	132.7
2013	58.7	15.7	91.3	45.8	25.0	106.0	33.7	15.4	62.7
2014	44.3	19.0	84.3	45.8	22.3	99.7	41.0	25.7	67.3
2015	44.3	20.7	90.3	25.3	29.0	76.6	30.0	23	67.8
2016	40.7	19.0	80.3	42.3	23.0	80.7	15.5	n/a	n/a

Source: X:\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016_Water_Balance_Update\MintoSnowMaster_2016.xlsx

Notes:

n/a – not available.
A: zero snow at #3, density is an average of snowpack at #1 and #2, average depth and water-equivalent is average of all three sites.

2.3 Water Management

Water that is suitable for release into Minto Creek is conveyed to the Water Storage Pond (WSP), while water collected from active mine areas is routed to the Main Pit Tailings Management Facility (MPTMF) or the Area 2 Pit Tailings Management Facility (A2PTMF). Since November 2012, the MPTMF has also been used for subaqueous deposition of tailings. Deposition of mine water and tailings (subaqueous) to the A2PTMF commenced in April 2015.

Other water management features on the Mine site include:

- W15 sump: collects surface runoff and seepage from:
  - The Southwest Waste Dump;
  - Part of the Main Waste Dump; and
  - Adjacent undisturbed catchments.

  In 2016, water collected at W15 was routed to the Main Pit TMF in early spring (March and most of April). Between April 27 and October 3, water from W15 was routed to the WSP. Approximately 50% of the catchment that report to W15 is covered by waste rock. Therefore, it is notable that water quality parameter concentrations are low enough that the water is suitable for discharge to Quarry Creek.

- W35a sump: collects surface runoff from the minimally disturbed southern catchments. Water collected at W35a in 2016 was piped to the Mai Pit in early April. From April 14 to October 3 the water was conveyed to the WSP. The remainder of the year the W35 water was routed to the Main Pit.

- W62 sump (formerly known as W36 or W37 sump): collects surface runoff and seepage from the mill valley, including contributions from the Dry Stack Tailings Storage Facility. Water collected at the W62 sump is pumped to the MPTMF.
- South Diversion Ditch: diverts water from minimally disturbed southern catchments to the WSP (can also be routed to the MPTMF).
- WSP: reservoir for water that meets discharge criteria and is destined for discharge to Minto Creek.

2.4 2016 Water Balance

Table 3 summarizes the monthly water and tailings inventory in Minto's MPTMF and A2PTMF as well as water inventory in the WSP. In 2016, the water inventory in the MPTMF was reduced by approximately 180,000 m^3, while the water inventory in A2PTMF increased by roughly 530,000 m^3. The increase in water inventory in the A2PTMF roughly corresponds to the volume of pore water in the sub-aqueously deposited tailings in 2016. The WSP water inventory was reduced by about 15,000 m^3 between January 1 and December 31, 2016.

Table 4 shows a summary of the 2016 water balance for the Mine site. The total surface runoff collected on site was estimated to be 590,000 m^3 based on the change in the water inventory and the known volume of water released to Minto Creek. Including an estimated inflow of 30,000 m^3 of groundwater, the total site-wide yield was estimated at about 620,000 m^3 for the year. The total catchment upstream of the Water Storage Dam measures approximately 1,040 ha. Therefore, 620,000 m^3 of runoff from 1,040 ha gives a unit yield of approximately 60 mm/year.

The water and load balance model used for forecasting surface runoff volumes uses a site-wide annual average runoff coefficient, which has been derived based on previous years' water balance results. The runoff coefficient is estimated based on the total annual precipitation as follows:

- For dry years with less than 190 mm total precipitation: runoff coefficient = 0.15.
- For average to wet years with more than 309 mm total precipitation: runoff coefficient = 0.30.
- Runoff coefficients for years with total precipitation between 190 mm and 309 mm: interpolated values between 0.15 and 0.30.

In 2016 (hydraulic year) the estimated total precipitation was 242 mm (Table 1), which corresponds to a modelled runoff coefficient of 0.22. The 2015 site-wide runoff coefficient, based on the 2015 water balance (measured flows, water inventory and total precipitation), is:

$$\textit{Annual Yield/ Total Annual Precipitation} = \textit{Runoff Coefficient} \rightarrow \quad 60\ mm/243\ mm = \mathbf{0.25}$$

The calculated value for the annual site-wide runoff coefficient is slightly higher but close to the interpolated coefficient of 0.22. Overall, the agreement with site-wide runoff coefficients used for evaluating water management options is good and the model results can be expected to yield reliable estimates of the volume of water that must be managed on site on an annual basis.

Table 3: 2015 Water Inventory and Release to Minto Creek

Month/	MPTMF Volume Occupied (Water + Tailings)[A]	Change in MPTMF Water Inventory	Tailings Solids Deposition in MPTMF	A2PTMF Volume Occupied (Water + Tailings)[A]	Change in A2PTMF Water Inventory	Tailings Solids Deposition in A2PTMF	WSP Volume[A]	Change in WSP Water Inventory
Year	m^3	m^3/month	BCM/month	m^3	m^3/month	BCM/month	m^3	m^3/month
Jan-16	4,108,000	-81,000	0	1,024,000	83,000	45,000	82,000	-3,000
Feb-16	4,027,000	-175,000	0	1,152,000	147,000	38,000	79,000	-2,000
Mar-16	3,852,000	-211,000	0	1,337,000	160,000	47,000	77,000	10,000
Apr-16	3,641,000	90,000	0	1,544,000	42,000	44,000	87,000	18,000
May-16	3,731,000	-29,000	0	1,629,000	23,000	49,000	105,000	55,000
Jun-16	3,702,000	28,000	0	1,702,000	-5,000	41,000	160,000	18,000
Jul-16	3,730,000	-28,000	0	1,737,000	52,000	45,000	177,000	23,000
Aug-16	3,702,000	-44,000	0	1,835,000	54,000	47,000	200,000	7,000
Sep-16	3,658,000	90,000	0	1,936,000	13,000	44,000	207,000	-85,000
Oct-16	3,749,000	67,000	0	1,993,000	-4,000	45,000	122,000	-48,000
Nov-16	3,815,000	63,000	0	2,034,000	-18,000	42,000	74,000	-3,000
Dec-16	3,878,000	46,000	0	2,058,000	-18,000	37,000	70,000	-4,000
Jan-17	3,924,000			2,077,000			67,000	
SUM		**-183,000**	**-**		**529,000**	**524,000**		**-15,000**

Source: X:\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016_Water_Balance_Update\2016 Water Balance Update REV00 KNK.xlsx

Notes:

A – on the first day of the month.

Table 4: Water Balance Summary of the Minto Mine Site, 2016 (Jan to Dec)

	Units	Main Pit TMF	Area 2 Pit TMF	WSP
Volume Change 2016 (water + tailings)	m^3	-183,000	1,053,000	-15,000
Tailings Deposited, total	BCM	-	524,000	-
Water Volume Change 2016	m^3	-183,000	529,000	-15,000
Estimated Groundwater Inflow	m^3	-	30,000	-
Total Water Inventory Increase in 2016	**m^3**	364,000		
Total Water Discharged to Minto Creek	m^3	254,000		
Total Site-Wide Yield in 2016	**m^3**	**617,000**		

Source: X:\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016_Water_Balance_Update\2016 Water Balance Update REV00 KNK.xlsx

3 Water Quality Model Update

3.1 Solid Phase Geochemistry

The neutralization potential ratio (NPR) and copper content of waste rock and tailings were reviewed in order to identify any new trends in the solid phase geochemistry that may have developed since the last source term update. Significant changes in the solid phase geochemistry would indicate a need for further analysis of the waste rock and tailings to generate new source terms that reflect the observed changes in the geochemistry.

The NPR and copper content of waste rock and tailings are shown in Figure 2 to Figure 5. No significant changes in geochemistry were observed in the properties of the materials produced in 2016 compared to similar materials produced in prior years. Therefore, no further evaluation of 2016 solid phase geochemistry was warranted.

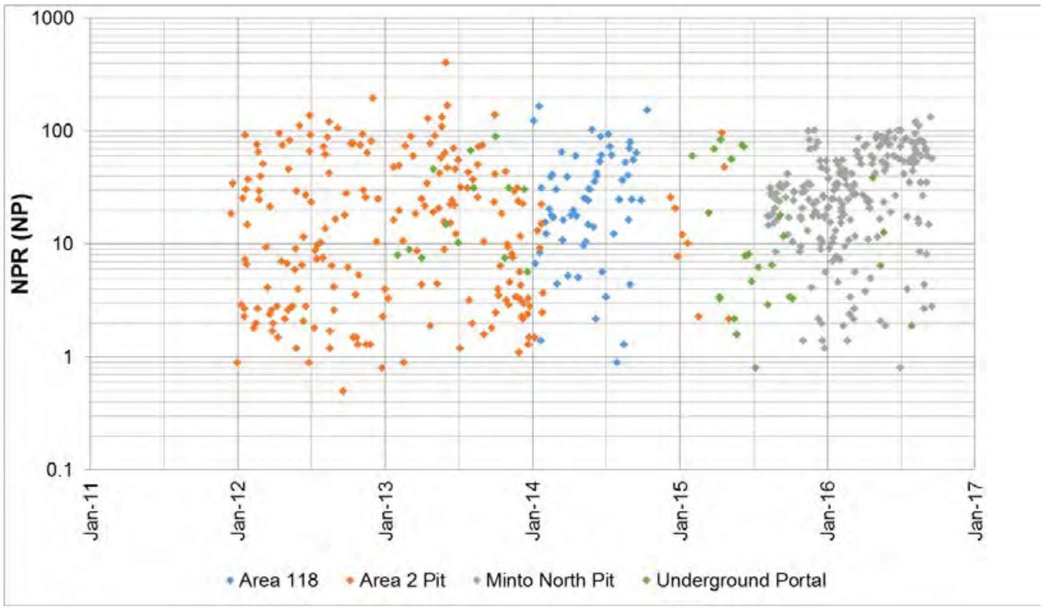

Figure 2: Waste Rock Neutralization Potential Ratio over Time

Z:\01_SITES\Minto\1CM002.024_Water_Balance_Support\!080_Deliverables\2016_Water_Bal_for_An_Rep\Figures\ABACharts_Cu_NPR_20160323_1CM002.024_REV00_KNK

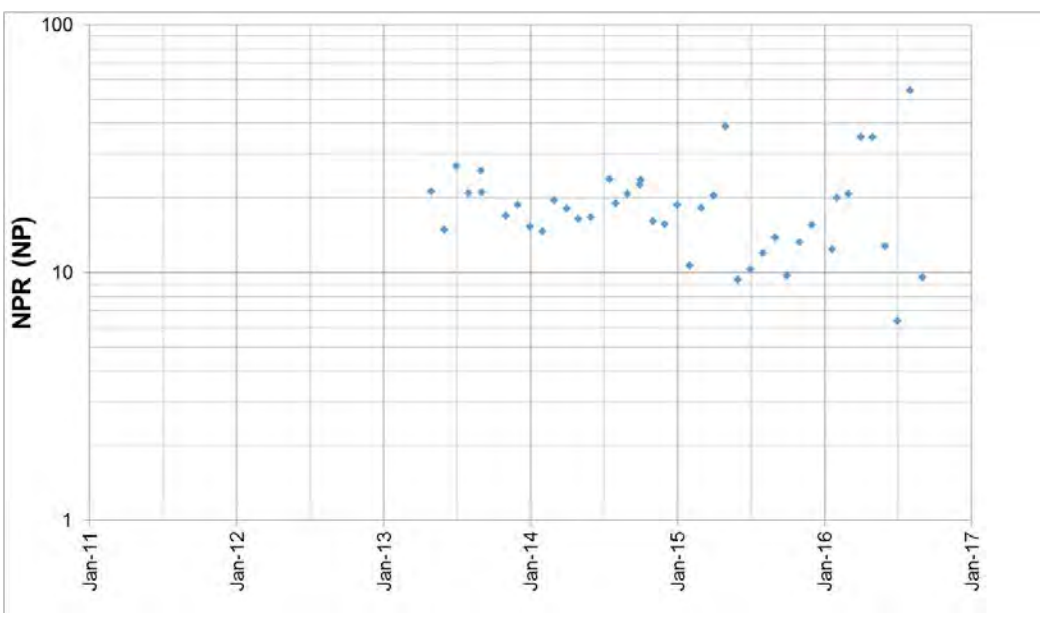

Figure 3: Tailings Neutralization Potential Ratio over Time

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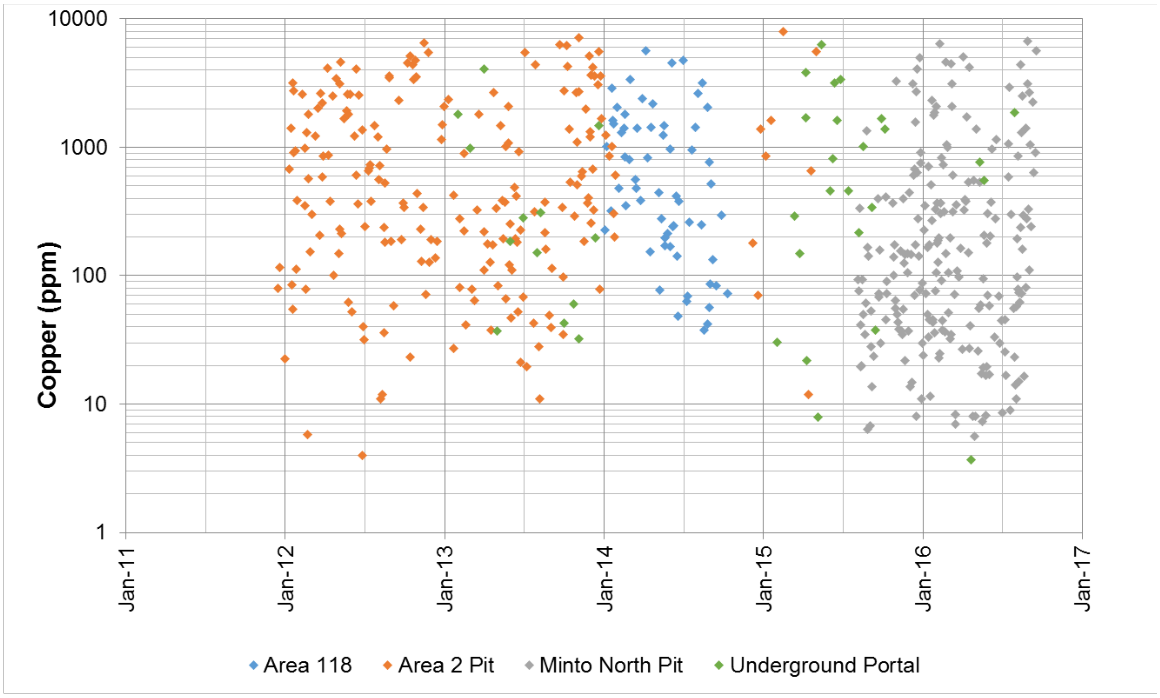

Figure 4: Waste Rock Copper Concentration over Time

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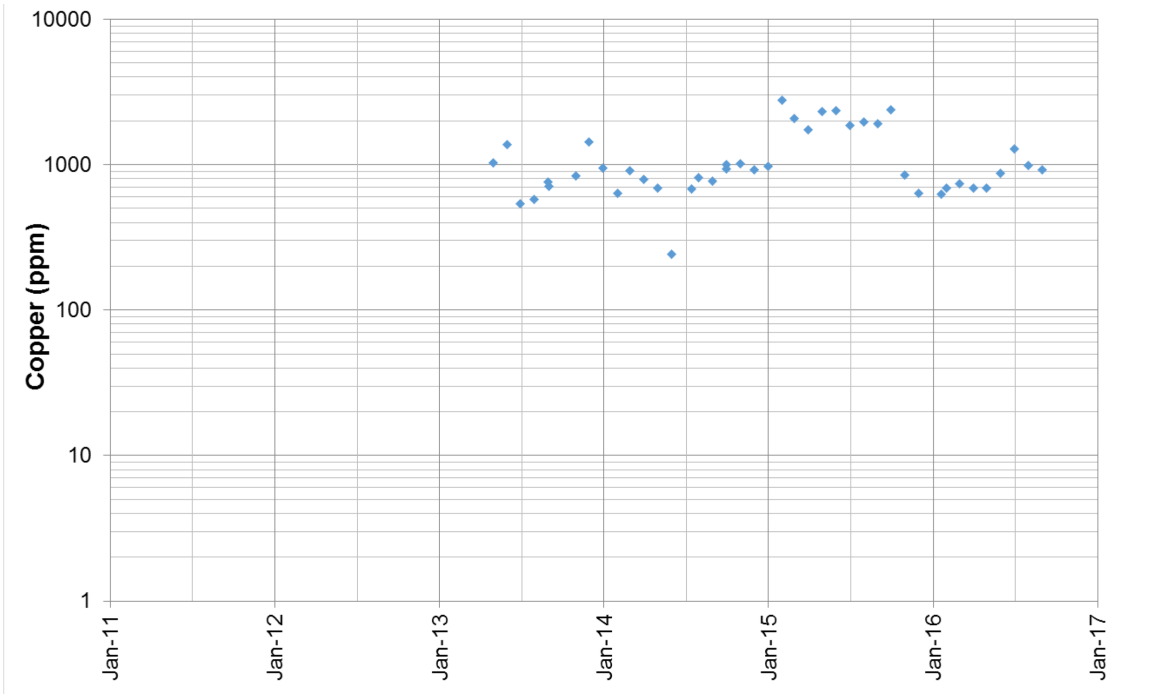

Figure 5: Tailings copper concentration over time

Z:\01_SITES\Minto\1CM002.024_Water_Balance_Support\!080_Deliverables\2016_Water_Bal_for_An_Rep\Figures\ABACharts_Cu_NPR_20160323_1CM002.024_REV00_KNK

3.2 Comparison of Measured Water Quality Data to Source Terms

3.2.1 Source Terms – Dry Stack Tailings Storage Facility

The Dry Stack Tailings Storage Facility (DSTSF) source terms used in the 2013 water and load balance model were developed based on the observed water chemistry at station W8. This station was chosen because it had the highest concentrations of copper, cadmium, selenium, and sulphate during the period of record available in 2013. The following points describe the source terms:

- Best Estimate source term: 50th percentile dissolved concentrations from W8 until 2013;
- Reasonable Worst Case source term: 95th percentile dissolved concentrations from W8 until 2013.

The Best Estimate and Reasonable Worst Case source terms were updated to include data to 2016 for comparison to the existing source terms. It was found that the updated source terms differed only marginally from the source terms used historically. Therefore, for consistency the 2013 DSTSF source terms will be used in the 2016 Updated Water Balance and Water Quality Model.

3.2.2 Source Terms – Waste Rock

The Main Waste Dump and the Southwest Waste Dump source terms used in the 2015 water and load balance model were defined based on the observed water chemistry at station W15, which collects runoff from the Southwest Waste Dump. Similar to the DSTSF source terms, the Best Estimate waste rock source term was the 50th percentile dissolved concentrations at W15 until 2015 and the Reasonable Worst Case waste rock source term was the 95th percentile dissolved concentrations from W15 until 2015.

The Best Estimate and Reasonable Worst Case source terms were updated to include data collected in 2016. Similar to the DSTSF source terms, the updated waste rock source terms differed only marginally from the source terms used historically. The 2015 waste rock source terms were therefore deemed acceptable and will be used in the 2016 Updated Water Balance and Water Quality Model for consistency.

3.2.3 Source Term – Tailings Slurry

A review of the mill influent water quality (reclaim water from the MPTMF, W12) and mill effluent water quality (Mill Thickener, W14) revealed that in 2015 and 2016 the processing of ore contributed greater loadings than in previous years. In light of this, the tailings slurry source term for the 2016 Updated Water Balance and Water Quality Model was updated as follows:

- Best Estimate source term: 50th percentile dissolved concentrations from W14 from 2015 and 2016 data only;
- Reasonable Worst Case source term: 95th percentile dissolved concentrations from W14 from 2015 and 2016 data only

However, the adjusted source terms for tailings slurry were not able to account for the greater-than-expected increase in parameter concentrations in the MPTMF. Similarly, adjustment of the waste rock source terms within limits of observed seepage concentrations were also not able to explain the concentration changes. One possible explanation for the additional observed load is that it is flushed from pit walls and waste rock as it is submerged by the rising water in the A2PTMF. This “first flush” effect is commonly observed and is caused by the buildup of weathering products as waste rock is exposed to the atmosphere for a period of time before becoming inundated. Once the A2PTMF has filled to capacity, this term is expected to become negligible. Ongoing monitoring and updates of the load balance will reveal whether flushing is indeed responsible for the additional loadings or if some other loading source not related to seepage or runoff characterized to date is the cause.

3.3 Water Quality Model Results

Table 6 and 7 show revised model outputs from the calibrated model of water quality in the Water Storage Pond (WSP) for 2016, 2018, and post-closure (best estimate and worst case) along with concentrations measured in 2016. Table 8 and 9 show revised model predictions of water quality in the MPTMF for 2016, 2018 and post-closure. Predictions for 2018 and post-closure were selected to provide representative short-term and long-term indications of water quality trends. Predictions are for average precipitation conditions. The Water Use Licence (QZ14-031) effluent limits are also listed in the tables. Model runs started on 1 January 2016 and ended on 1 January 2045, at which point concentrations in the model roughly have reached steady state.

The MPTMF was historically the primary water reservoir on site. In the model, the free water in the MPTMF and A2PTMF are more or less considered to belong to the same reservoir due to the high rate of flow between the two reservoirs. Reclaim water is drawn from the MPTMF and excess free water in the A2PTMF is pumped back to the MPTMF.

Therefore, a comparison of measured MPTMF water quality with concentrations predicted for pit water for the Phase V/VI environmental assessment provides a good measure of actual vs. expected geochemical performance of the site. Water collected in the WSP includes clean (non-contact) runoff and effluent from Minto’s water treatment plant.

Median measured concentrations in the WSP in 2016 are comparable to the revised model predictions using best estimate source terms (Table 6). The favorable agreement indicates that the revised source terms are appropriate for describing the existing geochemical performance and the actual water management practices on site. Best estimate source terms are intended to provide an indication of the general trend in water quality parameter concentrations, but are not intended to capture maximum or outlier concentration values. Therefore, the median values of best estimate model predictions are compared to measured median values.

Revised model predictions using reasonable worst case source terms are generally higher than comparable median and maximum measured values for the WSP (Table 7).

Revised model predictions for water quality in the MPTMF (and by extension the A2PTMF) using the best estimate source terms are in good agreement with median measured concentrations in 2016 (Table 8) when the additional “first flush” load is included in the model. Water quality model predictions using reasonable worst case source terms are generally higher than measured median and maximum concentrations, with the exception of dissolved copper. Median and maximum measured dissolved copper concentrations were both marginally higher than the concentrations predicted by the reasonable worst case source terms. The increase in dissolved copper concentration is not dramatic and may be caused by the flushing of rock that accompanied the inundation of the A2PTMF and related underground workings when deposition of tailings slurry was initiated. The source of the additional copper loadings (or increased copper solubility) will be evaluated based on water quality monitoring results in 2017.

Table 5: WSP Water Quality Model Predictions and Measured Concentrations in 2016, Best Estimate

Year		WUL Effluent Limits (QZ14-031)	WSP Measured Water Quality (Station W16) 2016	Modelling Predictions of Quality in WSP (Station W16) 2016	2018	Post-Closure
			Median	**Median**	**Median**	**Median**
Ammonia	mg/L	0.75	0.04	0.069	0.057	0.19
N-NO_2	mg/L	0.18	0.033	0.034	0.022	0.053
N-NO_3	mg/L	27.3	4.8	3.2	2	1.2
Ag-Dissolved	mg/L	0.0003	0.00001	0.000018	0.000013	0.000036
Al-Dissolved	mg/L	0.3	0.0066	0.034	0.032	0.14
As-Dissolved	mg/L	0.015	0.00034	0.00059	0.00048	0.0013
Cd-Dissolved	mg/L	0.0014[a]	0.0000075	0.000021	0.00002	0.000049
Cr-Dissolved	mg/L	0.003	0.0001	0.00093	0.00069	0.0015
Cu-Dissolved	mg/L	0.06/0.039[b]	0.018	0.012	0.0084	0.025
Fe-Dissolved	mg/L	3.3	0.027	0.37	0.31	0.49
Pb-Dissolved	mg/L	0.012	0.00005	0.00019	0.00015	0.00035
Mo-Dissolved	mg/L	0.219	0.0036	0.0021	0.0014	0.0076
Ni-Dissolved	mg/L	0.33	0.00066	0.0014	0.0012	0.002
Se-Dissolved	mg/L	0.006	0.0014	0.00084	0.00057	0.0025
Zn-Dissolved	mg/L	0.09	0.0013	0.005	0.0042	0.0081

Source: SRK, X:\01_SITES\Minto\1CM002.024_Water_Balance_Support\2015_Water_Balance_Update\All_Model_Results_for_WQ_Model_Comparison_for_2015_An_Report_SRJ_Rev00.xlsx

Notes:

Analytical data from Minto's water quality monitoring program.

a) at 50 mg/L hardness.

b) Cu effluent standard is 0.06 when [DOC] @ W2 > 10 mg/L and 0.039 when [DOC] @ W2 ≤ 10 mg/L.

Table 6: WSP Water Quality Model Predictions and Measured Concentrations in 2016, Reasonable Worst Case

Year		WUL Effluent Limits (QZ14-031)	WSP Measured Water Quality (Station W16)		Modelling Predictions of Quality in WSP (Station W16)					
			2016		2016		2018		Post-Closure	
			Median	Max	Median	Max	Median	Max	Median	Max
Ammonia	mg/L	0.75	0.04	0.31	0.16	0.23	0.11	0.21	0.31	0.41
$N\text{-}NO_2$	mg/L	0.18	0.033	0.094	0.17	0.26	0.11	0.24	0.1	0.13
$N\text{-}NO_3$	mg/L	27.3	4.8	5.7	20	30	12	29	3.4	4.5
Ag-Dissolved	mg/L	0.0003	0.00001	0.00002	0.000061	0.000089	0.00004	0.000085	0.00012	0.00019
Al-Dissolved	mg/L	0.3	0.0066	0.029	0.11	0.15	0.08	0.14	0.36	0.63
As-Dissolved	mg/L	0.015	0.00034	0.00088	0.00087	0.0011	0.00063	0.0011	0.0027	0.0047
Cd-Dissolved	mg/L	0.0014[a]	0.0000075	0.000017	0.000067	0.000095	0.000048	0.00009	0.00018	0.00029
Cr-Dissolved	mg/L	0.003	0.0001	0.001	0.0015	0.002	0.001	0.0019	0.0031	0.0049
Cu-Dissolved	mg/L	0.06/0.039[b]	0.018	0.026	0.029	0.043	0.019	0.041	0.062	0.089
Fe-Dissolved	mg/L	3.3	0.027	0.07	0.78	1.1	0.56	1	1.2	1.5
Pb-Dissolved	mg/L	0.012	0.00005	0.0002	0.00019	0.00025	0.00015	0.00024	0.001	0.0019
Mo-Dissolved	mg/L	0.219	0.0036	0.0051	0.0044	0.0063	0.0028	0.006	0.018	0.03
Ni-Dissolved	mg/L	0.33	0.00066	0.001	0.0024	0.0031	0.0017	0.003	0.0041	0.0058
Se-Dissolved	mg/L	0.006	0.0014	0.0016	0.004	0.006	0.0026	0.0057	0.0084	0.012
Zn-Dissolved	mg/L	0.09	0.0013	0.0063	0.0078	0.011	0.0059	0.01	0.016	0.025

Source: SRK, X:\01_SITES\Minto\1CM002.024_Water_Balance_Support\2015_Water_Balance_Update\All_Model_Results_for_WQ_Model_Comparison_for_2015_An_Report_SRJ_Rev00.xlsx

Notes:

Analytical data from Minto's water quality monitoring program.

a) at 50 mg/L hardness.

b) Cu effluent standard is 0.06 when [DOC] @ W2 > 10 mg/L and 0.039 when [DOC] @ W2 ≤ 10 mg/L.

Table 7: MPTMF Water Quality Model Predictions and Measured Concentrations in 2016, Best Estimate

Year		WUL Effluent Limits (QZ14-031)	MPTMF Measured Water Quality (Station W12)	Modelling Predictions of Quality in MPTMF (Station W12)		
			2016	2016	2018	Post-Closure
			Median	Median	Median	Median
Ammonia	mg/L	0.75	3.0	3.3	2.4	0.027
N-NO_2	mg/L	0.18	1.5	1.7	0.91	0.0057
N-NO_3	mg/L	27.3	26	22	18	0.14
Ag-Dissolved	mg/L	0.0003	0.00001	0.000037	0.000045	0.000045
Al-Dissolved	mg/L	0.3	0.011	0.13	0.18	0.15
As-Dissolved	mg/L	0.015	0.00045	0.0011	0.0015	0.0015
Cd-Dissolved	mg/L	0.0014[a]	0.000016	0.000038	0.000055	0.000048
Cr-Dissolved	mg/L	0.003	0.0001	0.0016	0.0018	0.002
Cu-Dissolved	mg/L	0.06/0.039[b]	0.025	0.017	0.029	0.031
Fe-Dissolved	mg/L	3.3	0.01	0.21	0.39	0.64
Pb-Dissolved	mg/L	0.012	0.00005	0.00035	0.00042	0.00043
Mo-Dissolved	mg/L	0.219	0.081	0.09	0.052	0.0061
Ni-Dissolved	mg/L	0.33	0.0017	0.0026	0.0025	0.0023
Se-Dissolved	mg/L	0.006	0.015	0.015	0.011	0.0023
Zn-Dissolved	mg/L	0.09	0.0037	0.008	0.0094	0.01

Source: SRK, X:\01_SITES\Minto\1CM002.024_Water_Balance_Support\2015_Water_Balance_Update\All_Model_Results_for_WQ_Model_Comparison_for_2015_An_Report_SRJ_Rev00.xlsx

Notes:

Analytical data from Minto's water quality monitoring program.

a) at 50 mg/L hardness.

b) Cu effluent standard is 0.06 when [DOC] @ W2 > 10 mg/L and 0.039 when [DOC] @ W2 ≤ 10 mg/L.

Table 8: MPTMF Water Quality Model Predictions and Measured Concentrations in 2016, Reasonable Worst Case

Year		WUL Effluent Limits (QZ14-031)	MPTMF Measured Water Quality (Station W12) 2016		Modelling Predictions of Quality in MPTMF (Station W12) 2016		2018		Post-Closure	
			Median	Max	Median	Max	Median	Max	Median	Max
Ammonia	mg/L	0.75	3	4.7	3.9	7.1	3.5	4.6	0.03	0.03
$N\text{-}NO_2$	mg/L	0.18	1.5	4.3	1.9	2.5	1.4	1.7	0.0099	0.011
$N\text{-}NO_3$	mg/L	27.3	26	29	34	45	45	49	0.65	0.78
Ag-Dissolved	mg/L	0.0003	0.00001	0.00002	0.00008	0.000096	0.00013	0.00014	0.00018	0.0002
Al-Dissolved	mg/L	0.3	0.011	0.018	0.27	0.34	0.42	0.44	0.43	0.46
As-Dissolved	mg/L	0.015	0.00045	0.0005	0.0021	0.0026	0.0031	0.0032	0.0031	0.0033
Cd-Dissolved	mg/L	0.0014[a]	0.000016	0.000034	0.00012	0.00014	0.0002	0.0002	0.00022	0.00024
Cr-Dissolved	mg/L	0.003	0.0001	0.001	0.0026	0.0031	0.0035	0.0038	0.0041	0.0045
Cu-Dissolved	mg/L	0.06/0.039[b]	0.025	0.053	0.039	0.05	0.073	0.078	0.082	0.091
Fe-Dissolved	mg/L	3.3	0.01	0.022	0.49	0.59	1	1.1	1.8	2
Pb-Dissolved	mg/L	0.012	0.00005	0.0002	0.00092	0.0011	0.0013	0.0013	0.001	0.0011
Mo-Dissolved	mg/L	0.219	0.081	0.087	0.098	0.13	0.071	0.087	0.018	0.019
Ni-Dissolved	mg/L	0.33	0.0017	0.0025	0.0038	0.0046	0.0049	0.0052	0.0055	0.006
Se-Dissolved	mg/L	0.006	0.015	0.017	0.019	0.028	0.019	0.022	0.011	0.013
Zn-Dissolved	mg/L	0.09	0.0037	0.0061	0.013	0.015	0.018	0.019	0.021	0.023

Source: SRK, X:\01_SITES\Minto\1CM002.024_Water_Balance_Support\2015_Water_Balance_Update\All_Model_Results_for_WQ_Model_Comparison_for_2015_An_Report_SRJ_Rev00.xlsx

Notes:

Analytical data from Minto's water quality monitoring program.

a) at 50 mg/L hardness.

b) Cu effluent standard is 0.06 when [DOC] @ W2 > 10 mg/L and 0.039 when [DOC] @ W2 ≤ 10 mg/L.

4 Closing

The summary of the 2016 Updated Water Balance and Water Quality Model for the Minto Mine was prepared in support of annual reporting. SRK would be pleased to address any questions or comments.

Appendix G – Daily Discharge Volumes into Minto Creek

2016 Daily Discharge Volumes		
Date	Actual Discharge for the day	Qeff-c= volume in Column H must be greater than or equal to the calculated rate of discharge
		Qeff-c
	(m3/day)	*=1/3*(Qmc(includesQro)-Qeff-m)*
7-Apr-16		2794
8-Apr-16	407	3580
9-Apr-16	834	5280
10-Apr-16	1233	5032
11-Apr-16	1960	9024
12-Apr-16	1871	7642
13-Apr-16	2163	12844
14-Apr-16	2284	16058
15-Apr-16	2270	7250
16-Apr-16	2277	8889
17-Apr-16	1713	6053
18-Apr-16	2247	2851
19-Apr-16	2275	2323
20-Apr-16	1124	1238
21-Apr-16	1711	2799
22-Apr-16	2287	3270
23-Apr-16	2271	3131
24-Apr-16	2292	3239
25-Apr-16	2264	3335
26-Apr-16	2331	3226
27-Apr-16	2253	4059
28-Apr-16	1321	1720
29-Apr-16	633	1373
30-Apr-16	643	1082
1-May-16	936	1099
2-May-16	801	1576
3-May-16	706	1291
4-May-16	718	740
5-May-16	278	768
6-May-16	253	not calculated
7-May-16	0	not calculated
8-May-16	0	not calculated
9-May-16	0	not calculated
10-May-16	0	not calculated
11-May-16	0	not calculated
12-May-16	0	not calculated
13-May-16	0	1526

14-May-16	0	1296
15-May-16	771	1267
16-May-16	925	1068
17-May-16	896	2687
18-May-16	110	2034
19-May-16	35	4168
20-May-16	4	3099
21-May-16	963	1868
22-May-16	659	1767
23-May-16	1081	1310
24-May-16	1224	1378
25-May-16	1673	2581
26-May-16	1776	2231
27-May-16	1188	1562
28-May-16	925	1218
29-May-16	870	1265
30-May-16	807	912
31-May-16	590	840
1-Jun-16	580	901
2-Jun-16	715	741
3-Jun-16	731	735
4-Jun-16	630	654
5-Jun-16	582	1477
6-Jun-16	809	1228
7-Jun-16	1118	1442
8-Jun-16	1213	1266
9-Jun-16	929	1015
10-Jun-16	780	863
11-Jun-16	294	575
12-Jun-16	0	622
13-Jun-16	434	634
14-Jun-16	589	921
15-Jun-16	915	1042
16-Jun-16	731	818
17-Jun-16	522	649
18-Jun-16	396	488
19-Jun-16	101	473
20-Jun-16	304	341
21-Jun-16	129	446
22-Jun-16	382	475
23-Jun-16	201	333
24-Jun-16	419	538
25-Jun-16	363	436
26-Jun-16	330	426
27-Jun-16	87	409
28-Jun-16	0	346
29-Jun-16	0	367

30-Jun-16	0	367
1-Jul-16	0	367
2-Jul-16	0	367
3-Jul-16	0	403
4-Jul-16	0	400
5-Jul-16	0	400
6-Jul-16	0	400
7-Jul-16	490	778
8-Jul-16	597	701
9-Jul-16	439	521
10-Jul-16	388	718
11-Jul-16	236	792
12-Jul-16	538	670
13-Jul-16	926	1059
14-Jul-16	398	728
15-Jul-16	289	674
16-Jul-16	490	566
17-Jul-16	232	413
18-Jul-16	363	441
19-Jul-16	352	455
20-Jul-16	358	430
21-Jul-16	360	486
22-Jul-16	631	744
23-Jul-16	1005	1143
24-Jul-16	1288	1422
25-Jul-16	943	4063
26-Jul-16	1759	3516
27-Jul-16	2106	2121
28-Jul-16	1252	1256
29-Jul-16	1215	1339
30-Jul-16	1088	1208
31-Jul-16	653	761
1-Aug-16	579	704
2-Aug-16	617	700
3-Aug-16	650	774
4-Aug-16	678	734
5-Aug-16	504	609
6-Aug-16	886	955
7-Aug-16	1058	1145
8-Aug-16	711	828
9-Aug-16	1742	2124
10-Aug-16	2001	2184
11-Aug-16	1203	1407
12-Aug-16	1008	1212
13-Aug-16	885	1075
14-Aug-16	628	771
15-Aug-16	538	770

16-Aug-16	550	713
17-Aug-16	548	767
18-Aug-16	622	796
19-Aug-16	1058	1175
20-Aug-16	1022	1116
21-Aug-16	683	783
22-Aug-16	686	838
23-Aug-16	605	751
24-Aug-16	567	778
25-Aug-16	734	877
26-Aug-16	1328	1454
27-Aug-16	1519	1861
28-Aug-16	1242	1308
29-Aug-16	1222	1516
30-Aug-16	1179	1321
31-Aug-16	1230	1220
1-Sep-16	1119	1231
2-Sep-16	1649	1672
3-Sep-16	893	1639
4-Sep-16	480	1920
5-Sep-16	1663	1971
6-Sep-16	1328	1951
7-Sep-16	1650	2149
8-Sep-16	2205	2301
9-Sep-16	1222	2087
10-Sep-16	1840	2444
11-Sep-16	1484	1864
12-Sep-16	1639	1723
13-Sep-16	1426	1210
14-Sep-16	1225	1627
15-Sep-16	1742	1809
16-Sep-16	1410	1781
17-Sep-16	1697	1690
18-Sep-16	1504	1969
19-Sep-16	1594	2004
20-Sep-16	1437	1859
21-Sep-16	1340	1883
22-Sep-16	1213	1598
23-Sep-16	1205	1612
24-Sep-16	1180	1355
25-Sep-16	1179	1651
26-Sep-16	1166	1623
27-Sep-16	1168	1570
28-Sep-16	1139	1396
29-Sep-16	1138	1319
30-Sep-16	879	1118
1-Oct-16	475	1608

2-Oct-16	728	994
3-Oct-16	745	1140
4-Oct-16	357	789
5-Oct-16	510	831
6-Oct-16	787	1472
7-Oct-16	773	1293
8-Oct-16	765	1355
9-Oct-16	747	1099
10-Oct-16		Discharge complete for year

Appendix H – Minto and McGinty Creek 2016 Surface Hydrology Update

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Memo

To:	Deborah Flemming	**Client:**	Minto Explorations Ltd.
From:	Sarah Portelance, PEng. (SRK)	**Project No:**	1CM002.054
Cc:	Soren Jensen and Dylan McGregor (SRK)	**Date:**	March 23, 2017
Subject:	Minto and McGinty Creek 2016 Surface Hydrology Memo		

1 Introduction

Minto Explorations Ltd. (Minto) maintains a hydrometric network as part of its regular monitoring of surface water conditions at the Minto Mine. The hydrometric network is composed of 7 stations located on Minto Creek and McGinty Creek. The hydrometric sites are listed below and are shown in Figure 1.

- Minto Creek
  - W3 – Flume Below Water Storage Pond
  - W7 – Tributary of Minto Creek
  - MC1 – Minto Creek Mid-Catchment
  - W1 – Lower Minto Creek Near Yukon River
- McGinty Creek
  - MN-0.5 – West Tributary of McGinty Creek
  - MN-2.5 – East Tributary of McGinty Creek
  - MN-4.5 – McGinty Creek near the Mouth

Section 2 of this report presents the methods applied to evaluate flows for the hydrometric program, Section 3 provides a summary of the 2016 hydrometric program for each station and Section 4 outlines the summary of the 2016 program and provides recommendations for future monitoring.

2 Methods

Hydrometric stations are installed at four locations along Minto Creek and three on McGinty Creek. Minto personnel conduct regular discrete discharge measurements and maintenance at the stations. In addition, a number of stations record water levels using Solinst Level Loggers and Barometric Loggers. Table 1 provides a summary of the instrumentation available at each station.

Table 1: Summary of Hydrometric Program

Station	Watershed	Years Monitored	Instrumentation
W3	Minto Creek	2012-2016	Flume
W7	Minto Creek	2013-2016	Staff Gauge
MC1	Minto Creek	2012-2016	Staff Gauge, Data Logger
W1	Minto Creek	2012-2016	Staff Gauge, Data Logger
MN-0.5	McGinty Creek	2014-2016	Staff Gauge, Data Logger
MN-2.5	McGinty Creek	2014-2016	Staff Gauge, Data Logger
MN-4.5	McGinty Creek	2011-2016	Staff Gauge, Data Logger

Stream-gauge data is collected and managed throughout the open water season by Minto. Velocities are measured using a Hach FH950 handheld electromagnetic flow meter. Velocity and water depth measurements are converted to flows using the area-velocity methods. All hydrometric data, calculated flows and the times-series of recorded water levels and temperature data from the level loggers were provided to SRK.

Level logger data were compared to measured staff gauge readings. Level logger water levels shifted up/down over the course of the monitoring season due to the repositioning of the logger after data was downloaded in the field. Where applicable, the level logger data were corrected to match the staff gauge readings.

Stage-discharge relationships (rating curves) where created using measured flows and staff gauge readings. For stations with level loggers, discharges were determined over the course of the 2016 study to calculate mean monthly flows and total monthly runoff.

3 Minto Creek

3.1 Station W3 – Flume below Water Storage Pond Dam

The W3 hydrometric station is composed of a flume located approximately 500 metres downstream of the water storage pond dam. Water levels are continuously measured and recorded every 30 minutes by a pressure transducer/level logger. In addition, water level and flow were recorded daily at the flume for most of the year. A summary of the level and flow data recorded at W3 is presented in Appendix A. This data provides the information necessary to correct recorded stage data and generate a stage-discharge relationship which enables the computation of creek discharge. The stage-discharge relationship is presented in Figure 2.

Figure 3 shows recorded water level and temperature data for Minto Creek at W3 from January to December, 2016.

W3 is highly influenced by discharge pumped to Minto Creek from the water storage pond. Figure 4 shows the 2016 hydrograph and discrete flow measurements. A comparison of monthly flows recorded at W3 and monthly discharge from the WSP are shown in Figure 5. As expected, the flows recorded at W3 are slightly higher than the rate of discharge due to the baseflow and runoff reporting directly to W3 year-round. W3 flow appear lower in April because of the incomplete data record for that month.

Water was pumped from the water storage pond from April 8 to October 25, 2016. This explains the water level and flow fluctuations during the open water season (April to October) at the W3 but does not explain the measured flows (discrete measurements) recorded in January/February and the high water level fluctuations recorded by the pressure transducer from February to beginning of April prior to pumped flows.

The monitoring staff at Minto noticed that ground seepage daylights between the water storage pond and W3 year-round and that the flume froze in February/March of 2016 (email from Minto). It is believed that the water level fluctuations from February to beginning of April are an artefact of the water above the pressure transducer freezing. The recorded discrete flows measured in January and February are believed to be high due to water potentially flowing above frozen ice. As such the data from January to beginning of April should be disregarded for analysis.

Table 2 provides a summary of the average water temperature, flow and total flow volume in 2016. The negative temperatures recorded in October indicate the start of the freeze-up period. Table 3 summarizes the historical mean monthly flows recorded in previous years of the hydrometric program. The history illustrates that freeze-up begins in October and that freshet typically occurs in April/May.

Table 2: W3 2016 Hydrometric Data and Temperature Summary

Month	Period of Record [day]	Mean Water Temperature [°C]	Mean Flow [m^3/s]	Total Flow Volume [m^3]
Jan	No Data			
Feb	No Data			
Mar	No Data			
Apr	20	1.5	0.022	39,736
May	31	2.6	0.010	25,785
Jun	30	5.5	0.008	21,751
Jul	31	8.0	0.009	24,466
Aug	31	8.6	0.013	34,159
Sep	30	7.6	0.035	92,009
Oct	31	2.9	0.019	51,936
Nov	30	2.4	0.002	4,868
Dec	5	3.7	0.002	1,009

Note: Shaded areas indicate incomplete months of data

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\Corrected Levelogger Data\W3_Logger_Data_2016_pz.xlsx

Table 3: W3 Historical Mean Monthly Flow [m^3/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012[1]	-	-	-	-	-	0.005	0.005	0.006	0.005	-	-	-
2013[1]	-	-	-	-	-	0.003	0.004	0.004	0.004	-	-	-
2014[1]	-	-	-	-	-	<0.001	<0.001	0.002	0.003	0.003	0.006	0.004
2015[1]	0.003	0.006	0.006	0.057	0.086	0.003	0.003	0.003	0.004	0.004	0.006	0.026
2016	-	-	-	0.022	0.052	0.003	0.003	0.004	0.004	0.004	0.003	0.004

Note:1- Data based on pervious Annual Surface Water Hydrology Analysis. Shaded areas indicate incomplete months of data. "-" No Data.

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\Corrected Levelogger Data\W3_Logger_Data_2016_pz.xlsx

3.2 Station W7 – Tributary of Minto Creek

A staff gauge was installed at this station the summer of 2013. Historically, this station has been regularly monitored surface water station prior to the installation of the staff gauge. In 2014, the staff gauge was damaged by ice and repaired for the hydrometric program in 2015. In 2016, several discrete discharge measurements were recorded without a corresponding stage. Table 4 provides a summary historical measured flows at W7. These flows are based on discrete measurements only. There currently is no pressure transducer at this site. A rating curve was not established for this site given the limited amount of flow and stage data available. To obtain good quality data with a pressure transducer, an artificial control such as a v-notch weir is recommended.

Table 4: W7 Historical Mean Monthly Flow [m3/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013[1]	-	-	-	-	-	-	0.013	0.031	0.019	0.006	-	-
2014[1]	-	-	-	-	0.112	-	-	-	-	-	-	-
2015[1]	-	-	-	-	-	0.006	0.004	0.011	0.011	0.029	-	-
2016	-	-	-	-	-	0.006	0.010	0.010	0.013	0.010	-	-

Note: 1- Data based on pervious Annual Surface water Hydrology Analysis. Shaded areas indicate incomplete months of data. "-" No Data.

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\ 2016 Hydrology Data_rev03_spb_pz.xlsx

3.3 Station MC1 – Minto Creek Mid-Catchment

The hydrometric station MC1 on Minto Creek is located downstream of the W3 Flume and immediately upstream of the canyon along Minto Creek. The pressure transducer installed at this station recorded temperature and water levels at 30 minute intervals for a 122-day record. Figure 6 shows water level and temperature data for Minto Creek at MC1 from June 6 to October 6, 2016.

Over the course of the hydrometric program in 2016, numerous discrete discharge measurements were recorded in conjunction with water level readings recorded by both the pressure transducer and the staff gauge. A summary of this data is included in Appendix A. This data provides the information necessary to generate a stage-discharge relationship which enables the computation of creek discharge for the recorded stage data. The stage-discharge relationship is presented in Figure 7.

The 2016 hydrograph and discrete measurements for MC1 are shown in Figure 8. In 2016, the maximum measured flow of 0.16 m^3/s occurred on July 26, 2016.

Table 5 provides a summary of the average water temperature, flow and total flow volume in 2016. The negative temperatures recorded in October indicate the start of the freeze-up period. Table 6 summarizes the historical mean monthly flows to previous years of the hydrometric program.

Table 5: MC1 2016 Hydrometric Data and Temperature Summary

Month	Period of Record [day]	Mean Water Temperature [°C]	Mean Flow [m^3/s]	Total Flow Volume [m^3]
Jan	No Data			
Feb	No Data			
Mar	No Data			
Apr	No Data			
May	No Data			
Jun	24	3.5	0.029	61,139
Jul	31	5.7	0.036	96,292
Aug	31	5.4	0.048	128,349
Sep	30	3.5	0.076	196,739
Oct	No Data			
Nov	No Data			
Dec	No Data			

Note: Shaded areas indicate incomplete months of data

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\Corrected Levelogger Data\MC1_Logger_Data_2016_pz.xlsx

Table 6: MC1 Historical Mean Monthly Flow [m^3/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012[1]	-	-	-	-	0.179	0.065	0.052	0.041	0.108	-	-	-
2013[1]	-	-	-	-	0.358	0.085	0.103	0.44	0.089	0.064	-	-
2014[1]	-	-	-	-	0.187	0.028	0.031	0.036	0.028	0.033	-	-
2015[1]	-	-	-	-	0.862	0.014	0.028	0.042	0.035	0.031	-	-
2016	-	-	-	-	-	0.029	0.036	0.048	0.076	-	-	-

Note:1- Data based on pervious Annual Surface Water Hydrology Analysis. Shaded areas indicate incomplete months of data. "-" No Data.

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\Corrected Levelogger Data\MC1_Logger_Data_2016_pz.xlsx

3.4 Station W1 – Lower Minto Creek above Road Crossing

W1 station is located on the lower reach of Minto Creek before flowing into the Yukon River. In 2016, water level and temperature data were continuously measured and recorded every 30 minutes by the pressure transducer/data logger. Figure 9 shows Minto Creek at W1 water level and temperature data for the 189-day record from April 4 to October 11, 2016.

A summary of discrete discharge measurements and corresponding water level is presented in Appendix A. The stage-discharge relationship for W1 is presented in Figure 10. The 2016 hydrograph and discrete measurements for W1 are shown in Figure 11. In 2016, the maximum measured flow of 1.10 m^3/s occurred on April 13, 2016. Figure 11 shows W1 and MC1 flows. W1 is located downstream of MC1 and it is expected that flows would be larger because it has a much larger catchment area than MC1. W1 flows are lower than MC1 because it has been observed through the monitoring program that upstream of W1 is a losing reach. Water downstream of MC1 passes through a preferential pathway and by-passes W1.

Table 7 provides a summary of the average water temperature, flow and total flow volume in 2016. The negative temperatures recorded in October indicates the start of the freeze-up period. Table 8 summarizes the historical mean monthly flows to previous years of the hydrometric program. The history shows that freeze-up begins in October and that freshet typically occurs in April/May.

Table 7: W1 2016 Hydrometric Data and Temperature Summary

Month	Period of Record [day]	Mean Water Temperature [°C]	Mean Flow [m^3/s]	Total Flow Volume [m^3]
Jan	No Data			
Feb	No Data			
Mar	No Data			
Apr	25	-0.8	0.252	545,297
May	31	0.9	0.047	126,338
Jun	30	5.2	0.020	52,302
Jul	31	7.2	0.017	45,334
Aug	31	6.8	0.024	63,236
Sep	30	3.7	0.043	112,232
Oct	11	-1.1	0.026	23,833
Nov	No Data			
Dec	No Data			

Note: Shaded areas indicate incomplete months of data

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\Corrected Levelogger Data\W1_Logger_Data_2016_pz.xlsx

Table 8: W1 Historical Mean Monthly Flow [m^3/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012[1]	-	-	-	-	0.269	0.073	0.052	0.051	0.078	0.056	-	-
2013[1]	-	-	-	-	0.485	0.064	0.065	0.044	0.085	0.059	-	-
2014[1]	-	-	-	-	0.138	0.022	0.020	0.014	0.031	0.025	-	-
2015[1]	-	-	-	-	0.117	0.010	0.010	0.030	0.024	0.020	-	-
2016	-	-	-	0.252	0.047	0.020	0.017	0.024	0.043	0.026	-	-

Note:1- Data based on pervious Annual Surface water Hydrology Analysis. Shaded areas indicate incomplete months of data. “-“ = No Data.

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\Corrected Levelogger Data\W1_Logger_Data_2016_pz.xlsx

4 McGinty Creek

4.1 Station MN-0.5 – West Tributary of McGinty Creek

MN-0.5 station is located on the upper west stem of McGinty Creek. In 2016, water level and temperature data were continuously measured and recorded every 30 minutes by a pressure transducer/data logger. Figure 12 shows McGinty Creek at MN-0.5 water level and temperature data for the 101-day record from June 22 to October 10, 2016.

A summary of discrete discharge measurements and corresponding water level for 2016 is presented in Appendix A. A stage-discharge relationship could not be established for MN-0.5 because of limited flow data and corresponding staff gauge reading. Additional flow measurements would be required to establish a stage-discharge curve for the station.

Table 9 provides a summary historical measured flows at MN-0.5. These flows are based on discrete measurements only.

Table 9: MN-0.5 Historical Mean Monthly Flow [m^3/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014[1]	-	-	-	-	0.045	-	-	-	-	-	-	-
2015[1]	-	-	-	-	0.035	0.013	0.054	0.098	0.029	0.025	-	-
2016	-	-	-	-	0.028	0.016	0.010	0.016	0.035	0.018	-	-

Note: 1- Data based on pervious Annual Surface water Hydrology Analysis. Shaded areas indicate incomplete months of data. "-" = No Data.

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\ 2016 Hydrology Data_rev03_spb_pz.xlsx

4.2 Station MN-2.5 – East Tributary of McGinty Creek

MN-2.5 station is located on the lower stem of McGinty Creek. In 2016, water level and temperature data were continuously measured and recorded every 30 minutes by a pressure transducer/data logger. Figure 13 shows McGinty Creek at MN-2.5 water level and temperature data for the 136-day record from May 28 to October 11, 2016.

A summary of discrete discharge measurements and corresponding water level for 2016 is included in Appendix A. A stage-discharge relationship could not be established for MN-2.5 because of limited data flow and corresponding staff gauge reading.

Table 10 provides a summary of historical measured flows at MN-2.5. These flows are based on discrete measurements only.

Table 10: MN-2.5 Historical Mean Monthly Flow [m³/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014[1]	-	-	-	-	0.032	-	-	-	-	-	-	-
2015[1]	-	-	-	-	0.015	0.003	0.011	0.038	0.010	0.010	-	-
2016	-	-	-	0.034	0.008	-	-	0.009	0.014	0.003	-	-

Note: 1- Data based on pervious Annual Surface water Hydrology Analysis. Shaded areas indicate incomplete months of data. “-“ = No Data.

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\ 2016 Hydrology Data_rev03_spb_pz.xlsx

4.3 Station MN-4.5 – McGinty Creek near the Mouth

MN-4.5 station is located on the lower reach of McGinty Creek before flowing into the Yukon River. In 2016, water level and temperature data were continuously measured and recorded every 30 minutes by the pressure transducer/data logger. Figure 14 shows McGinty Creek at MN-4.5 water level and temperature data for the 136-day record from May 28 to October 11, 2016.

A summary of discrete discharge measurements and corresponding water level is presented in Appendix A. The stage-discharge relationship for MN-4.5 is presented in Figure 15. The 2016 hydrograph and discrete measurements for MN-4.5 are shown in Figure 16. In 2016, the maximum measured flow of 0.20 m^3/s occurred on July 26, 2016.

Table 11 provides a summary of the average water temperature, flow and total flow volume in 2016. Table 12 summarizes the historical mean monthly flows to previous years of the hydrometric program.

Table 11: MN-4.5 2016 Hydrometric Data and Temperature Summary

Month	Period of Record [day]	Mean Water Temperature [°C]	Mean Flow [m³/s]	Total Flow Volume [m³]
Jan	No Data			
Feb	No Data			
Mar	No Data			
Apr	No Data			
May	4	1.9	0.017	4,760
Jun	30	3.9	0.015	39,549
Jul	31	5.9	0.026	70,413
Aug	31	5.5	0.028	74,254
Sep	30	2.5	0.028	71,557
Oct	11	0.8	0.010	8,939
Nov	No Data			
Dec	No Data			

Note: Shaded areas indicate incomplete months of data

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\Corrected Levelogger Data\ MN_4.5_Logger_Data_2016_pz.xlsx

Table 12: MN-4.5 Historical Mean Monthly Flow [m^3/s]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011[1]	-	-	-	-	0.444	0.093	0.125	0.134	0.068	0.045	-	-
2012[1]	-	-	-	0.212	0.230	0.180	0.082	0.053	0.109	-	-	-
2013[1]	-	-	-	-	-	0.054	0.103	0.093	0.116	-	-	-
2014[1]	-	-	-	-	0.230	0.041	0.037	0.026	0.046	-	-	-
2015[1]	-	-	-	-	-	0.013	0.046	0.049	0.029	0.029	-	-
2016	-	-	-	-	0.017	0.015	0.026	0.028	0.028	0.010	-	-

Note:1- Data based on pervious Annual Surface water Hydrology Analysis. Shaded areas indicate incomplete months of data. “-“ = No Data.

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.024_Water_Balance_Support\2016 Hydrology\Corrected Levelogger Data\MN4.5_Logger_Data_2016_pz.xlsx

5 Closure

The summary of the 2016 surface hydrology data for the Minto Mine was prepared in support of annual reporting. SRK would be pleased to address any questions or comments or provide additional analysis of the hydrological data, if required.

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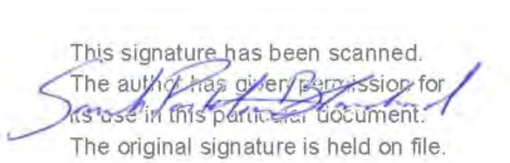

Sarah Portelance, MEng. PEng.
Senior Consultant – Hydrotechnical Engineer

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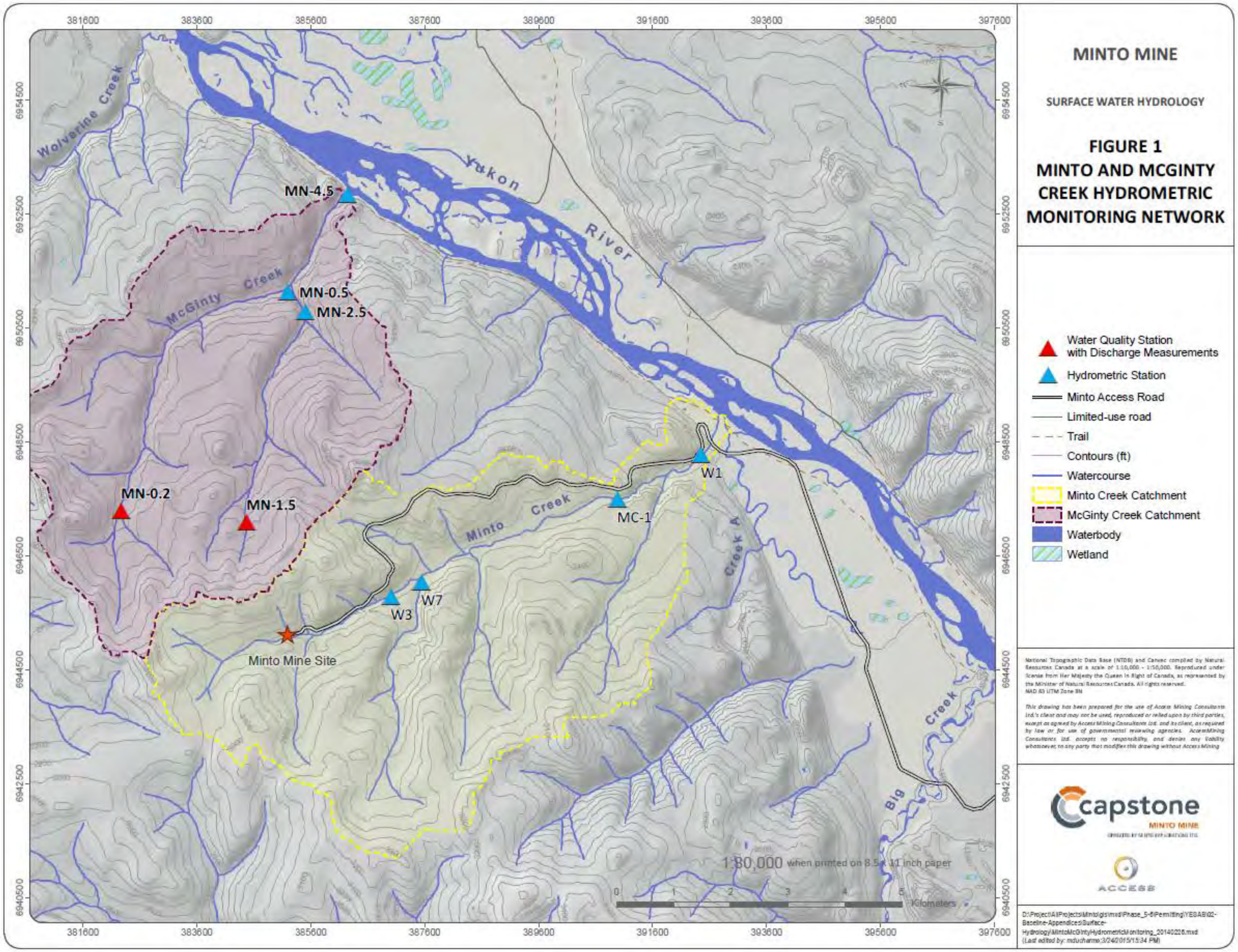
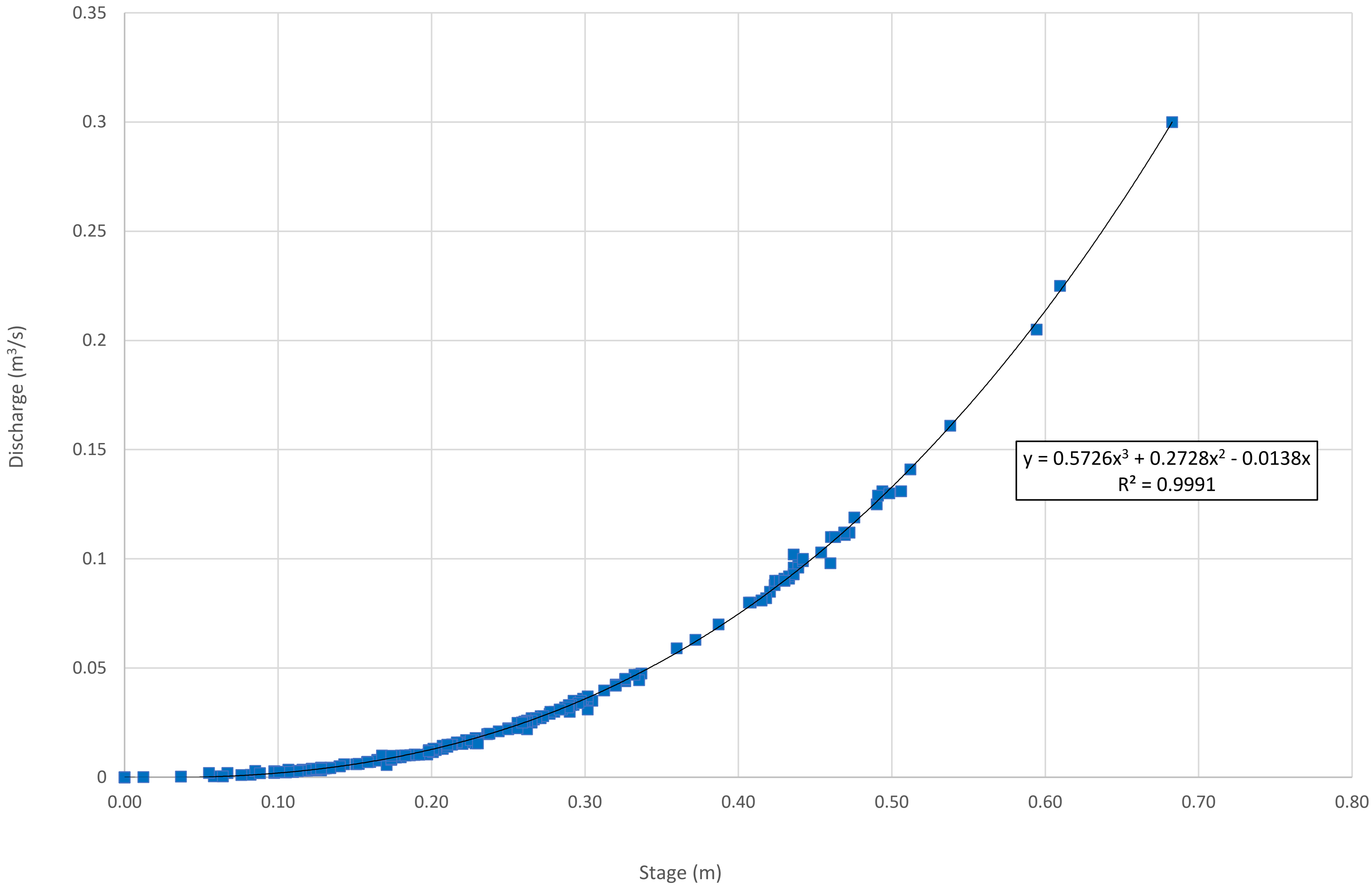
The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

Figures



	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo **Minto and McGinty Creek Hydrometric Monitoring Program**
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017 · Approved: SPB · Figure: **1**



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Minto and McGinty Creek 2016 Surface Hydrology Memo

W3 Rating Curve

Job No: 1CM002.054

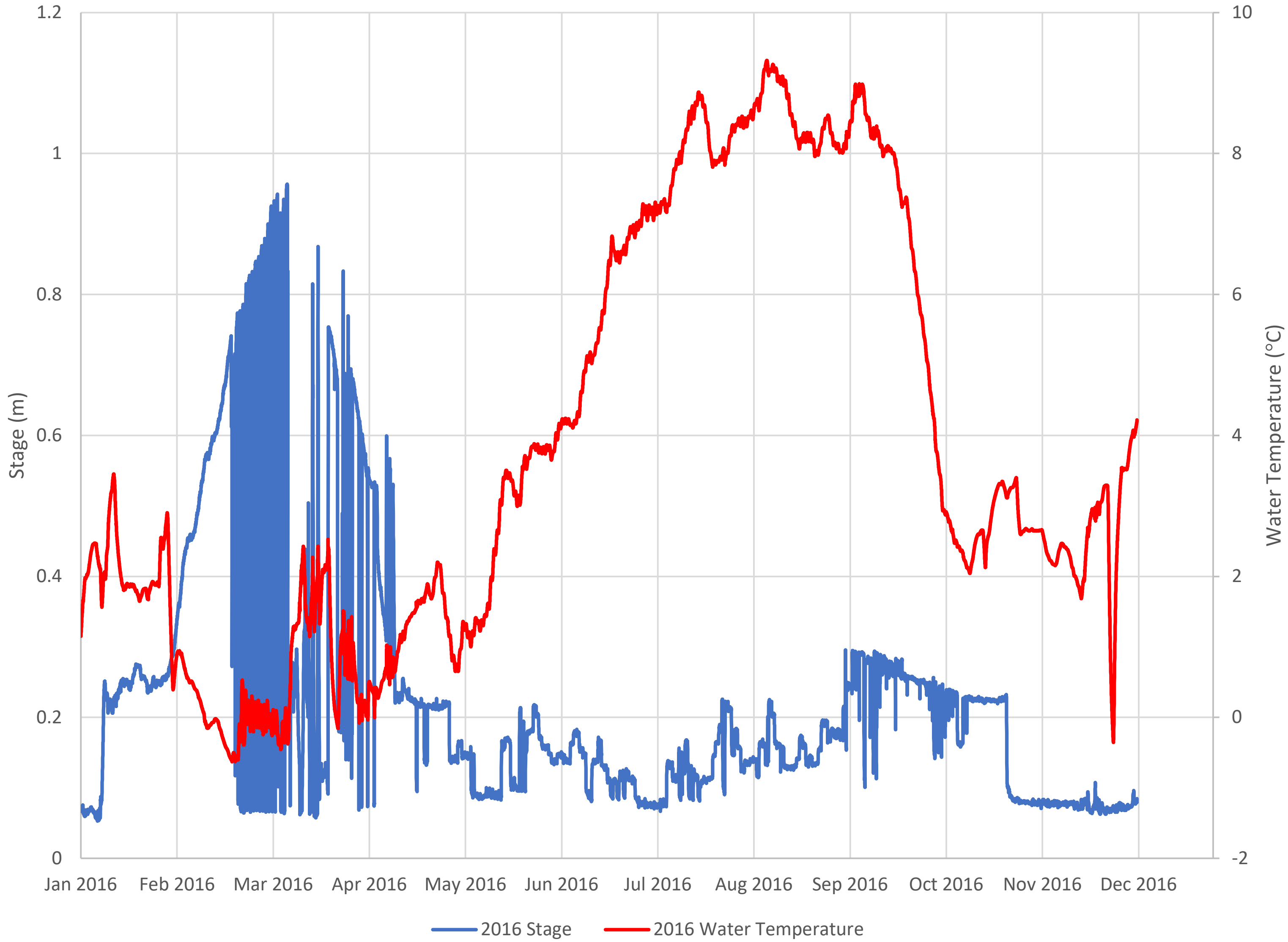
Filename: Figures.pptx

Minto

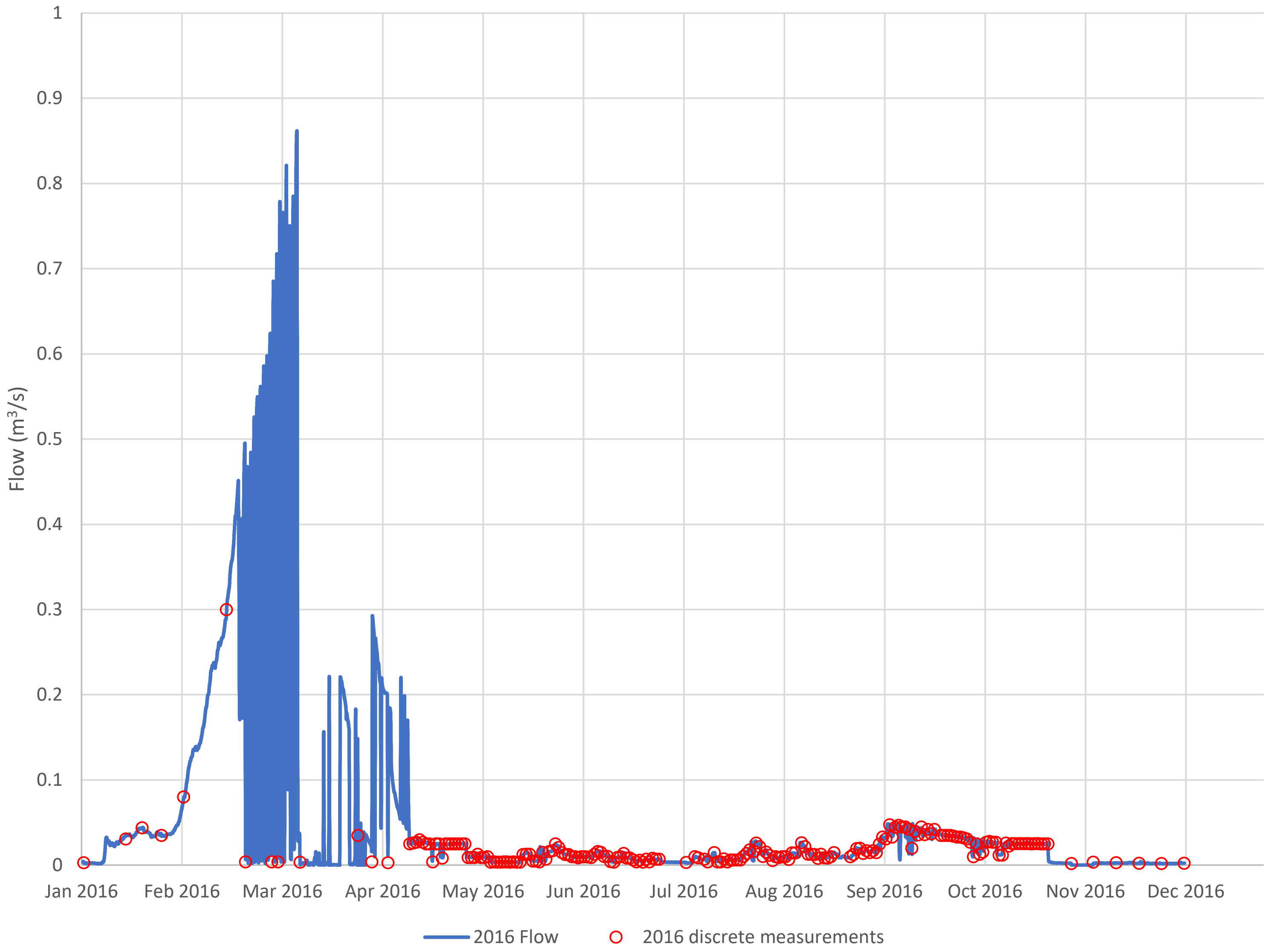
Date: March 23, 2017

Approved: SPB

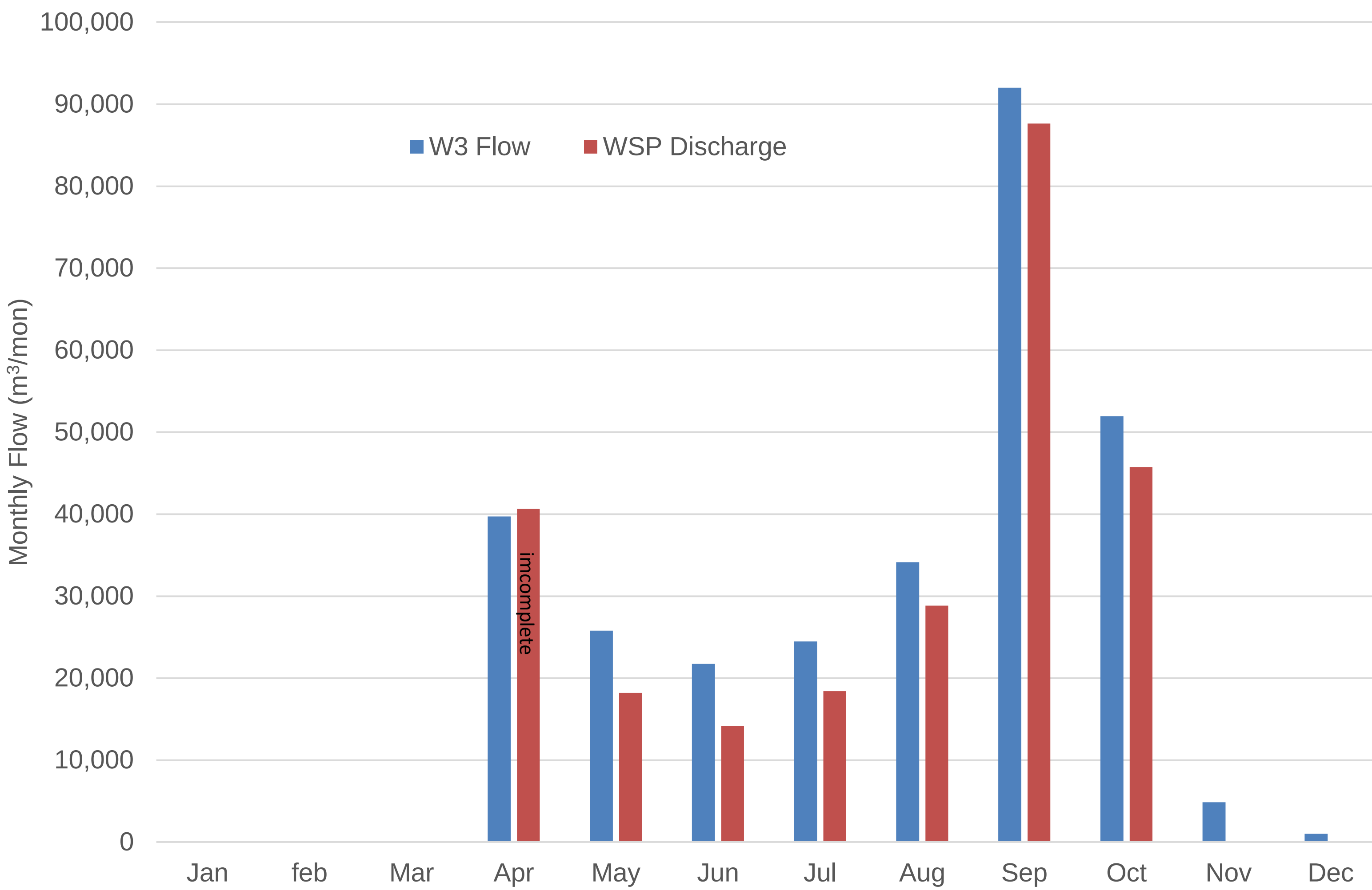
Figure: **2**



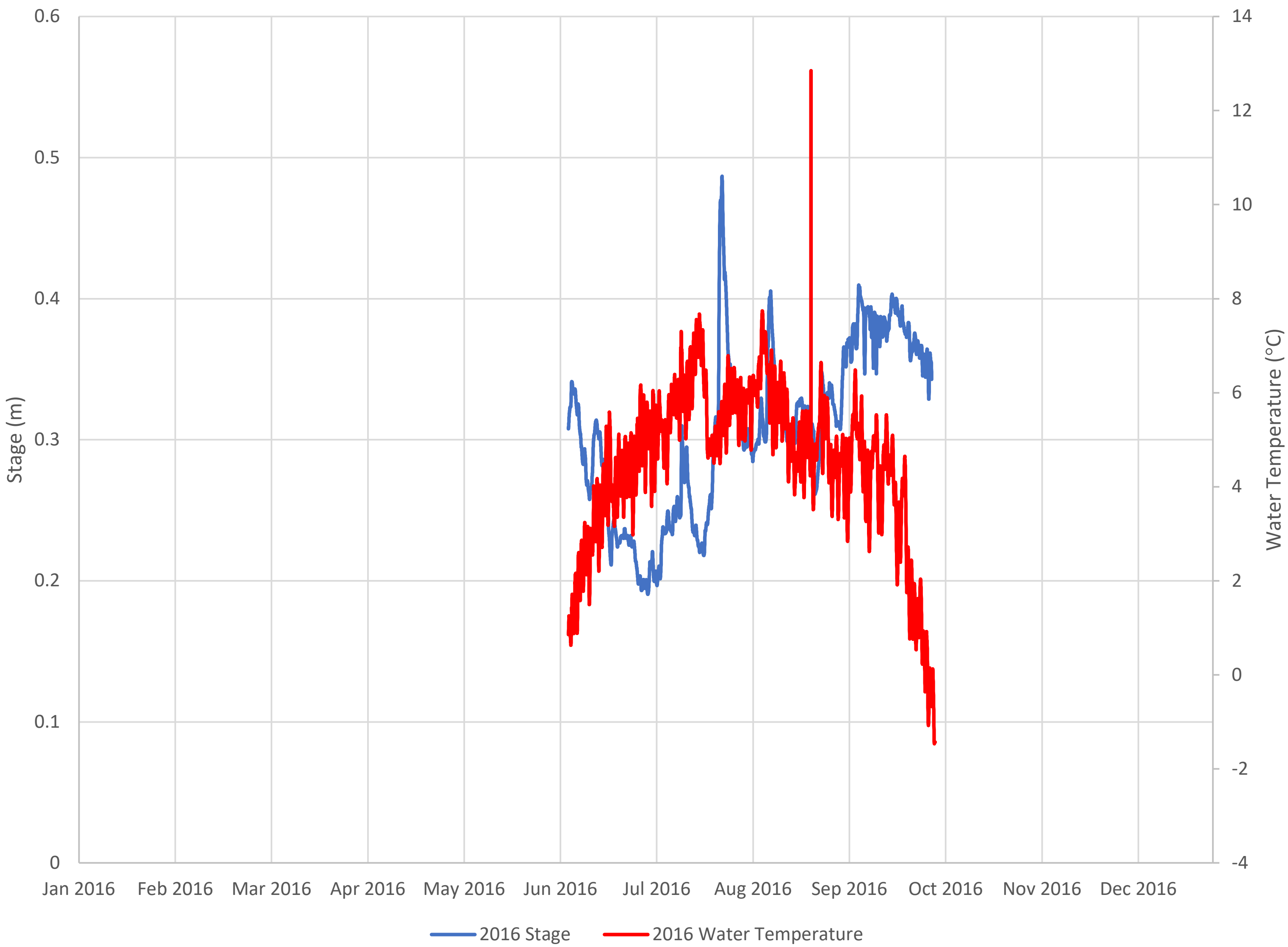
srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo		
		W3 Stage and Temperature Hydrograph		
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017	Approved: SPB	Figure: **3**



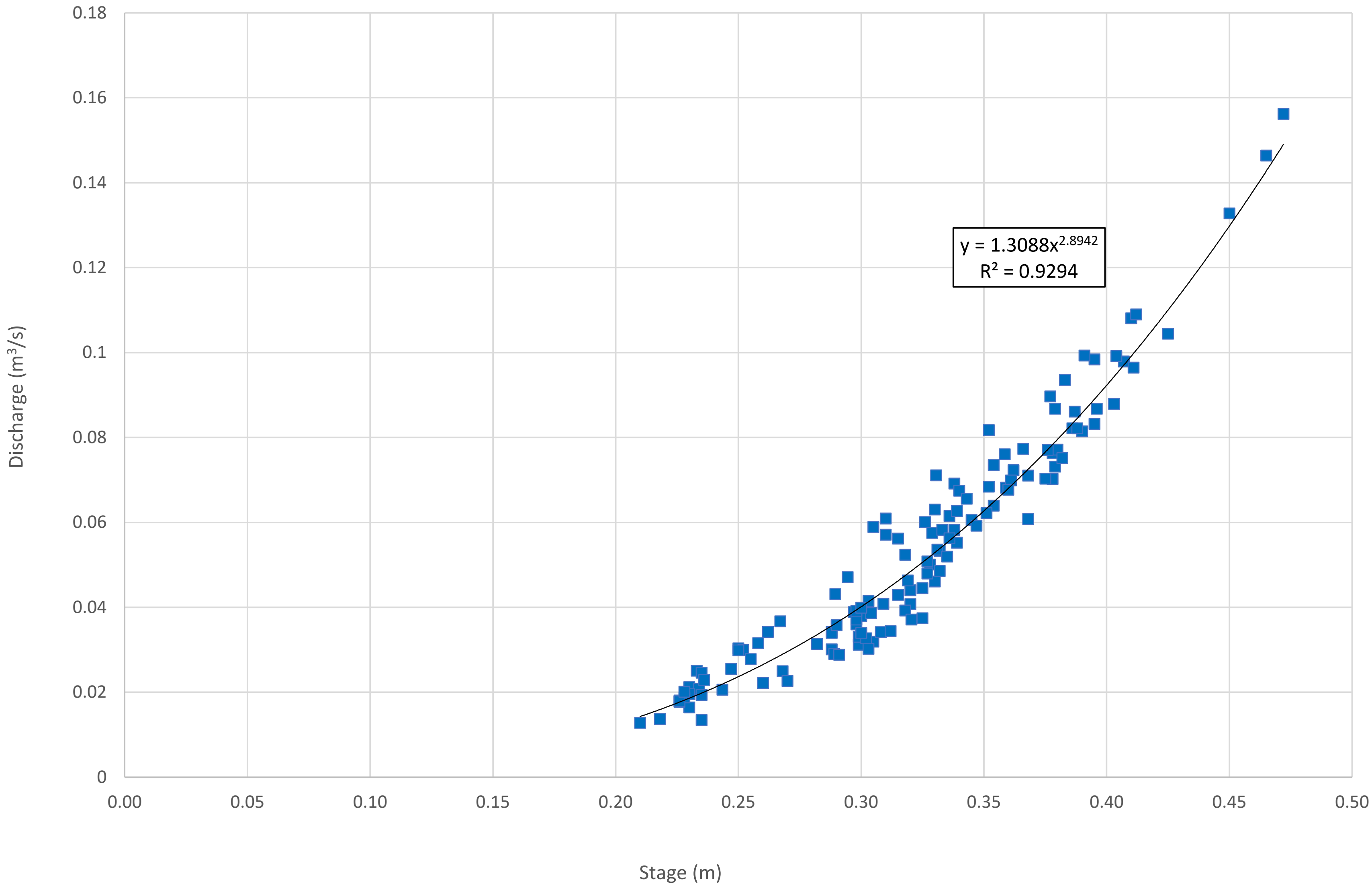
srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo		
		W3 Flow Hydrograph		
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017	Approved: SPB	Figure: **4**



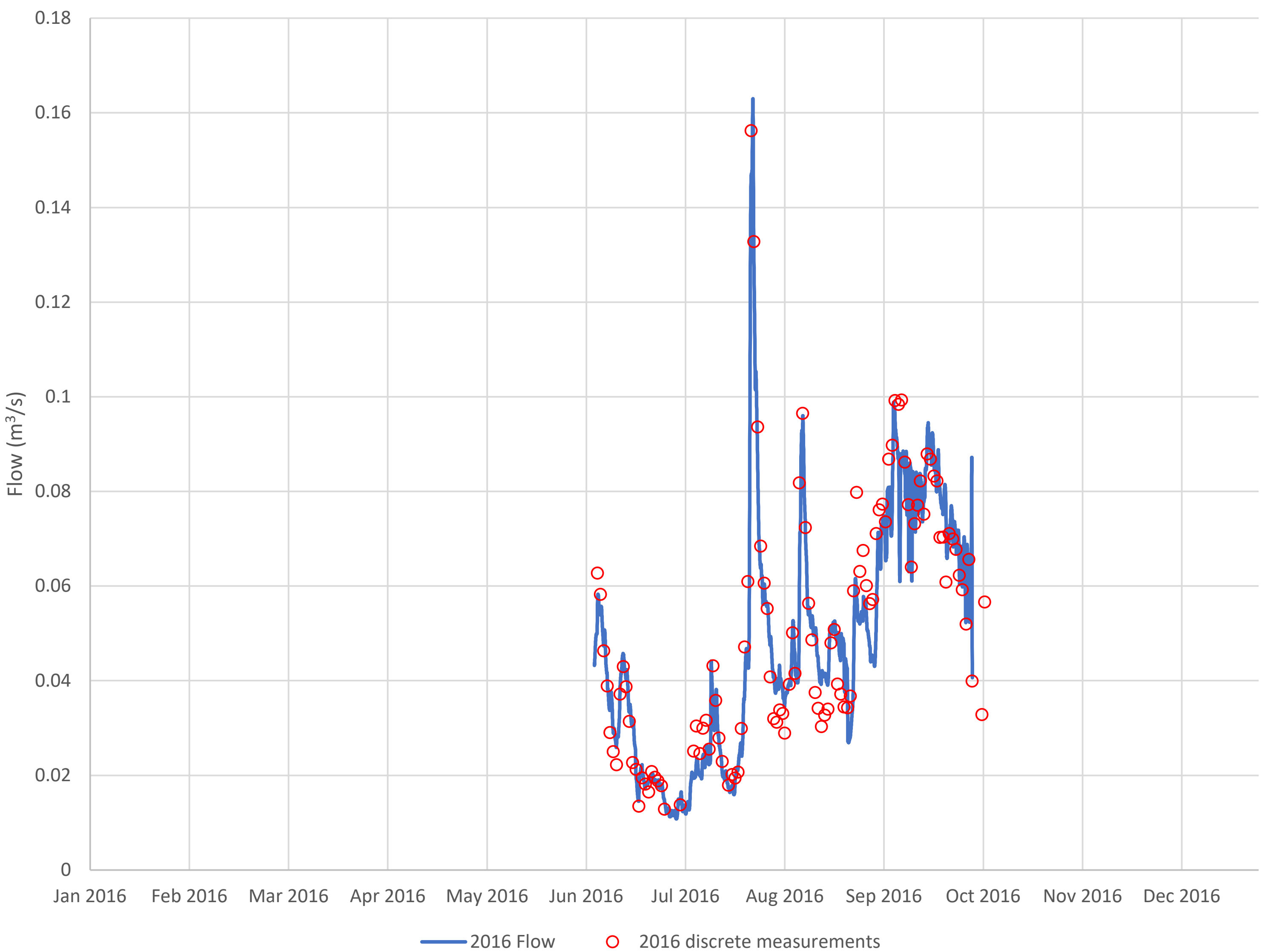
srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo **Monthly WSP Discharge and Flows at W3**
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017 / Approved: SPB / Figure: **5**



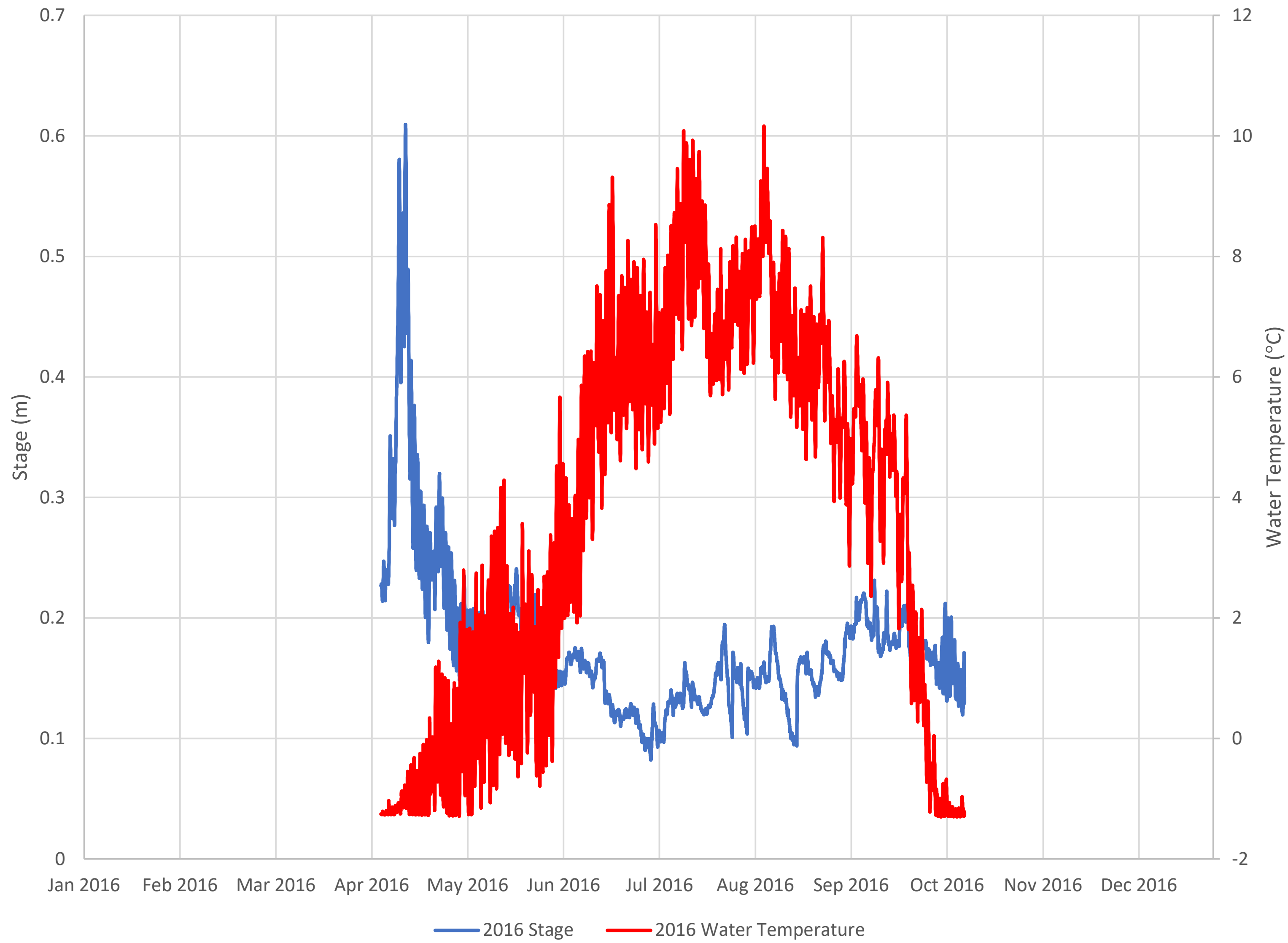
srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo
		MC1 Stage and Temperature Hydrograph
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017 / Approved: SPB / Figure: **6**



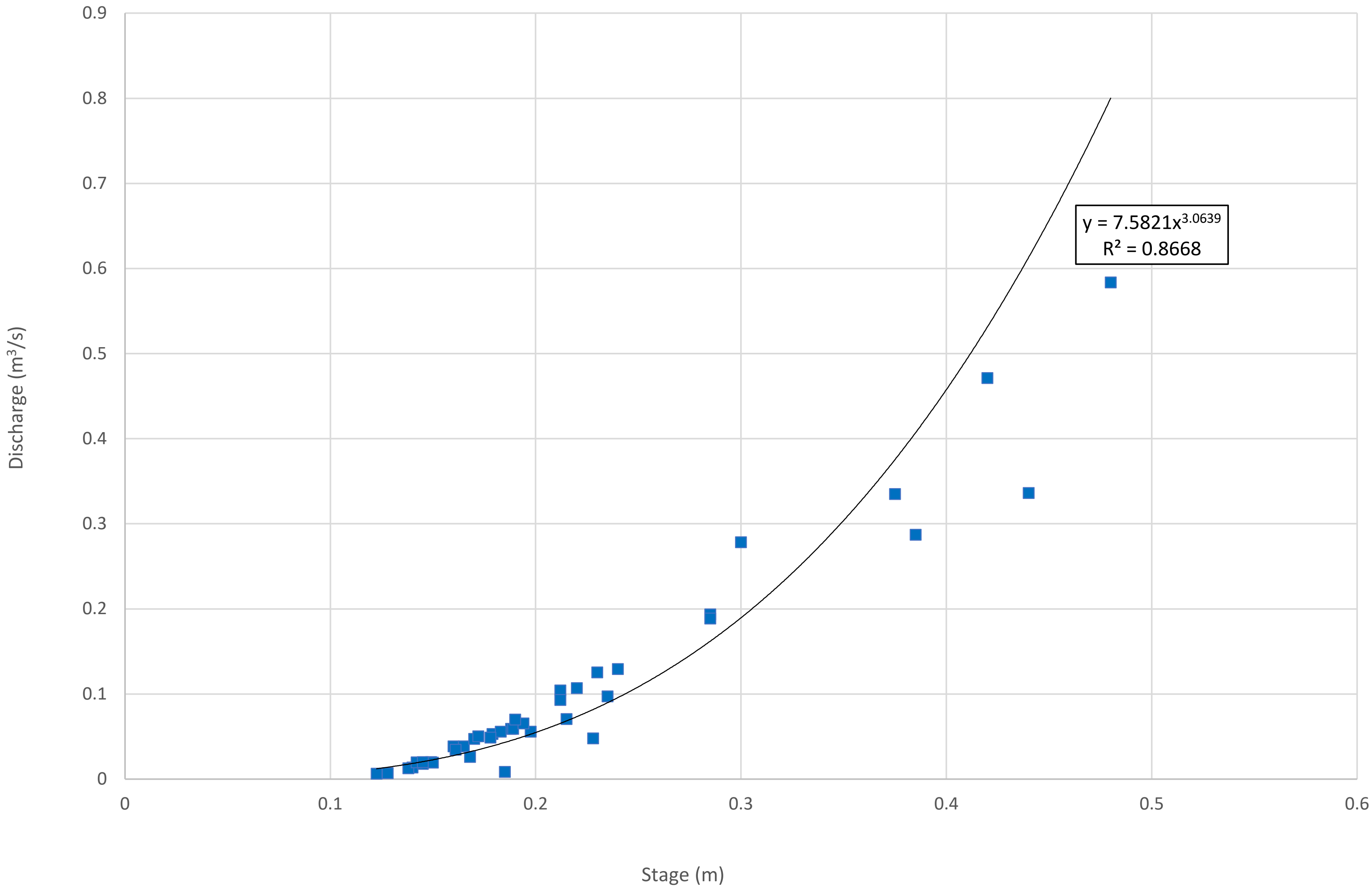
srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo
		MC1 Rating Curve
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017 · Approved: SPB · Figure: 7



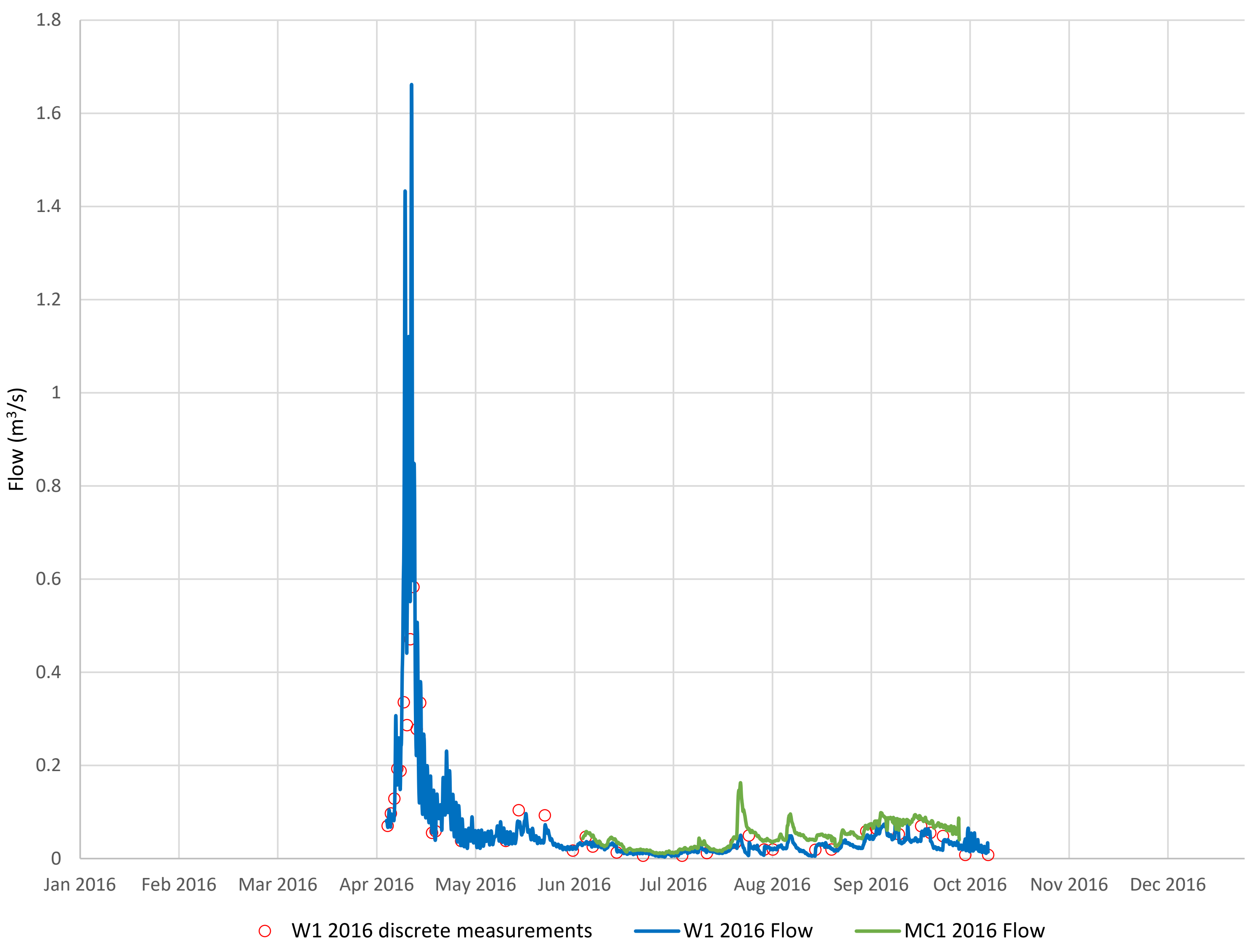
srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo **MC1 Flow Hydrograph**
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017 · Approved: SPB · Figure: **8**



srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo **W1 Stage and Temperature Hydrograph**		
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017	Approved: SPB	Figure: **9**



srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo
		W1 Rating Curve
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017 · Approved: SPB · Figure: **10**



srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo		
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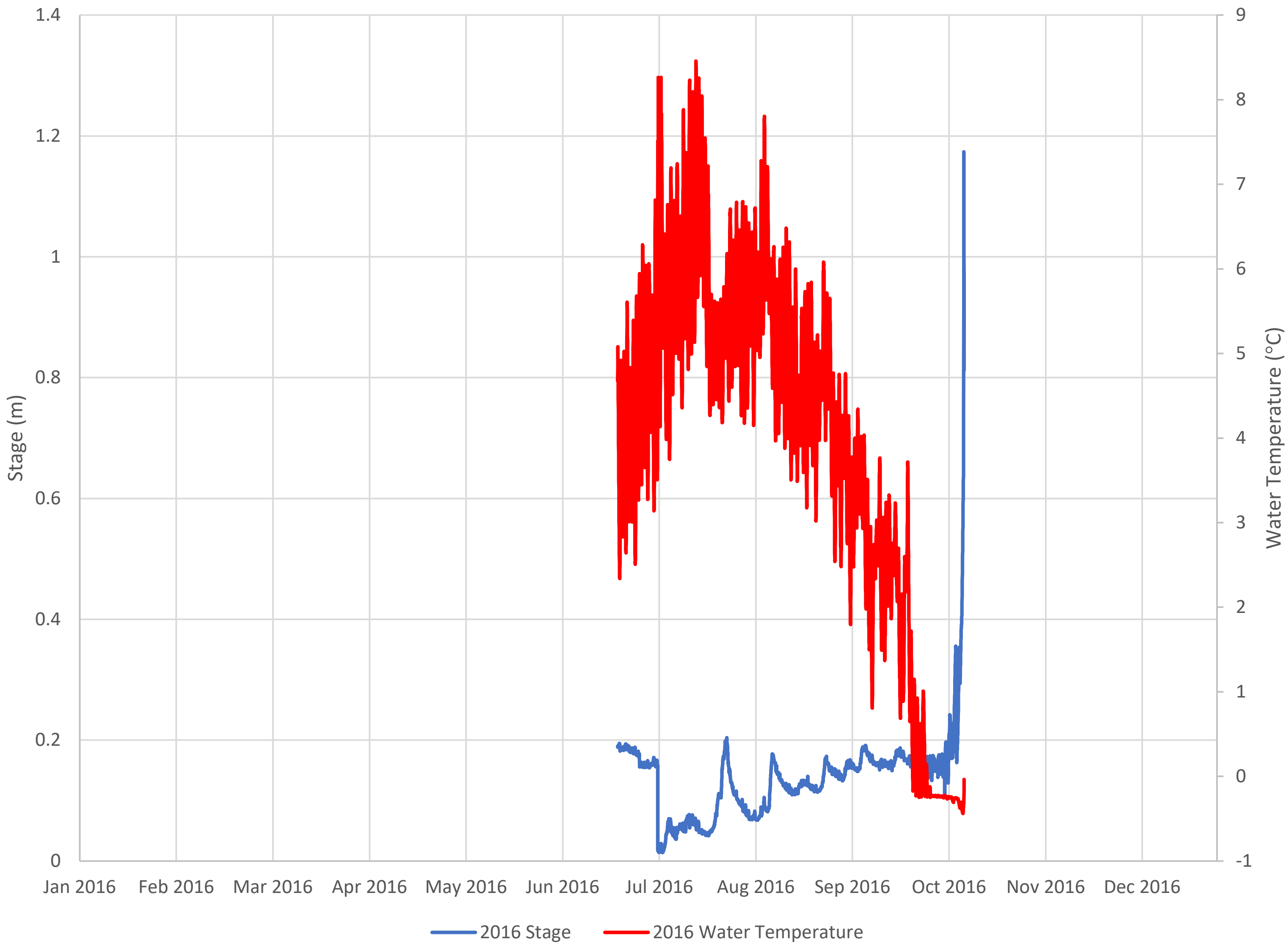
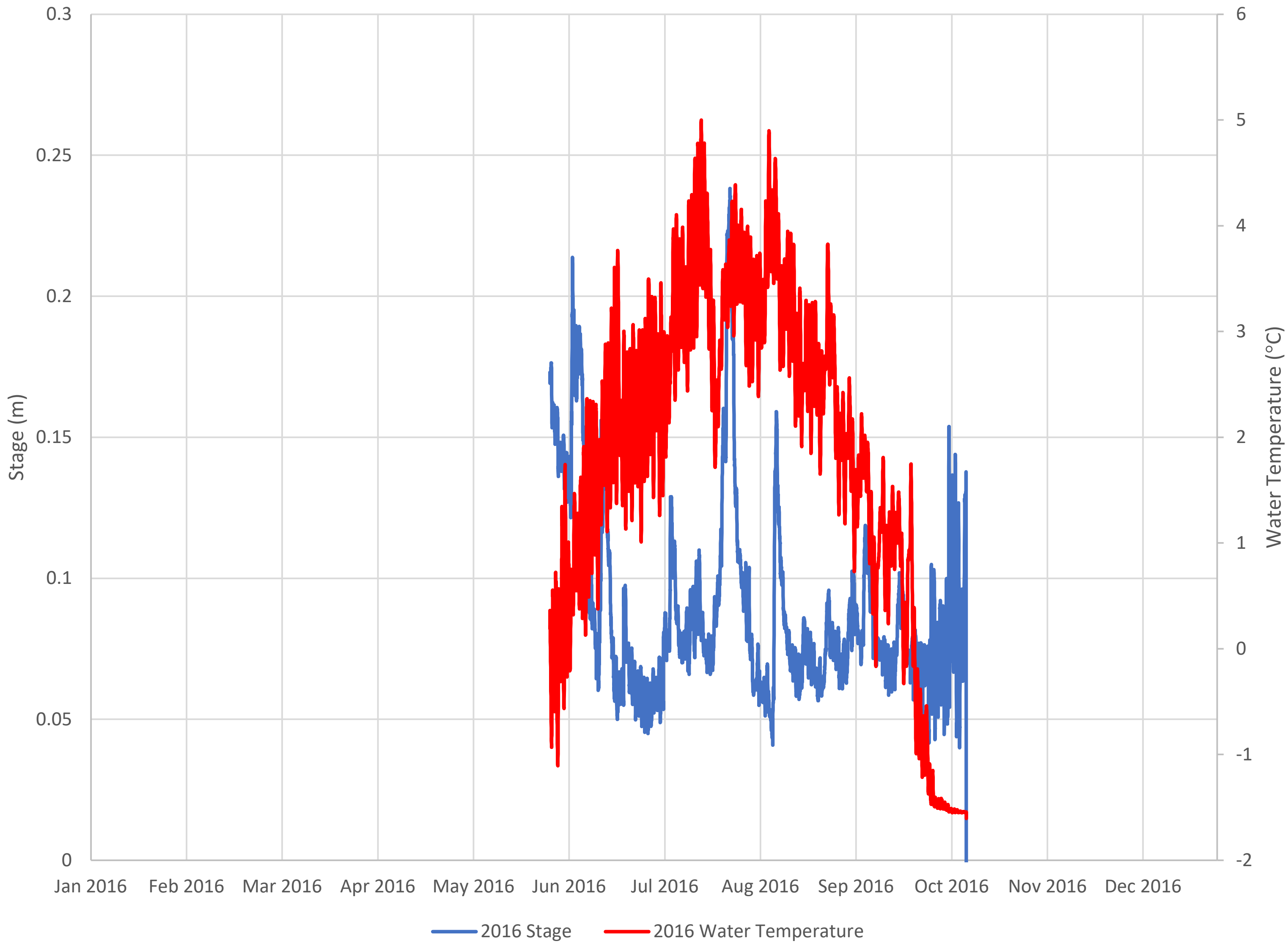
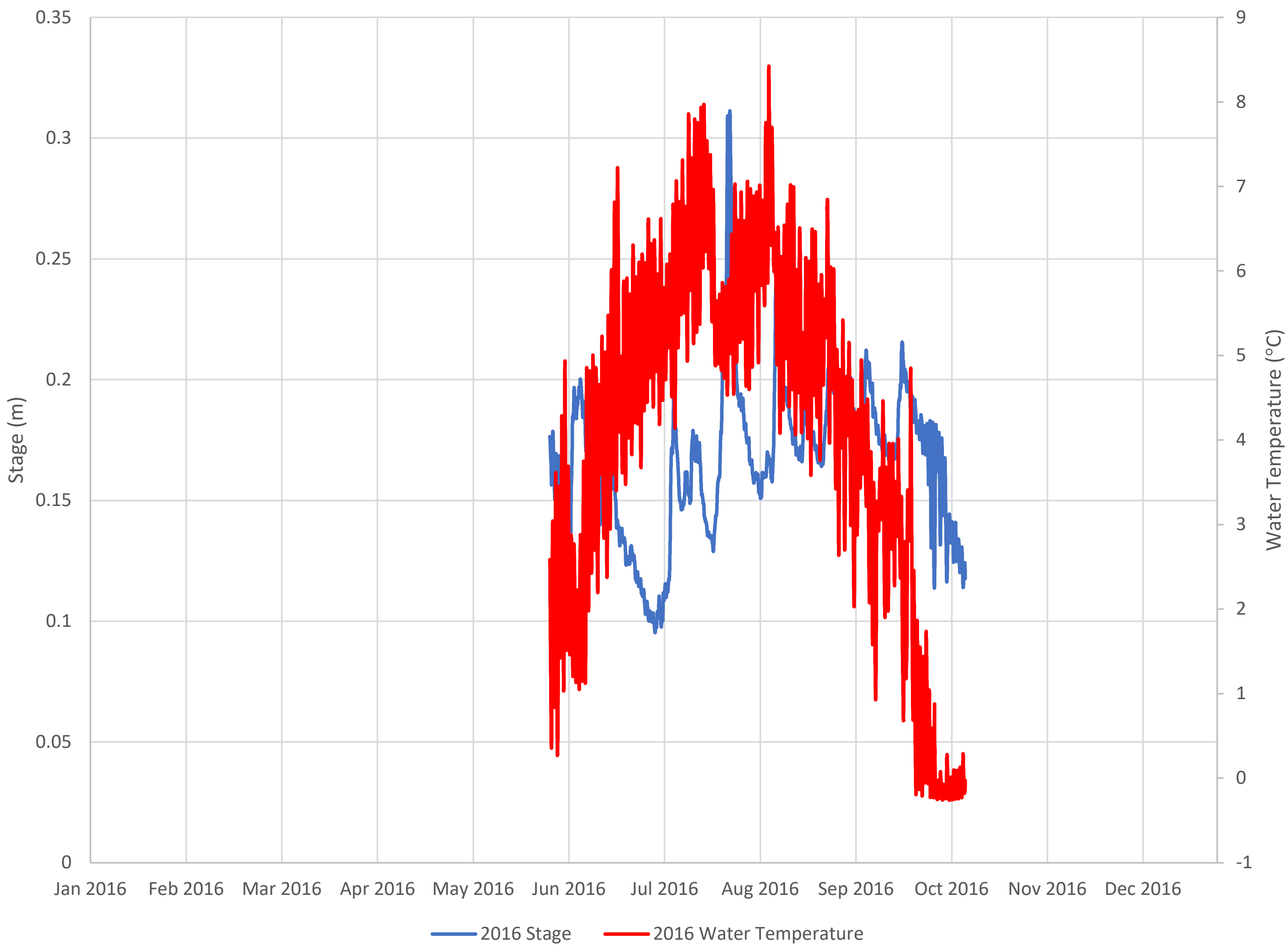


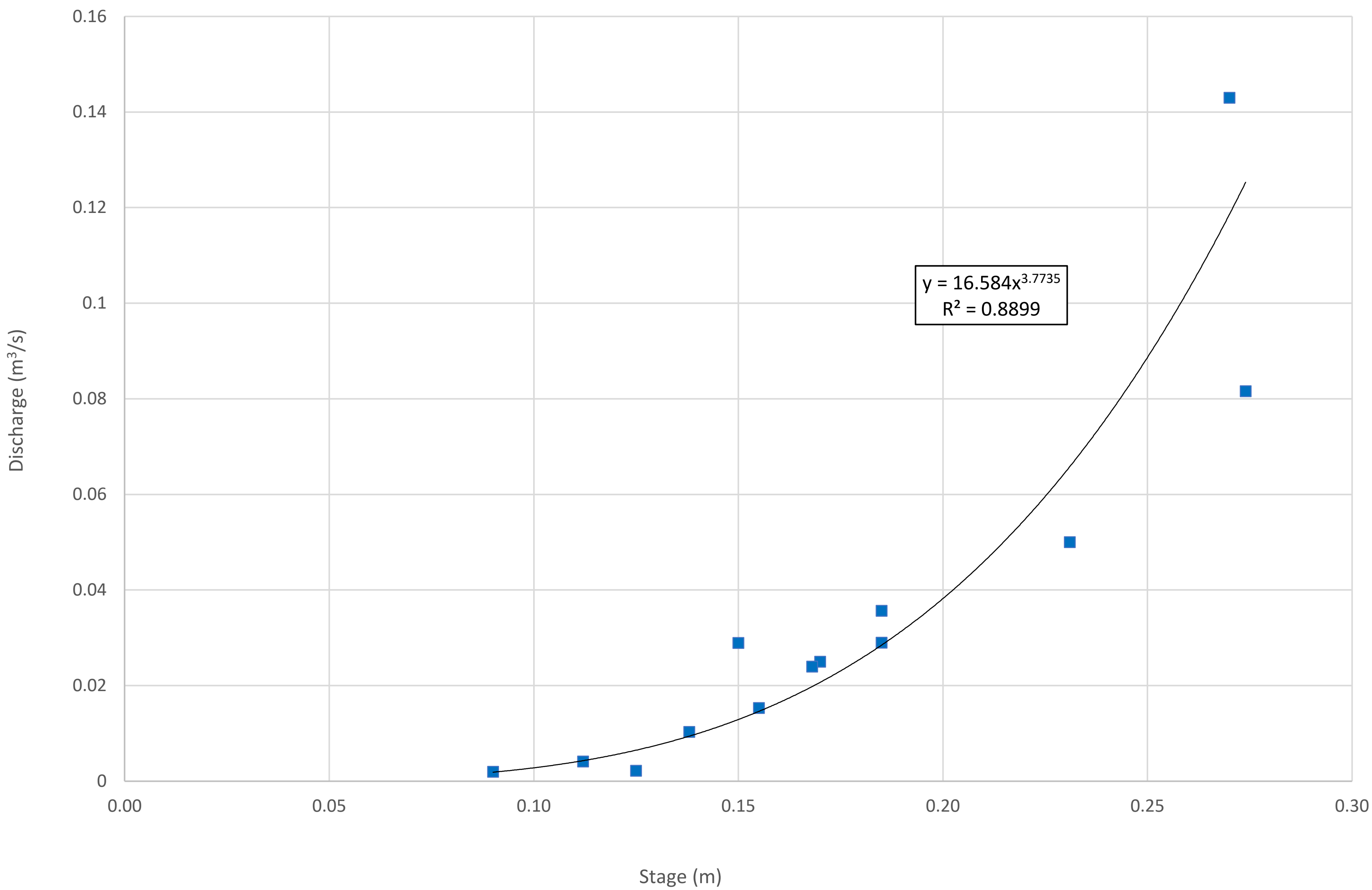
srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo		
		MN-0.5 Stage and Temperature Hydrograph		
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017	Approved: SPB	Figure: **12**



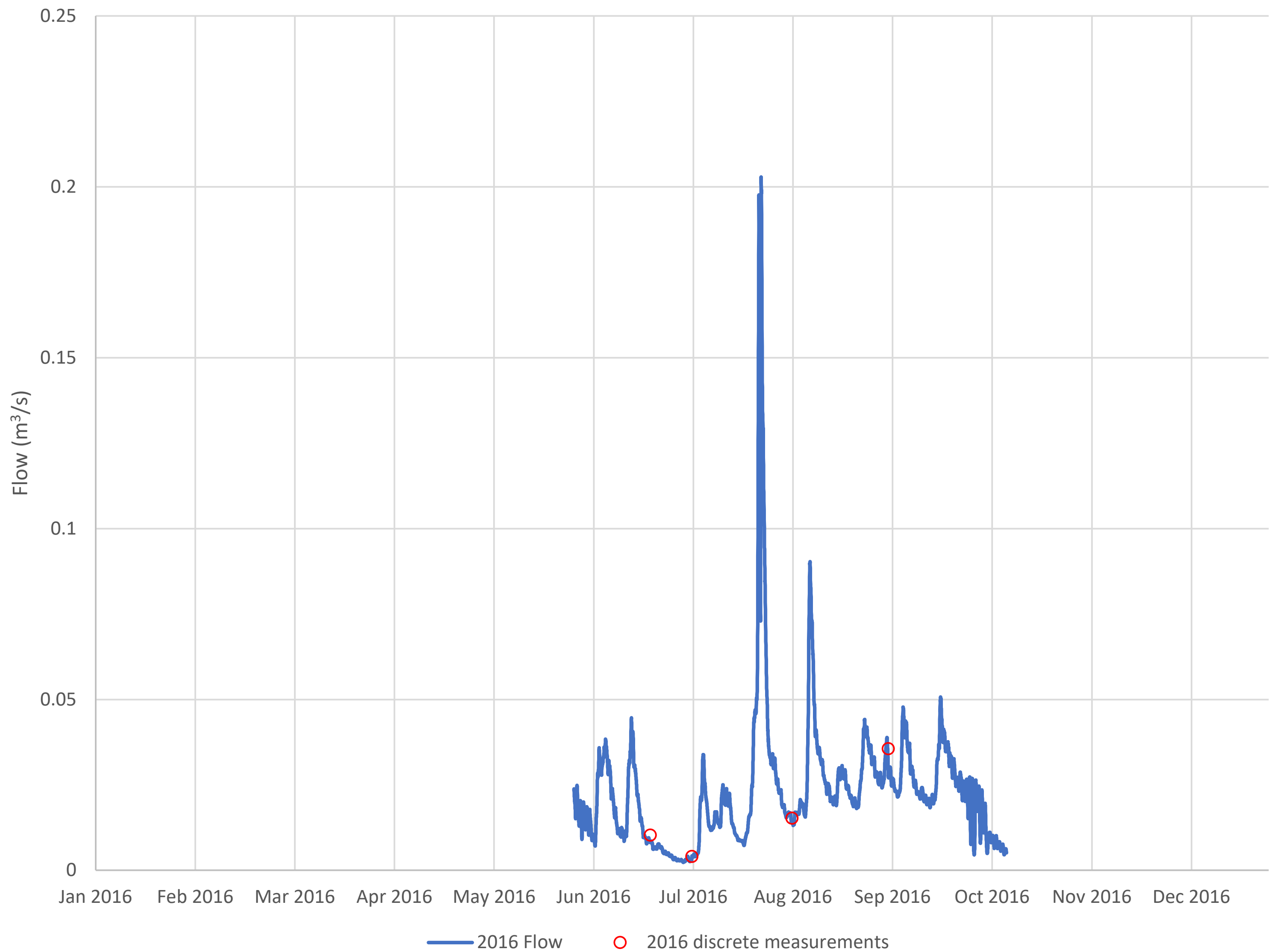
srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo		
		MN-2.5 Stage and Temperature Hydrograph		
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017	Approved: SPB	Figure: **13**



srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo **MN-4.5 Stage and Temperature Hydrograph**
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017 / Approved: SPB / Figure: **14**



srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo
		MN-4.5 Rating Curve
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017 | Approved: SPB | Figure: **15**



srk consulting	Minto Explorations Ltd.	Minto and McGinty Creek 2016 Surface Hydrology Memo **MN-4.5 Flow Hydrograph**
Job No: 1CM002.054 Filename: Figures.pptx	Minto	Date: March 23, 2017 · Approved: SPB · Figure: **16**

Appendix I – 2016 Physical Monitoring Plan

Revision 2016-1
Physical Monitoring Plan
Minto Mine, YT

Prepared by:
Minto Explorations Ltd.
Minto Mine
December 2016

Minto Mine Physical Monitoring Plan

First Issue: June 2014

REVISION INFORMATION

Rev. Number	Issue Date	Description & Revisions Made
-	June, 2014	First issue
2015-1	November, 2015	Annual update of existing instrumentation and monitoring frequencies. Instruments Added: A215, A216, A217, A218, A2RAMP01, A2RAMP02, A2RAMP03, A2RAMP04, DSSH-26, DSSH-27, M82, M83, M84, M85, M86, M87, SWD06 Instruments Removed: DSI-14, DSI-21, DSSH-21, DSSH-22, DSSH-23, DSSH-25, WSP2
2016-1	December, 2016	Annual update of existing instrumentation and monitoring frequencies. Instruments Added: DSP-07, DSP-08, DSP-10, DSSH-28, DSSH-29, DSSH-30, DSSH-31, MV1, MV2, SWD-07, SWD-08, SWD-09 Instruments Replaced: DSSH-06, DSSH-10, DSSH-15, DSSH-18, DSSH-19, DSSH-20 Instruments to be installed in 2016: DSI-22, DSI-23, SWD-10, SWD-11 Instruments Removed: A2RAMP01, A2RAMP02, A2RAMP03, A2RAMP04, SWD-02, SWD-02A, SWD-04A, SWD-05A, DSP-09

Updated by:

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Geotechnical Engineer-in-Training

Reviewed by:

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Chief Engineer

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1 Introduction

The following document describes the instrumentation and monitoring program currently in place at Minto to monitor the stability of mining structures including waste rock, tailings, and water storage facilities. The program consists of two main components: instrumentation to measure ground conditions and deformation, and regular geotechnical inspections. The following sections summarize inspection and data collection frequencies, instrument installation details and locations, and data collection procedures.

Mining and monitoring activities at Minto included in this plan are licensed under the following:

- Type A Water Licence QZ14-031, August, 2015
- Type B Water Licence MS15-094, July 2016
- Quartz Mining Licence QML-0001, December, 2014

Existing mine structures at Minto are shown in Figure 1-1, and described in the following section.

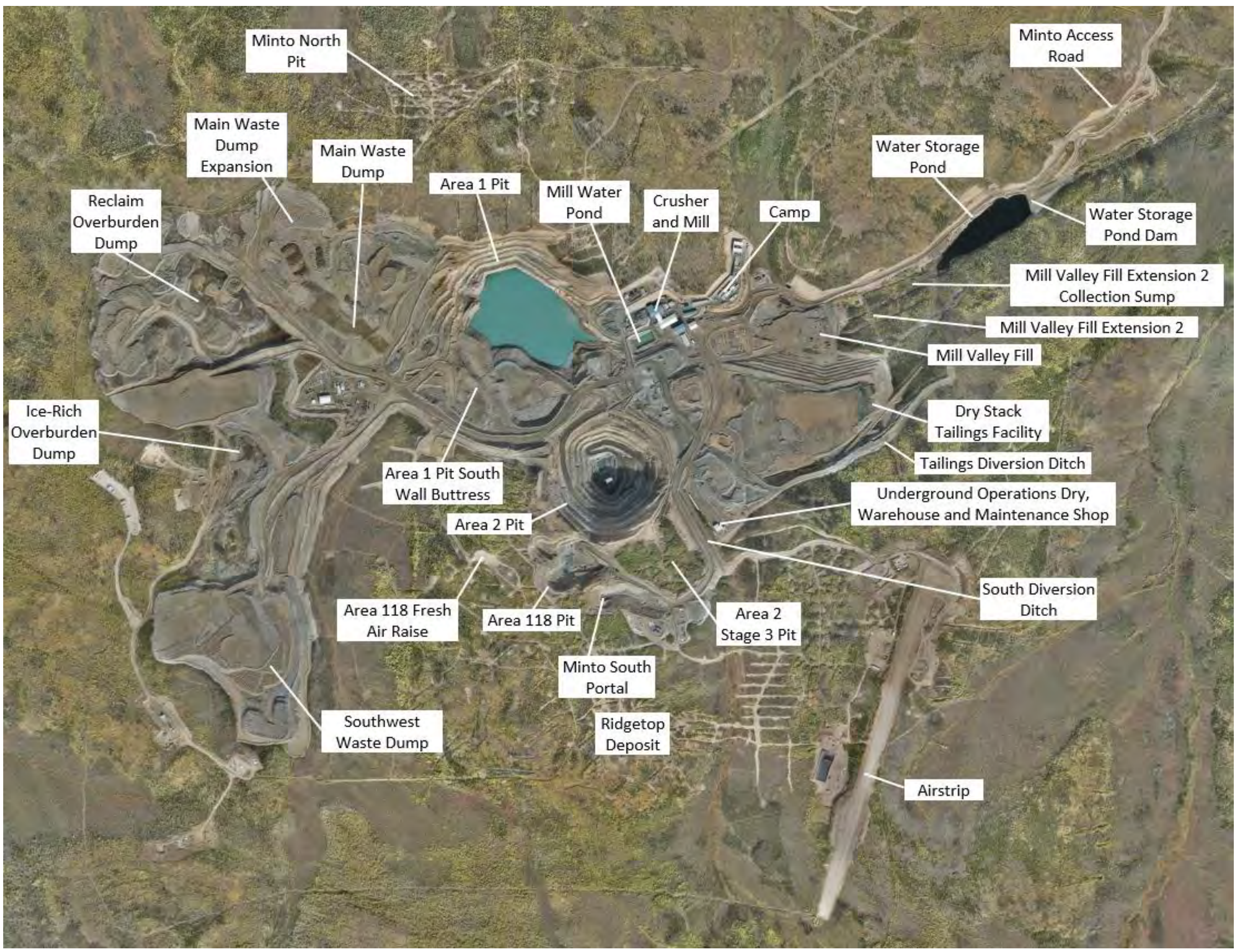


Figure 1-1: Minto site plan (October 2014)

2 Mine Structures

Mine structures currently being monitored at Minto as well as future structures included in the Phase V/VI plan are listed in Table 1.

Table 1: Description of Mine Structures at Minto

Structure	Description	Instrumentation
Area 2 Pit and Area 2 Pit Tailings Management Facility (A2PTMF)	The Area 2 Pit was completed in 2015 to the extents licensed under Phase IV (Stages 1 and 2); the pit will be extended to the south as part of Phase V/VI (Stage 3), scheduled to commence in January, 2017. Tailings deposition Area 2 Stage 2 pit (A2S2) began in March, 2015 and the pit is now maintained as a tailings management facility.	• Survey hubs • GroundProbe radar (during A2S3 mining)
Area 2 Underground	The Area 2 underground began development in 2016 and is accessed by a portal and decline south of the Area 2 and Area 118 Pits. Production mining is currently taking place using a longhole stoping method and is expected to be completed in 2017.	None
Area 118 Pit	Mining of the Area 118 Pit was carried out in 2014. The pit is currently inactive and the access is barrricaded. As part of Area 2 Stage 3 pit mining, overburden will be dispatched to the Area 118 pit, scheduled to start in January, 2017.	• Survey hubs
Area 118 In-Pit Dump	The Area 118 In-Pit Dump is included in the Phase V/VI licence and has not commenced yet. The dump will fill in the Area 118 Pit. It is scheduled to commence in January, 2017 as part of A2S3 pit mining.	None
Area 118 Underground	The Area 118 underground began development in 2013 and was completed in 2016. It is accessed by a portal and decline south of the Area 2 and Area 118 Pits. Production mining took place using a longhole stoping method.	None
Big Creek Bridge	Bridge on the Minto access road crossing Big Creek, located at Km 19. Licenced under Type B water licence MS15-094.	None
Barge Landings	Barge landings on the Minto access road at the yukon river. Licensed under Type B water license MS15-094.	None
Camp	The camp consists of several connected bunkhouse buildings (Sherwood, Minto, Selkirk), a kitchen buidling, and several separate buildings including the gym and Site Services offices.	None
Dry Stack Tailings Storage Facility (DSTSF)	Construction of the DSTSF with filtered tailings placement was carried out from 2007 to November 2011. As part of progressive reclamation activities in 2012-2013, the DSTSF was covered with a layer of overburden approximately one to four meters thick. The DSTSF began showing deformation in 2009, interpreted as primarily horizontal sliding towards the north/northeast on an ice-rich layer in the underlying overburden, several meters above bedrock. The movement has continued since then but at a decreasing rate in response to construction of both the Mill Valley Fill waste rock buttress and the Mill Valley Fill Extension 2 waste rock buttress.	• Survey hubs • Thermistors • Inclinometers • Piezometers
Ice Rich Overburden Dump (IROD)	Originally constructed as a free-standing rockfill structure to contain ice-rich overburden. The IROD is no longer active and is now entirely surrounded by the Southwest Waste Dump rockfill.	None
Main Pit (Area 1 Pit) and Main Pit Tailings Management Facility (MPTMF)	Mining in the Main Pit was completed in 2011. Instability in the south wall of the pit occurred in 2009 during mining of Stage 3 of the pit, and subsequently a larger failure occurred in 2011 after completion of Stage 5. Continued sloughing and creep movement of the south wall led to the design and	• Survey hubs • Inclinometer

Structure	Description	Instrumentation
	construction of a waste rock buttress, known as the South Wall Buttress, completed in 2013. Slurry tailings deposition into the pit began in 2012 and the pit is now maintained as a tailings management facility. Dumping of NP:AP<3 waste rock (SAT), intended to be below the final water table at closure, continues into the pit, forming several benches of "in-pit dumps". Tension cracking on the west in-pit dump is monitored with a series of survey hubs installed in 2015 as recommended in previous inspection reports.	
Main Pit Dump	The Main Pit Dump is included in the Phase V/VI licence and has not commenced yet. The dump will be located on the southwest side of the Main Pit, partially on top of the South Wall Buttress. It is scheduled to commence in January, 2017 as part of A2S3 pit mining.	None
Main Waste Dump (MWD)	The Main Waste Dump stores waste rock released during the mining of the first three stages of the Main Pit. The dump is no longer active.	• Inclinometer
Main Waste Dump Expansion (MWDE)	This dump is an extension of the MWD that stores waste rock released from the Minto North Pit. The dump is no longer active. Reclamation re-sloping began in 2016.	• Inclinometer
Mill Site	The mill site consists of the mill building, crusher and crusher stockpile pad.	None
Mill Valley Fill Extension (MFVE)	A waste rock buttress to the north of the DSTSF, constructed from January 2012 to March 2013 to prevent or decrease movement of the DSTSF.	• Survey hubs
Mill Valley Fill Extension 2 (MVFE2)	An extension of the MVFE waste rock buttress to the northeast, constructed from November 2015 toAugust 2016 to further decrease movement of the DSTSF.	• Piezometers • Survey hubs • Inclinometers
Mill Valley Fill Extension 2 Collection Sump	A replacement sump for the Minto Creek Detention Structure (MCDS), constructed in 2016. It detains surface water considered impacted from upstream sub-catchment areas and directs it to the MPTMF or water treatment plant.	None
Minto Access Road	Road from the Yukon River barge crossing to the mine site. Licenced under Type B water licenceMS15-094.	None
Minto East, Copper Keel, Wildfire Underground	The Minto East, Copper Keel and Wildfire underground are in the phase V/VI mining plan and have not commenced yet.	N/A
Minto North Pit	Mining of the North Pit was completed in Septmember 2016. The pit is currently inactive and the access is barrricaded.	None
Ore Stockpiles	There are two primary ore stockpiles on site – North and South stockpile. These are located south of the crusher and east of the Area 2 pit.	None

Structure	Description	Instrumentation
Reclamation Overburden Dump (ROD)	Received the bulk of the overburden released as part of Phase IV and earlier mining of the Main Pit. The material in the ROD is available for use in reclamation of the mine at closure.	None
Ridgetop Pit (Ridgetop North Pit, Ridgetop South Pit)	The Ridgetop Pit (North and South) is included in the Phase V/VI licence and has not commenced yet.	• Thermistors
Ridgetop Waste Dump	The Ridgetop Waste Dump is included in the Phase V/VI licence and has not commenced yet.	N/A
South Diversion Ditch (SDD)	A diversion ditch located southeast of the Area 2 Pit to divert unimpacted surface water around the mine workings.	None
South Wall Buttress (SWB)	Waste rock buttress constructed against the Main Pit south wall from 2009-2011 as a result of instability in the south wall of the pit.	• Survey hubs
Southwest Waste Dump (SWD)	The Southwest Waste Dump (SWD) stores waste rock released during phase IV mining. Dumping at the SWD is now complete and reclamation re-sloping began in 2015. Re-sloping is expected to be completed in 2017.	• Survey hubs • Inclinometers • Thermistors • Piezometers
Tailings Diversion Ditch (TDD)	A diversion ditch located south of the DSTSF to divert unimpacted water around the tailings facility.	None
Water Storage Pond Dam (WSP)	The Water Storage Pond and Dam are located east of the mine along Minto Creek. The dam was constructed in 2006 as a clay-core water retention dam for collecting precipitation and surface water runoff at the site. Maximum depth of water at the face of the dam is approximately 15 m.	• Survey hubs • Thermistors • Piezometers

3 Design and Monitoring References

Table 2 lists the design reports for each structure and the monitoring/inspection guidance reports used to develop the inspection (Section 5) and instrumentation (Section 6) programs for each structure.

Table 2: Design Documents and Monitoring/Inspection Guidance Documents

Structure	Design Reports	Monitoring/Inspection Guidance Reports
Area 2 Pit and Area 2 Pit Tailings Management Facility (A2PTMF)	*Prefeasibility Geotechnical Evaluation, Phase IV, Minto Mine.* SRK, December 2009. *Review of Minto Area 2 West Wall Stability*. SRK, September 11, 2012. *Review of Minto Area 2 West Wall Stability-April 2013*. SRK, April 18, 2013. *Review of Minto Area 2 West Wall Stability-September 2013*. SRK, September 30, 2013. *Main Dam – Area 2 Pit Stability Assessment.* SRK Consulting Project: 1CM002.003.0701, February, 2015.	*Operation, Maintenance, and Surveillance Manual - Area 2 Pit Tailings Management Facility* Revision 2015-2. Minto, December 2015. *Minto Mine Operations Adaptive Management Plan* Revision 2016-01. Minto, May, 2016.
Area 2 Stage 3 Pit	*Pit Slope Stability Evaluation, Minto Mine, Area 2 Pit – Stage 3.* SRK Consulting Project: 219500.190, August 2015.	*Minto Mine Ground Control Plan – Open Pit Operations.* Minto, 2016.
Area 2 Underground	*Area 2 Mining Stability Assessment Summary.* Golder Associates, June, 2016. *Area 2 Mining Stability Assessment Summary.* Golder Associates, December, 2016.	*Minto Mine Ground Control Plan – Underground Operations.* Minto, 2016.
Area 118 Pit	*Prefeasibility Geotechnical Evaluation, Phase IV, Minto Mine.* SRK, December 2009. *Review of Final Area 118 Pit Design*. SRK Consulting, Project: 219500.070. January, 2015.	-
Area 118 In-Pit Dump	*Phase V/IV Ridgetop South and Area 118 Backfill Dumps Physical Stability Assessment.* SRK, October 2013.	-
Area 118 Underground	*Minto 118-Zone – FLAC3D Analysis of the Longhole Base Case Option.* Itasca, August 2014. *Geotechnical Characterization of Existing and Proposed Longhole Open Stope Mining Areas.* Golder Associates File: 1528754-002-R-Rev0-3000. July 30, 2015. *Longhole Open Stope Stability Addendum – Revised Mining Heights.* Golder Associates, File 1528754-006-TM-Rev0-3000, November 2015.	*Minto Mine Ground Control Plan – Underground Operations.* Minto, 2016. *Ground Control Management Plan Review.* Golder Associates, File 1528754-007-TM-Rev0-1000. September 2015.

Structure	Design Reports	Monitoring/Inspection Guidance Reports
	Area 118 Plunge Mining Stability Assessment Summary. Golder Associates, File: 1528754-008-PP-Rev0-5000, December 2015	
Big Creek Bridge	-	-
Camp	-	-
Dry Stack Tailings Storage Facility (DSTSF)	*Geotechnical Design Report, Dry Stack Tailings Storage Facility, Minto Mine, Yukon*. EBA File: 1200173. January 2007.	*Operation, Maintenance, and Surveillance Manual, Dry Stack Tailings Storage Facility, Minto Mine, YT.* Revision 2014-1 Minto, November 2014. *Minto Mine Operations Adaptive Management Plan.* Revision 2016-01. Minto, May, 2016.
Ice Rich Overburden Dump (IROD)	*Geotechnical Design Ice-Rich Overburden Dump, Minto Mine, Minto, YT.* EBA file: 1200173. January 2006. *Ice-Rich Overburden Dump Containment Berm Inspection Report, Minto Mine Site, Minto Yukon.* EBA File: 1200173.001. June 19, 2007.	*Geotechnical Design Ice-Rich Overburden Dump, Minto Mine, Minto, YT.* EBA file: 1200173. January 2006. EBA, 2007. *Minto Mine Operations Adaptive Management Plan* Revision 2016-01. Minto, May, 2016. .
Main Pit (Area 1 Pit) and Main Pit Tailings Management Facility (MPTMF)	*Pit Slope Evaluation for Area 1 Open Pit.* SRK Consulting, Project: 2CM022.03, July 2007. *SAT Dump on Tailings.* SRK Consulting Project: 1CM002.043, March 2016.	*Operation, Maintenance, and Surveillance Manual - Main Pit Tailings Management Facility*. Revision 2015-2 Minto, December, 2015. *Minto Mine Operations Adaptive Management Plan* Revision 2016-01. Minto, May, 2016.
Main Pit Dump	*Phase V/VI Main Pit Dump Physical Stability Assessment.* SRK Consulting Project: 1CM002.003.0701, November, 2013. *Update to the Main Pit Dump Physical Stability Assessment.* SRK Consulting Project: 1CM002.003.0701. February, 2015.	-
Main Waste Dump (MWD)	*Geotechnical Evaluation Proposed Main Waste Dump Minto Mine, Minto, YT.* EBA. April, 1998.	*Geotechnical Evaluation Proposed Main Waste Dump Minto Mine, Minto, YT.* EBA. April, 1998. *Minto Mine Operations Adaptive Management Plan* Revision 2016-01. Minto, May, 2016.
Main Waste Dump Expansion (MWDE)	*Minto Mine Phase V/VI Expansion Waste Rock and Overburden Management Plan.* Minto. June, 2014. *Phase V/VI Main Waste Dump Expansion – Physical Stability Assessment.* SRK Consulting Project: 1CM002.012.012, November, 2013	*Minto Mine Operations Adaptive Management Plan* Revision 2016-01. Minto, May, 2016.
Mill Site	-	-

Structure	Design Reports	Monitoring/Inspection Guidance Reports
Mill Valley Fill Extension (MFVE)	*Waste Rock and Overburden Management Plan, Phase IV Development, Minto Mine YT.* EBA File: W14101068.015. September 9, 2011. *Upstream Water Management for the Mill Valley Fill Expansion and Dry Stack Tailings Storage Facility.* EBA File: W14101168.013. September 14, 2011.	*Minto Mine Operations Adaptive Management Plan* Revision 2016-01. Minto, May, 2016.
Mill Valley Fill Extension 2 (MVFE2)	*Minto Mine Phase V/VI Expansion Waste Rock and Overburden Management Plan.* Minto. June, 2014. *Mill Valley Fill Extension Stage 2 Preliminary Design Report.* SRK Consulting Project: 1CM002.015. March, 2014 *Mill Valley Fill Extension Stage 2 Final Design Report.* SRK Consulting Project: 1CM002.040. September, 2015. *Mill Valley Fill Extension Stage 2 Record of Construction.* Minto. November, 2016.	*Mill Valley Fill Extension Stage 2 – Expected Performance and Evaluation Criteria.* SRK Consulting Project: 1CM002.050, November, 2016. *Minto Mine Operations Adaptive Management Plan* Revision 2016-01. Minto, May, 2016. .
Mill Valley Fill Extension 2 Collection Sump	*Design for the MVFE Stage 2 Collection Sump.* SRK Consulting Project: 1CM002.020. June, 2015. *Mill Valley Fill Extension Stage 2 Colleciton Sump Record of Construction*. Minto. April, 2016.	-
Minto Access Road	-	-
Minto East, Copper Keel, Wildfire Underground	*Wildfire Proposed Underground Mine Area – Geotechnical Characterization and Long Hole Open Stope Stability Assessment.* Golder Associates, September, 2016. *Minto East – Revised Longhole Open Stope Stability.* Golder Associates, File: 1528754-009-TM-Rev0-6000, January, 2016. *Geotechnical Characterization of Existing and Proposed Longhole Open Stope Mining Areas,* Golder Associates, Reference No. 1528754-002-R-Rev0-3000, July, 2015. *Minto Mine Underground Reserve Update Geotechnical Input*, Golder Associates, Reference No. 1528754-003-R-Rev0-3000, July, 2015. *Minto Phase VI Underground Geotech Evaluation*, SRK Consulting Project: 2UC031.005, February, 2012.	-
Minto North Pit	*Minto North South Wall Wedge Analysis.* SRK, August, 2016. *Site Visist and Review of North Pit – South Wall.* BGC Engineering, July, 2016. *Review of Minto North Wall Stability.* SRK, May, 2016.	*Minto Open Pit Ground Control Plan_Rev0.* Minto, 2016.

Structure	Design Reports	Monitoring/Inspection Guidance Reports
	Minto Phase VI Preliminary Feasibility Study Technical Report. SRK, January 2012.	
Ore Stockpiles	-	-
Reclamation Overburden Dump (ROD)	*Geotechnical Design Proposed Reclamation Overburden Dump, Minto Mine, Yukon.* EBA File: W14101068.004. February 2008. *Reclamation Overburden Dump Expansion Geotechnical Design Report.* EBA File: W14101068.0040. June 29, 2010.	*Reclamation Overburden Dump Expansion Geotechnical Design Report.* EBA File: W14101068.0040. June 29, 2010. *Minto Mine Operations Adaptive Management Plan* Revision 2016-01. Minto, May, 2016.
Ridgetop Pit (Ridgetop North Pit, Ridgetop South Pit)	*Pre-Feasibility Geotechnical Evaluation Phase IV Minto Mine,* SRK Consulting Project: 2CM022.006, December, 2009. *Ridgetop North Pit TMF Stability Assessment,* SRK Consulting Project: 1CM002.003.710, February, 2015.	-
Ridgetop Waste Dump	*Phase V/VI Ridgetop Waste Dump Physical Stability Assessment.* SRK Consulting Project: 1CM002.012.0.12, November, 2013.	-
South Diversion Ditch (SDD)	*Phase 1 – Preliminary Engineering, Stormwater Diversion Ditches Minto Mine, YT,* EBA File: W14101068.013	-
South Wall Buttress	*Area 1 South Wall Buttress Design Report, Minto Mine, Yukon.* EBA File: W141010668.012, July 2011.	-
Southwest Waste Dump (SWD)	*Geotechnical Design Proposed Southwest Waste Dump, Minto Mine, Yukon.* EBA File: W14101068.005. September 2008.	*Geotechnical Design Proposed Southwest Waste Dump, Minto Mine, Yukon.* EBA File: W14101068.005. September 2008. *Minto Mine Operations Adaptive Management Plan* Revision 2016-01. Minto, May, 2016.
Tailings Diverion Ditch (TDD)	*Preliminary Design of the Tailings Diversion Ditch Upgrade,* SRK Consulting Project: 1CM002.012.006, November, 2013.	-
Water Storage Pond Dam (WSP)	*Geotechnical Design Tailings/Water Dam, Minto Project, Yukon.* EBA File: 0201-95-11509. Dec. 1995. *As-built Construction Report, Water Retention Dam, Minto Mine, Minto, YT.* EBA File: 1200173.001. April 2008.	*Operation, Maintenance and Surveillance Manual, Water Retention Dam, Minto Mine, Minto, YT.* EBA File: W14103414-01. August 2014.

4 Roles and Responsbilities

Table 3 lists the roles and responsibilites for physical monitoring on the site.

Table 3: Roles and Responsibilities

Role	Responsibilities
Mine Technician Assistants	• Collect instrumentation data at specified frequencies • Input data into monitoring spreadsheets/databases • Internal reporting of monitoring data • Maintain equipment
Geotechnical Engineers	• QA/QC of data collection • Ensure compliance with license requirements • Monthly and annual Water Licence reporting • Visual inspections at specified frequencies • Communicate with consultants as required • Review and update Physical Monitoring Plan
Environmental Officers	• Compile monthly and annual Water Licence reports • Visual inspections of water diversion/collection structures
Chief Engineer	• Review monthly and annual Water Licence reports • Ensure compliance with licence requirements

5 Inspections

Table 4 lists the regular, required inspections.

Table 4: Inspections

Structure	Frequency	Description
Area 2 Pit and Area 2 Pit Tailings Management Facility (A2PTMF)	Quarterly	Visual inspection by Geotechnical Engineer and review of monitoring data as per OMS Manual.
Area 2 Stage 3 Pit	Weekly (during active mining)	Weekly visual inspection by Geotechnical Engineer/EIT during active pit mining. Documented in weekly wall inspection report and two-week operating plan documents.
Area 2 Underground	Quarterly	Visual inspection by Geotechnical Engineer as per Underground Ground Control Plan.
Area 118 Pit	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Area 118 In-Pit Dump	Minimum every 4 hours during active dumping	Visual inspection by the supervisor or other competent person (typically the Pelly Shifter or Minto Operations Supervisor) as per O.I.C. 2006/178 Clause 15.44.
Area 118 Underground	N/A	No longer accessible.
Big Creek Bridge	Annually	Visual inspection by a Professional Engineer as per MS15-094.
Camp	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Dry Stack Tailings Storage Facility (DSTSF)	Monthly	Visual inspection by Geotechnical Engineer and review of monitoring data as per OMS Manual.
Ice Rich Overburden Dump (IROD)	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Main Pit (Area 1 Pit) and Main Pit Tailings Management Facility (MPTMF)	Quarterly	Visual inspection by Geotechnical Engineer and review of monitoring data as per OMS Manual.

Structure	Frequency	Description
Main Pit Dump	Minimum every 4 hours during active dumping	Visual inspection by the supervisor or other competent person (typically the Pelly Shifter or Minto Operations Supervisor) as per O.I.C. 2006/178 Clause 15.44.
Main Waste Dump (MWD)	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Main Waste Dump Expansion (MWDE)	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Mill Site	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Mill Valley Fill Extension (MFVE)	Monthly	Visual inspection by Geotechnical Engineer and review of monitoring data as part of DSTSF monthly inspection.
Mill Valley Fill Extension 2 (MVFE2)	Monthly	Visual inspection by Geotechnical Engineer and review of monitoring data as part of DSTSF monthly inspection.
Mill Valley Fill Extension 2 Collection Sump	Monthly	Visual inspection by Geotechnical Engineer and review of monitoring data as part of DSTSF monthly inspection.
Minto Access Road	Annually	Visual inspection by a Professional Engineer as per MS15-094.
Minto East, Copper Keel, Wildfire Underground	N/A	N/A – structure does not exist yet.
Minto North Pit	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Ore Stockpiles	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Reclamation Overburden Dump (ROD)	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.

Structure	Frequency	Description
Ridgetop Pit (Ridgetop North Pit, Ridgetop South Pit)	N/A	N/A – structure does not exist yet.
Ridgetop Waste Dump	N/A	N/A – structure does not exist yet.
South Diversion Ditch (SDD)	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
South Wall Buttress (SWB)	Quarterly	Visual inspection by Geotechnical Engineer and review of monitoring data as part of the MPTMF quarterly inspection.
Southwest Waste Dump (SWD)	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Tailings Diversion Ditch (TDD)	Semi-Annually – May/June post thaw, and September pre freeze-up	Included in site-wide geotechnical inspection - Inspection and data review by Professional Engineer as per QZ14-031 (Clause 100) and QML-0001 (Clause 13.2). Q2 inspection must be completed by an independent engineer by June 30 each year.
Water Storage Pond Dam (WSP)	Monthly	Visual inspection by Geotechnical Engineer as per OMS Manual.

6 Instrumentation

A map of site wide active instrumentation is shown in Appendix A. Installation information and data collection schedules are contained in the following sections.

Inclinometers

Inclinometers are used to measure lateral, differential ground movement in a borehole. Inclinometer stations consist of grouted, slotted PVC pipe into which the inclinometer probe is lowered and deflection is measured at 0.5m intervals. The current probe used on site is an RST digital MEMS inclinometer system.

Table 5: Inclinometers

Area	ID	Northing (m)	Easting (m)	Elevation (m)	A0 Azimuth	Hole Depth (m)	Date Installed	Reading Frequency
Area 2 Pit	A2I-1	6944164.73	385298.95	822.46	302	55.5	2013-04-26	Quarterly
Dry Stack Tailings Storage Facility and Mill Valley Fill Extension 2	DSI-22	-	-	-	-	-	To be installed in Q4 2016	Bi-weekly
Dry Stack Tailings Storage Facility and Mill Valley Fill Extension 2	DSI-23	-	-	-	-	-	To be installed in Q4 2016	Bi-weekly
Dry Stack Tailings Storage Facility and Mill Valley Fill Extension 2	DSI-24	-	-	-	-	-	To be installed in Q4 2016	Bi-weekly
Main Pit (Area 1 Pit) and Main Pit Tailings Management Facility (MPTMF)	MDI -2	6945013.08	384217.20	858.67	93	50.5	2010-02-10	Quarterly
Southwest Waste Dump	SDI-3	6944591.11	383966.00	847.42	90	46.5	2010-02-11	Quarterly

Survey Hubs

Survey hubs are used to monitor surface movement of structures and are comprised of steel posts cemented into waste rock or bedrock and equipped with a threaded base to which a high precision RTK-corrected GPS instrument is attached. The GPS currently used on site is a Trimble R8.

Table 6: Survey Hubs

Area	ID	Northing (m)	Easting (m)	Elevation (m)	Date Installed	Frequency
Area 2 Pit	A210	6944268.42	384934.69	861.28	2011-07-01	Monthly
Area 2 Pit	A215	6944649.45	385155.49	808.72	2015-09-17	Monthly
Area 2 Pit	A216	6944749.21	385046.39	805.78	2015-09-17	Monthly
Area 2 Pit	A217	6944756.78	384852.52	806.68	2015-09-17	Monthly
Area 2 Pit	A218	6944707.23	384783.21	806.83	2015-09-17	Monthly
Dry Stack Tailings Storage Facility	ASH05	6944280.52	385830.65	850.16	2011-03-07	Monthly
Dry Stack Tailings Storage Facility	ASH06	6944331.73	385623.79	824.17	2011-03-07	Monthly
Dry Stack Tailings Storage Facility	DSSH-24	6944757.90	385712.10	792.07	2014-02-28	Weekly
Dry Stack Tailings Storage Facility	DSSH-26	6944601.28	385490.96	796.35	2015-07-28	Weekly
Dry Stack Tailings Storage Facility	DSSH-27	6944755.11	385894.59	792.70	2015-07-28	Weekly
Dry Stack Tailings Storage Facility	DSSH-06	6944971.372	385553.396	783.866	2016-08-21	Weekly
Dry Stack Tailings Storage Facility	DSSH-10	6944992.584	385806.037	769.004	2016-08-21	Weekly
Dry Stack Tailings Storage Facility	DSSH-12	6944947.303	385707.165	778.364	2016-08-16	Weekly
Dry Stack Tailings Storage Facility	DSSH-14	6944920.27	385606.55	782.88	2012-04-21	Weekly
Dry Stack Tailings Storage Facility	DSSH-15	6944944.092	385490.104	784.82	2016-08-16	Weekly
Dry Stack Tailings Storage Facility	DSSH-17	6944980.74	385896.26	772.07	2012-04-21	Weekly
Dry Stack Tailings Storage Facility	DSSH-18	6945070.727	385513.039	782.379	2016-08-16	Weekly
Dry Stack Tailings Storage Facility	DSSH-19	6945109.679	385575.406	781.303	2016-08-16	Weekly
Dry Stack Tailings Storage Facility	DSSH-20	6945072.083	385754.334	775.779	2016-08-21	Weekly
Dry Stack Tailings Storage Facility	DSSH-28	6945045.688	385931.012	767.752	2016-08-21	Weekly
Dry Stack Tailings Storage Facility	DSSH-29	6945162.176	385833.535	766.045	2016-08-21	Weekly
Dry Stack Tailings Storage Facility	DSSH-30	6944883.247	385890.044	789.008	2016-08-21	Weekly
Dry Stack Tailings Storage Facility	DSSH-31	6945030.732	386040.736	776.254	2016-11-01	Weekly
Dry Stack Tailings Storage Facility	MV1	6945249.731	386021.140	727.554	2016-04-04	Weekly
Dry Stack Tailings Storage Facility	MV2	6945216.537	385979.321	740.349	2016-04-04	Weekly
South Wall Buttress	M73	6944723.57	384312.30	840.77	2011-05-23	Monthly

Area	ID	Northing (m)	Easting (m)	Elevation (m)	Date Installed	Frequency
South Wall Buttress	M75	6944639.43	384475.64	837.55	2011-05-23	Monthly
South Wall Buttress	M76	6944623.10	384560.12	835.27	2011-05-23	Monthly
South Wall Buttress	M79	6944846.97	384208.90	847.66	2011-09-04	Monthly
South Wall Buttress	M80	6944931.70	384256.33	842.06	2011-09-04	Monthly
Main Pit	M81	6944971.63	384890.13	806.83	2012-05-08	Monthly
South Wall Buttress	M82	6944844.39	384433.50	820.17	2015-05-23	Bi-weekly
South Wall Buttress	M83	6944947.98	384475.79	809.06	2015-01-08	Bi-weekly
South Wall Buttress	M84	6945021.46	384445.11	807.37	2015-01-08	Bi-weekly
South Wall Buttress	M85	6944846.60	384315.66	826.08	2015-07-27	Monthly
South Wall Buttress	M86	6944668.03	384400.26	837.96	2015-07-27	Monthly
South Wall Buttress	M87	6944894.30	384383.86	821.67	2015-09-19	Bi-weekly
Southwest Waste Dump	SWD01	6944760.85	384077.86	859.07	2011-03-07	Monthly
Southwest Waste Dump	SWD05A	6943939.94	383837.70	869.16	2011-03-07	Monthly
Southwest Waste Dump	SWD06	6944762.06	384189.37	836.42	2015-07-27	Monthly
Southwest Waste Dump	SWD07	6944743.49	384111.649	840.00	2016-11-21	Monthly
Southwest Waste Dump	SWD08	6944560.14	383883.182	867.25	2016-11-21	Monthly
Southwest Waste Dump	SWD09	6944163.106	383790.749	861.532	2016-11-21	Monthly
Southwest Waste Dump	SWD10	-To be installed Q1, 2017 as a replacement for SWD-05A				Monthly
Southwest Waste Dump	SWD11	To be installed Q1, 2017 as a replacement for SWD-03A				Monthly
Water Storage Pond Dam	WSP1	6945613.04	386480.98	723.31	2011-06-09	Monthly
Water Storage Pond Dam	WSP3	6945551.85	386548.62	719.73	2011-06-09	Monthly
Water Storage Pond Dam	WSP4	6945531.56	386555.22	719.93	2011-06-09	Monthly
Water Storage Pond Dam	WSP5	6945504.74	386560.23	721.02	2011-06-09	Monthly

Thermistors

Thermistor strings are used to measure ground temperature profiles in boreholes, and in particular permafrost conditions at Minto. Thermistor strings consist of multiple temperature sensor nodes distributed along a single multi-conductor cable, installed within or attached to the outside of grouted PVC pipe. EBA and RST thermistor strings have been installed on site. EBA thermistors are read using a basic ohmmeter and RST thermistors are read using a RST TH2016B readout unit.

Table 7: Thermistors

Area	ID	Northing (m)	Easting (m)	Elevation (m)	Thermistor String No.	Nodes	Hole Depth (m)	Date Installed	Reading Frequency
Area 2 Pit	A2T-1	6944162.01	385305.61	822.39	3491	16	63.4	2013-04-21	Quarterly
Dry Stack Tailings Storage Facility	DST-10	6944584.06	385489.49	797.13	3492	16	63.4	2013-04-17	Quarterly
Dry Stack Tailings Storage Facility	DST-11	6944899.64	385538.89	787.66	3494	16	86.9	2013-04-05	Quarterly
Dry Stack Tailings Storage Facility	DST-13	6945014.60	386271.29	777.01	3495	16	101.5	2013-04-02	Quarterly
Dry Stack Tailings Storage Facility	DST-14	6944769.09	385713.42	791.47	3497	16	66.5	2013-04-12	Quarterly
Dry Stack Tailings Storage Facility	DST-15	6945033.78	385958.17	764.51	3493	16	64.0	2013-03-25	Quarterly
Water Storage Pond	WDT-1	6945523.08	386550.83	720.03	2072	16	42.49	2007-11-16	Monthly
Water Storage Pond	WDT-2	6945532.89	386574.77	713.66	2073	6	44.50	2007-11-07	Monthly
Water Storage Pond	WDT-3	6945544.10	386544.43	719.78	2074	16	49.42	2007-11-11	Monthly
Water Storage Pond	WDT-4	6945534.98	386547.90	719.85	2075	16	49.42	2007-11-10	Monthly
Water Storage Pond	WDT-5	6945504.57	386557.50	721.03	2076	16	35.13	2007-11-13	Monthly
Water Storage Pond	WDT-6	6945505.55	386556.32	721.03	2077	16	33.72	2007-11-13	Monthly
Water Storage Pond	WDT-7	6945504.65	386556.39	721.08	2078	16	33.92	2007-11-13	Monthly

Water Storage Pond	WDT-8	6945532.89	386574.77	713.66	2079	16	34.14	2007-11-07	Monthly
Southwest Waste Dump	SDT-1	6944766.71	384779.13	836.36	2220	16	59.1	2010-02-04	Quarterly
Southwest Waste Dump	SDT-2	6944595.06	383971.30	847.11	2221	16	14.6	2010-01-31	Quarterly
Southwest Waste Dump	SDT-3	6944333.87	383824.67	860.17	2222	16	15.8	2010-01-28	Quarterly
Southwest Waste Dump	SDT-4	6944163.62	383783.54	860.99	2223	16	13.1	2010-01-30	Quarterly

Vibrating Wire Piezometers

Vibrating wire piezometer strings are used to measure piezometric pressure profiles in boreholes. They consist of multiple vibrating wire sensors installed on PVC pipe in grouted boreholes. RST vibrating wire piezometers are installed on site and data is collected with an RST VW2106 readout unit.

Table 8: Vibrating Wire Piezometers

Area	ID	Northing (m)	Easting (m)	Elevation (m)	Sensor	No.	Sensor Elevation (m)	Date Installed	Reading Frequency
Dry Stack Tailings Storage Facility	DSP-5	6944769	385713	791.47	DSP-5A	VW24851	765.47	2013-04-16	Monthly
					DSP-5B	VW24853	761.47		
Dry Stack Tailings Storage Facility	DSP-6	6944900	385539	787.66	DSP-6A	VW24850	769.56	2013-04-05	Monthly
					DSP-6B	VW24852	765.56		
Dry Stack Tailings Storage Facility	DSP-7	6944990	385390	780.404	DSP-7-1	VW34657	771.404	2015-12-09	Bi-weekly
					DSP-7-2	VW34658	763.404	2015-12-09	Bi-weekly
					DSP-7-3	VW34659	756.404	2015-12-09	Bi-weekly
					DSP-7-4	VW34660	753.404	2015-12-09	Bi-weekly
					DSP-7-5	VW34661	751.404	2015-12-09	Bi-weekly
					DSP-7-6	VW34662	747.404	2015-12-09	Bi-weekly
Dry Stack Tailings Storage Facility	DSP-8	6945058	385872	755.548	DSP-8-1	VW34663	750.548	2015-12-10	Bi-weekly
					DSP-8-2	VW34664	745.548	2015-12-10	Bi-weekly
					DSP-8-3	VW34665	740.548	2015-12-10	Bi-weekly
					DSP-8-4	VW34666	735.458	2015-12-10	Bi-weekly
					DSP-8-5	VW34667	730.458	2015-12-10	Bi-weekly
					DSP-8-6	VW34668	720.458	2015-12-10	Bi-weekly

Dry Stack Tailings Storage Facility	DSP-10	6945223	385944	724.509	DSP-10	VW34617	717.209	2015-11-27	Weekly
Southwest Waste Dump	SDP-2	6944595.06	383971.30	843.41	SDP-2A	VW12912	843.414	2010-01-31	Monthly
					SDP-2B	VW12911	842.714		
Southwest Waste Dump	SDP-3	6944333.87	383824.67	854.27	SDP-3A	VW12906	854.266	2010-01-28	Monthly
					SDP-3B	VW12907	853.566		
Southwest Waste Dump	SDP-4	6944163.62	383783.54	858.49	SDP-4A	VW12908	858.494	2010-01-30	Monthly
					SDP-4B	VW12909	857.794		
Water Storage Pond	WDP-2	6945632	386545	701.67	WDP-2	VW7212	701.67	2007-11-04	Monthly
Water Storage Pond	WDP-3A	6945618	386498	712.62	WDP-3A	VW7557	712.62	2007-11-28	Monthly
Water Storage Pond	WDP-3	6945609	386500	712.60	WDP-3	VW7202	712.60	2007-11-12	Monthly
Water Storage Pond	WDP-4	6945609	386500	702.60	WD -4	VW7210	702.60	2007-11-14	Monthly
Water Storage Pond	WDP-5	6945605	386526	712.35	WDP-5	VW7204	712.35	2007-11-20	Monthly
Water Storage Pond	WDP-6	6945605	386526	701.50	WDP-6	VW7214	701.50	2007-11-20	Monthly
Water Storage Pond	WDP-7	6945605	386526	689.20	WDP-7	VW7208	689.20	2007-11-20	Monthly
Water Storage Pond	WDP-8	6945554	386542	693.10	WDP-8	VW7200	693.10	2007-11-18	Monthly
Water Storage Pond	WDP-9	6945554	386542	687.93	WDP-9	VW7206	687.93	2007-11-18	Monthly
Water Storage Pond	WDP-10	6945554	386542	676.17	WDP-10	VW7211	676.17	2007-11-18	Monthly
Water Storage Pond	WDP-11	6945523	386551	712.96	WDP-11	VW7201	712.96	2007-11-16	Monthly
Water Storage Pond	WDP-12	6945523	386551	694.64	WDP-12	VW7209	694.64	2007-11-16	Monthly
Water Storage Pond	WDP-13	6945533	386578	684.55	WDP-13	VW7205	684.55	2007-11-07	Monthly

7 Instrumentation Procedures and Documentation

Data collection manuals for all monitoring devices are included in Appendix B.

After collection, data is input into a series of spreadsheets and databases used for storing, tracking and interpreting instrumentation data. Instructions for data input are contained in the instrumentation manuals in Appendix B.

8 Quality Assurance/Quality Control

Planned job obsrevations (PJO's) are routinely performed and documented on Mine Technician Assistants to verify data collection is consistent with the designed procedures.

Data collection equipment is returned to the manufacturers as per their recommended calibration schedules, typically annually.

All data is reviewed and summarized by the Geotechnical Engineer monthly as part of the Water Licence reporting.

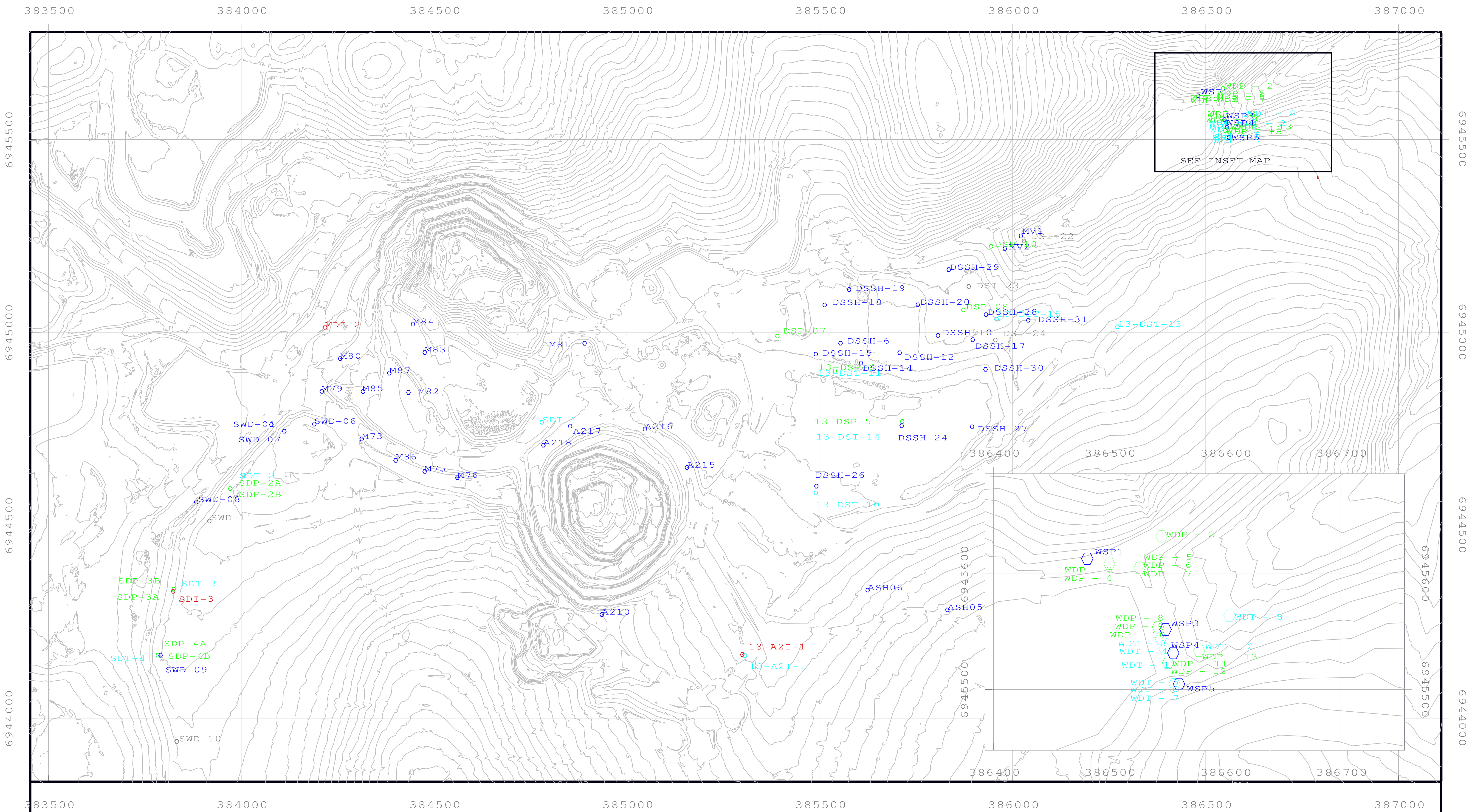
9 Reporting

Regular processing and review of monitoring data is completed and presented in the following documents.

Table 9: Reporting

Report	Frequency	Submission
Pit Wall Inspection Reports	Weekly	Submitted internally each week
Minto Mine Type A Water Licence QZ14-031 Monthly Report (Clause 4.4)	Monthly	Submitted to Yukon Water Board maximum 30 days following each month
DSTSF Inspection Reports	Monthly	Filed internally within one week of the inspection
Water Storage Pond Dam Inspection Reports	Monthly	Filed internally within one week of the inspection
Area 2 and Main Pit Tailings Storage Facility Inspection Reports	Quarterly	Filed internally within one month of the inspection
Semi-Annual Site-wide Geotechnical Inspection Report	After spring melt (May/June) and before freeze-up (September)	Submitted to Yukon Water Board within 60 days of inspection.
Minto Mine Type A Water Licence QZ14-031 Annual Report (Clause 4.5)	Annually	Submitted to Yukon Water Board by March 31 each year
Minto Mine Type B Water Licence MS15-094 Annual Inspection Report (Clause 34)	Annually	Submitted to Yukon Water Board with the Annual Report

Appendix A: Instrumentation Map



DESIGNED BY: HF	DATE PLOTTED: 20-Dec-2016	Monitoring Instrumentation 2016	LEGEND
CHECKED BY:	SCALE:	Comments:	SURVEY HUBS, THERMISTORS, PIEZOMETERS, INCLINOMETERS

capstone
MINTO MINE

Appendix B: Data Collection and Input Manuals

Inclinometer Measurements

Please refer to RST MEMS Digital Inclinometer System Instruction Manual for complete instruction.

System Overview:

Figure 1 – System Overview

1. Soft Shell Case
2. Digital Inclinometer Probe (w/ protective end cap)
3. Reel Battery Charger
4. 70mm/2.75" OD Cable Grip
5. 85mm/3.34" OD Cable Grip
6. Ultra-Rugged Field PC
7. 12V DC car adapter for Reel Battery Charger or Ultra-Rugged Field PC
8. Spare Reel Battery
9. Silicone Lubricant (for use on connectors)
10. USB Cable for Ultra-Rugged Field PC
11. AC Adapter (110-240V) for Reel Battery Charger
12. AC Adapter (110-240V) for Ultra-Rugged Field PC
13. Cable Reel with Wireless Communication System and protective end cap
14. Reel Carrying Case

1. Make sure the battery for the reel and the Field PC are charged.
2. Lift up protective box with two hands and put it on side as a work bench.

3. Remove cap from inclinometer casing and look for A_0 marking (black mark).

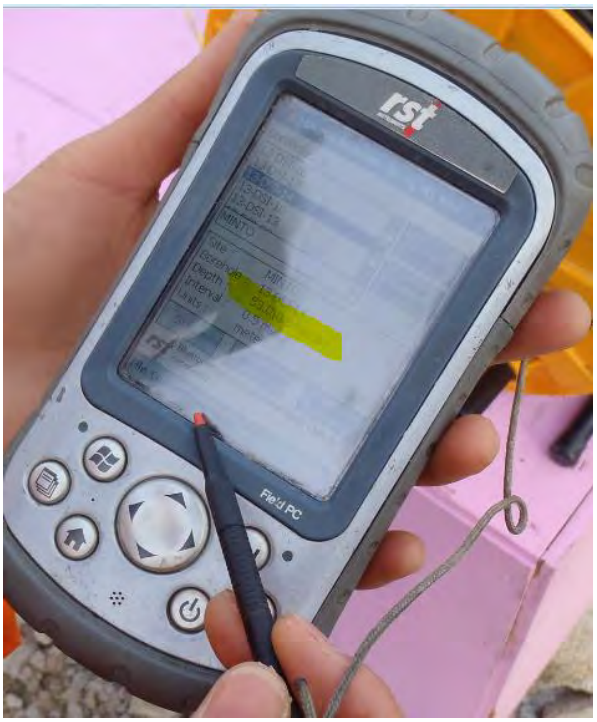
4. Remove excess water inside the probe and the cable connector.
   Probe is very sensitive and susceptible to vibration. **DO NOT BANG THE PROBE**. Use a paper towel to wipe it.

5. Apply silicon lubricant to probe and cable connector when needed.

6. Connect the inclinometer cable to the probe by aligning the keyways and threading the connector onto the probe. Turn the threaded ring, but not the cable.

7. Turn on the power of the reel. A green light indicates that the power is on. This energizes the accelerometers and makes them less susceptible to shock.

8. Check the depth of the hole. Turn on Field PC and select the hole you are going to measure.



9. Always start with **UPPER** Wheel in the A_0 direction.

10. Lower the probe gently and carefully. When it gets close to the bottom lower it very gently to avoid bouncing the probe off the bottom of the hole. The cable has aluminum sleeve marks which are spaced at 0.5m and it has a red measure mark with label every 5m.

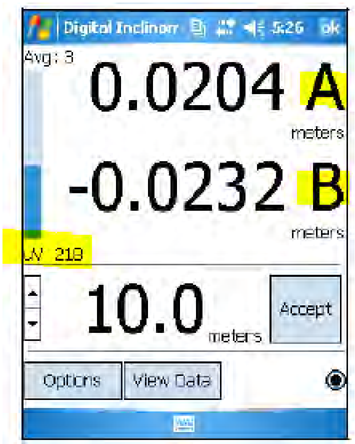
11. Lower the probe gently to ensure the bottom of the hole is encountered. (Slightly passed the designated depth). Double check your correct depth by pulling out reel to the next 5m mark and counting back each 0.5m for each increment.

12. Place the cable grip on top of the casing and hang the cable by the aluminum crimps.

13. Connect the Field PC to the reel. Use the pen attached to the field PC and press "*Connections".*

14. Once connected, hit “*Readings*”.

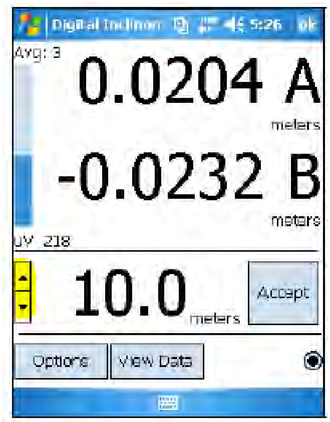
15. At each depth allow the A and B readings as well as the noise level become stabilized before you accept the readings. Ideally noise level should be at or below 30 μV.



16. Wear gloves as the Envirobind inside the inclinometer casing can be sticky and irritable. Pull up gently to the next marker and let the aluminum crimp to sit on the metal grip. Wait for the readings and noise level to stabilize and then hit *“Accept”*.


17. If you accidentally pull the probe too far (more than an inch), lower the probe back down to the previous bead then pull up to the bead you want to measure. This will ensure that the readings remain consistent.

18. At each 5m mark, check that you are at the right location. If you miss or overpass a reading, go back to the previous 5m depth. For examples, if something goes wrong at 41.5m, go back to 45m and drop the cable to 45.5m. Then gently pull up to 45m and hit *"Accept"* again. There are arrow keys on the Field PC which allow you to adjust your depth.



19. Once the last reading (0.5m) is taken, gently take out the probe and turn it 180° so that the **Lower** wheel is now in the A_0 direction.

20. Go back gently to the bottom of hole and take the second set of readings.

21. During the measurement of the second set of readings, checksum data will appear in a smaller font below the current readings. Checksum should be reasonably small and consistent. Ideally it should be somewhere between -0.0035m to +0.0045m.

22. If the checksum is large (> 0.01m) and inconsistent, check the following:
    - Is the probe at the right depth?
    - Is the probe in the correct direction?
    - Lower the probe to the previous depth and retake the reading again.

    It is possible that checksum is high due to differential pressure in the ground. In that case continue measurement and keep monitoring checksum.

23. Once readings are completed, take out the probe and wipe away the Envirobind gently. Put the caps back onto the probe and connector.

Data Input

Note: Windows Mobile Device Center must be installed on the computer in order to collect the readout unit to the computer.

1. Connect the USB cable from the readout unit to the computer and turn the power on.
2. Open DMM for Windows

3. *File – Open – Project Database*
   The database for all inclinometer data is stored here:
   X:\Mine Technical\03 - Monitoring\! Inclinometers\Master Database

4. *File – Import – Import RPP file*
   Navigate to the mobile device and select the .rpp file for the appropriate monitoring station and date. The data will then import and save in the database automatically.

Thermistor Readings

Two different types of thermistors are currently installed on site – RST and EBA thermistors.

To read RST thermistors:

1. Connect adapter cord to the TH2016B Readout Box.
2. Record the resistivity (Ohms) for each thermistor node on paper or store the data in the readout box with the following steps:
   a. Scroll with the Up/Down arrows to the ***Memory*** screen and press enter (arrow key)

   b. Scroll with the Up/Down arrows to the ***Store Data*** screen and press enter

   c. Scroll with the Up/Down arrows to the station being monitored and press enter to store the reading

   d. The data is now stored and the readbox can be turned off by pressing the escape button (ESC) three times to get back to the main menu and scrolling to Power Off.

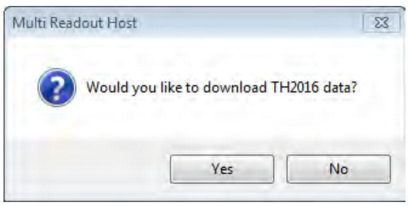
To read EBA thermistors:

1. Connect the EBA 16 Point Ground Temperature Dial into the thermistor cable.
2. Connect the multi-meter to the EBA 16 Point Ground Temperature Dial.
3. Record on paper the resistance in Ohm’s (Ω) for each point.

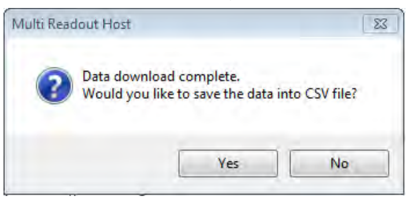
Data Downloading

1. Connect USB cord from computer to the readout box.
2. Open the software Multi Readout Host.

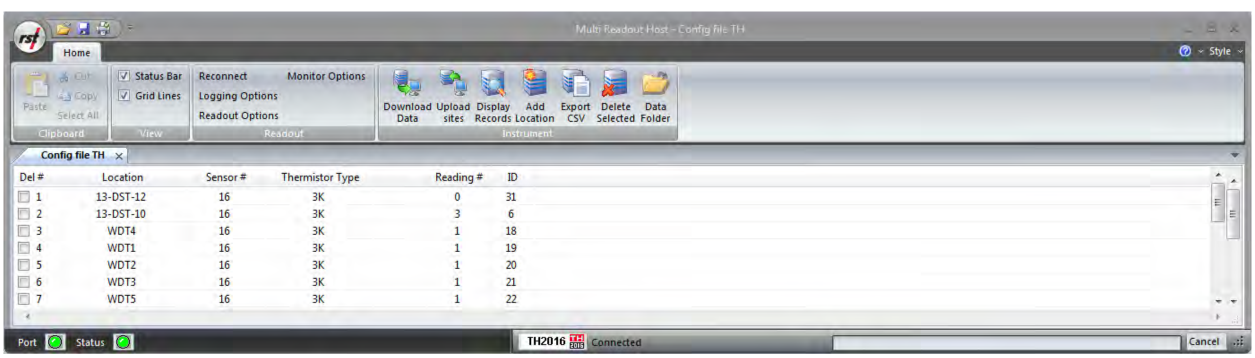
3. Turn on the power on the readout box.
4. The software will recognize the readout unit and prompt to download data. Choose "Yes" to download the data from the readout unit.



5. Once data is downloaded you will have the option to save all data as .csv file. Choose "Yes" and the data will be stored in My Documents in a folder named "TH2016data".



6. The software can be used to setup new locations or view data but no further steps are required.

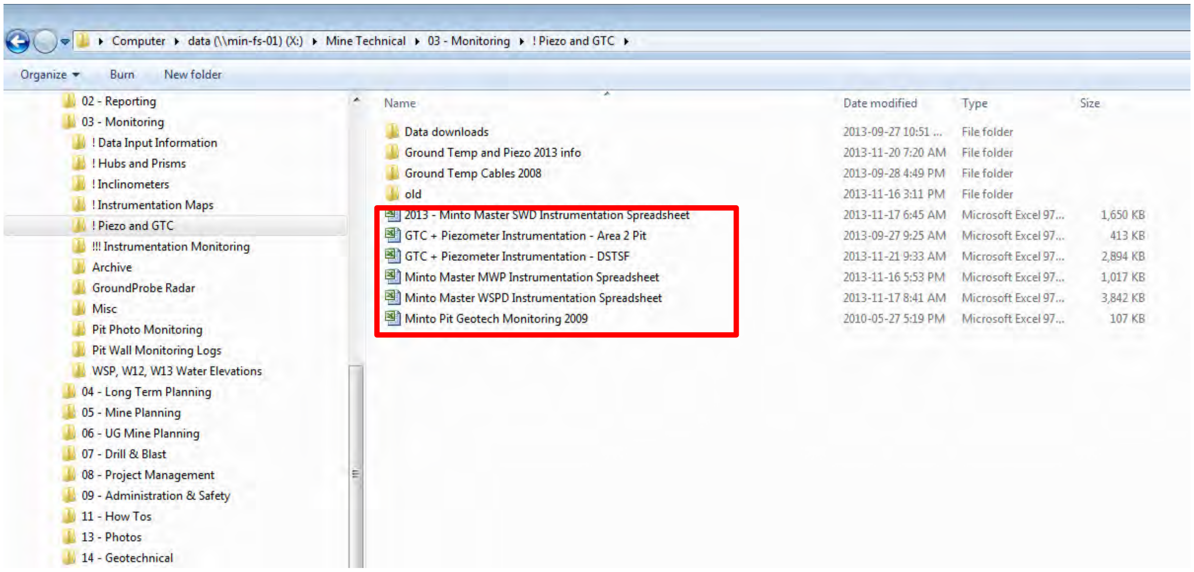


Data Input

Spreadsheets for piezometer data input and tracking are stored here:

X:\Mine Technical\03 - Monitoring\! Piezo and GTC

1. Open the spreadsheet for the area monitored



2. Open the tab "GTC Readings"

3. In a new column enter the date and copy the resistivity data (Ohms) from the paper records, or from the .csv file saved in either “TH2016data” or “VW2016data” saved in My Documents.

	WDT-3											
11	Date / Bead No.	15-Sep-11	5-Oct-11	24-Nov-11	28-Feb-12	27-Mar-12	11-Apr-12	18-Apr-12	14-May-12	#######	14-Jul-12	
12	1	9.71	10.24	12.55	13.73	14.00	14.11	14.15	14.17	11.30	9.77	
13	2	10.55	10.86	12.59	13.68	13.87	13.95	13.98	14.04	12.57	10.84	
14	3	11.03	11.11	12.53	13.71	13.90	13.98	14.01	14.08	13.66	11.99	
15	4	11.38	11.26	12.36	13.61	13.80	13.89	13.93	14.02	13.89	12.58	
16	5	11.99	11.71	12.39	13.55	13.75	13.84	13.87	13.97	13.97	13.16	
17	6	12.49	12.16	12.50	13.50	13.69	13.78	13.81	13.91	13.96	13.49	
18	7	13.05	12.70	12.69	13.49	13.67	13.75	13.79	13.89	13.97	13.78	
19	8	13.38	13.10	12.88	13.45	13.61	13.69	13.72	13.82	13.90	13.87	
20	9	13.57	13.40	13.15	13.50	13.63	13.69	13.71	13.80	13.86	13.89	
21	10	13.67	13.61	13.42	13.58	13.66	13.70	13.73	13.79	13.84	13.89	
22	11	13.66	13.66	13.55	13.58	13.63	13.66	13.67	13.72	13.76	13.81	
23	12	13.68	13.70	13.66	13.63	13.66	13.68	13.68	13.72	13.75	13.79	
24	13	13.74	13.77	13.77	13.71	13.71	13.72	13.72	13.74	13.77	13.80	
25	14	13.87	13.89	13.90	13.83	13.82	13.83	13.83	13.85	13.87	13.90	
26	15	13.95	13.96	13.94	13.88	13.87	13.88	13.88	13.90	13.92	13.95	
27	16	13.99	13.99	13.92	13.87	13.88	13.88	13.89	13.91	13.94	13.97	

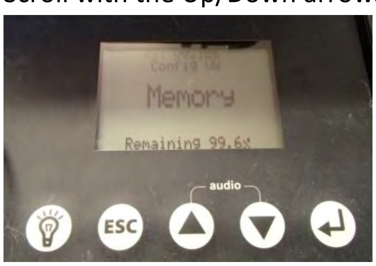
INDEX | Site Plan | Install Info | Piezo Readings | Piezo Calcs | Piezo Graphs | GTC Readings | GTC Calcs | GTC Graphs | GTC Graph | SH Re

Vibrating Wire Piezometer Readings

1. Connect adapter cord to the VW2106 Readout Box.
2. Connect the coloured wires to the correct wire clips on the extension cable. Make sure the wires do not touch each other.
3. Record the **DATE** and **TIME** as barometric pressure will be needed to calibrate the water level.
4. Record the measurement (between 7000B to 9000B) and the temperature (°C) for each piezometer. The piezometer ID should be labeled on the wire (eg. P5a and P5b).

5. Alternatively the data can be stored in the readout box:

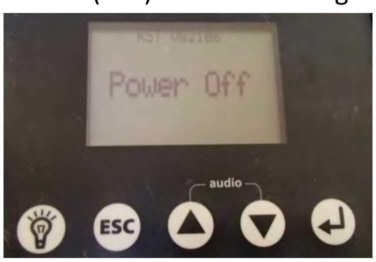
   a. Scroll with the Up/Down arrows to the ***Memory*** screen and press enter (arrow key)



   b. Scroll with the Up/Down arrows to the ***Store Data*** screen and press enter

c. Scroll with the Up/Down arrows to the station being monitored and press enter to store the reading

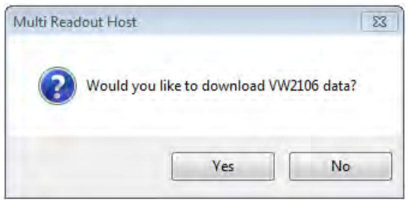
d. The data is now stored and the readout box can be turned off by pressing the escape button (ESC) three times to get back to the main menu and scrolling to Power Off.



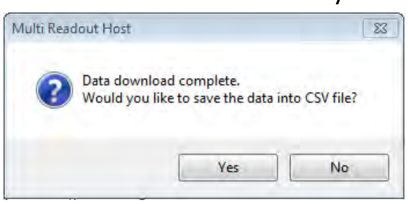
Data Downloading

7. Connect USB cord from computer to the readout box.
8. Open the software Multi Readout Host.

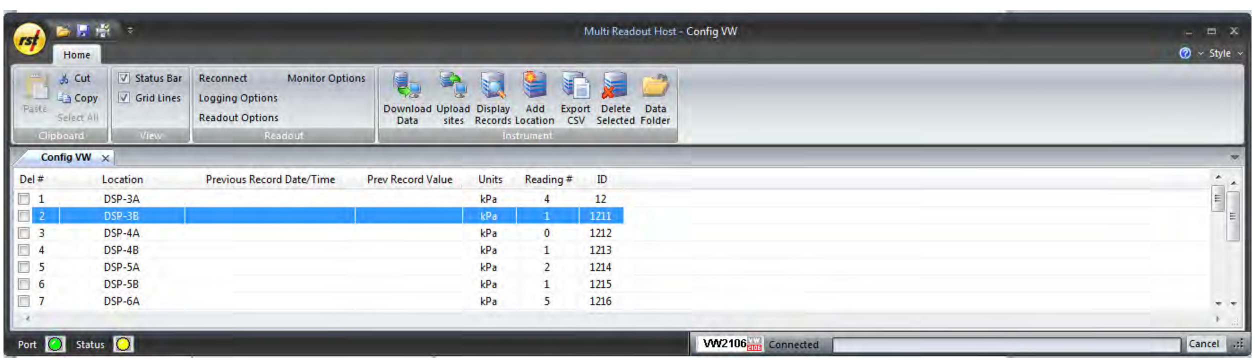
9. Turn on the power on the readout box.
10. The software will recognize the readout unit and prompt to download data. Choose “Yes” to download the data from the readout unit.



11. Once data is downloaded you will have the option to save all data as .csv file. Choose “Yes” and the data will be stored in My Documents in a folder named “VW2016data”.



12. The software can be used to setup new locations or view data but no further steps are required.

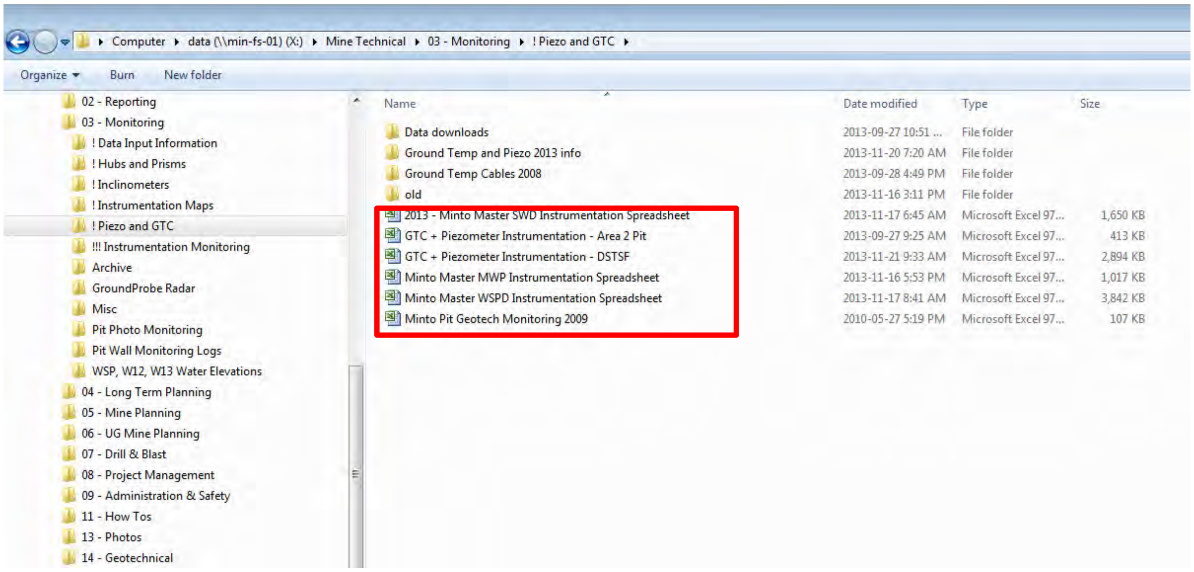


Data Input

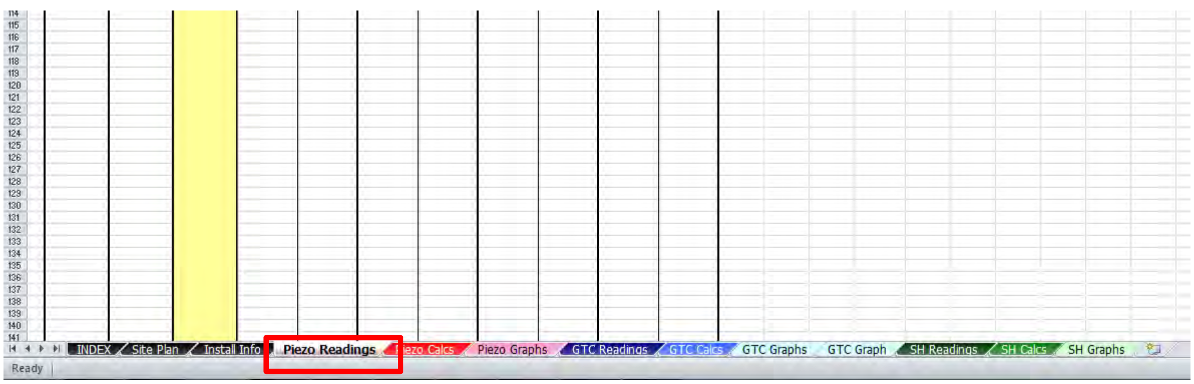
Spreadsheets for piezometer data input and tracking are stored here:

X:\Mine Technical\03 - Monitoring\! Piezo and GTC

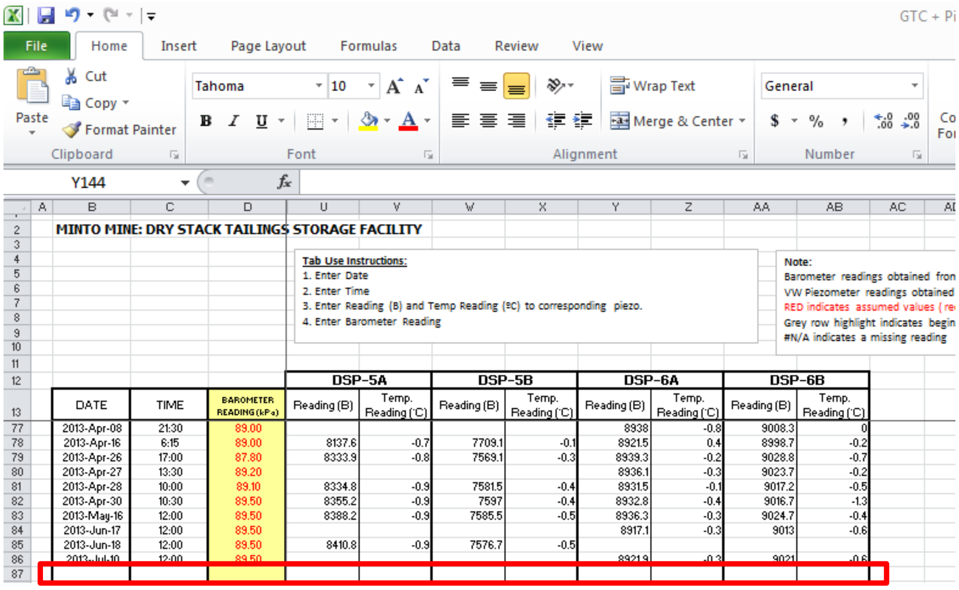
4. Open the spreadsheet for the area monitored



5. Open the tab "Piezo Readings"



6. In a new row, input the date, time, barometric pressure, B-unit and temperature readings for each instrument.



Barometric pressure can be obtained from the site's weather monitoring stations. Data is stored here:

X:\Environmental\Environmental Monitoring Program\1 MASTER LOGS\Meteorology Station Data\Met Station 1 and 2 Data Summary.xlsx

Appendix J – 2016 AMP Groundwater SRK Memo

srk consulting

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2

T: +1.604.681.4196
F: +1.604.687.5532
vancouver@srk.com
www.srk.com

February 27, 2017
Project No: 1CM002.046

Environmental Manager
Minto Mine
Capstone Mining Corp.
PO Box 11
Whitehorse, YT Y1A5X9

Attention: Ryan Herbert

Dear Ryan:

Subject: December 2016 Groundwater AMP Events

As part of the Minto Mine Operational Adaptive Management Plan, Minto Mine has collected and reviewed groundwater quality data. Minto completed an initial review of data compared to thresholds defined in the Minto Mine Operations Adaptive Management Plan (MEL, 2015), the adaptive management plan currently approved by regulators. MEL identified exceedances of certain thresholds and, as per the plan, has contracted a qualified professional to review those data and provide recommendations. SRK Consulting (Canada) Inc. was contacted by Minto environmental staff on January 25, 2017 to act as the qualified professional. This letter presents results of that review and recommendations.

SRK compared data against the 2015 AMP thresholds, historical data and data from other nearby monitoring locations. Table 1 summarizes exceedances, observations on the data, interpretation and recommendations.

Sincerely,
SRK Consulting (Canada) Inc.

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Dan Mackie, PGeo
Principal Consultant

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Dylan MacGregor, PGeo
Principal Consultant

Table 1. Summary of Groundwater Quality Data, AMP Thresholds, Observations and Recommendations

Location	Parameter & Concentration Data		Threshold Exceeded	Observations	Interpretations & Recommendation
Minto Creek Catchment					
MW12-05-05	Zn-D	mg/L			
	10/21/2016	0.076	**2015 AMP**: Exceedance of W2 WQO (0.03 mg/L)	Order of magnitude variability between October sample and duplicate. This is a shallow monitoring zone and elevated concentrations not seen in nearby surface water at WSP or at W3. Increase is observed in other zones over similar time period.	Zinc not previously identified as contaminant of concern at this site. Increasing trend possible but not yet a confirmed trend above threshold. More samples required to determine significance. Continue monitoring and compare future results with Zone 6 and nearby surface water. Review sample handling procedures and ensure no contamination during sampling or other site activities that could be a zinc source.
	10/21/2016	0.0136			
	12/23/2016	0.118			
MW12-05-06	Zn-D	mg/L			
	7/6/2016	0.0624	**2015 AMP**: Exceedance of W2 WQO (0.03 mg/L)	This zone has not been monitored historically. Measurements inconsistently above 2015 trigger. Variability over time and between October sample and duplicates. Duplicate and some other values less than threshold. This is a shallow monitoring zone and elevated concentrations not seen in nearby surface water at WSP or at W3. Increase is observed in other zones over similar time period.	Increasing trend possible but not yet a confirmed trend above threshold. More samples required to determine significance. Continue monitoring and compare future results with Zone 5 and nearby surface water. Review sample handling procedures and ensure no contamination during sampling or other site activities that could be a zinc source.
	9/30/2016	0.0271			
	10/21/2016	0.0521			
	10/21/2016	0.0136			
	12/23/2016	0.115			
MW12-06-01	As-D	mg/L			
	10/25/2016	0.00640	**2015 AMP**: Exceedance of W2 WQO (0.005 mg/L)	This is the only zone with these observed concentrations and this is the deepest zone in well (120 to 140 mbgs). These are the only samples from this zone. This deep monitoring zone has not been sampled historically.	Deep zone not historically sampled. More samples required to confirm significance. Continue monitoring.
	12/29/2016	0.00759			
MW12-06-01	Cr-D	mg/L			
	10/25/2016	0.00333	**2015 AMP**: Exceedance of W2 WQO (0.001 mg/L)	This is the only zone with these observed concentrations and this is the deepest zone in well (120 to 140 mbgs). These are the only samples from this zone. This deep monitoring zone has not been sampled historically. Values are order of magnitude higher than zone above this one.	Deep zone not historically sampled. More samples required to confirm significance of concentrations. Continue monitoring
	12/29/2016	0.00318			
MW12-06-03	Fe-D	mg/L			
	9/2/2016	1.19	**2015 AMP**: Exceedance of W2 WQO (1.1 mg/L)	These are the only samples from this zone. Significant variability over time and only very slightly above threshold.	Shallow zone not historically sampled. Variability common for dissolved Fe in groundwater. More samples required to confirm significance. Continue monitoring
	10/25/2016	0.02			
	12/30/2016	1.17			

Appendix K – MMER Effluent Monitoring and Environmental Effects Monitoring Water Quality 2016 Submissions

Data Submitted

Your data has been successfully submitted.

Facility Name:	Minto Explorations Limited - Minto Mine (Pelly Crossing, YT)
Date and Time Submitted (GMT):	2017-03-15 17:03:34
Tracking ID:	PYmmSCC469-2017-03-15-17-03-34-32042
Reporting Period:	2016

This is the official receipt of your submission.
You may wish to print and retain this receipt for your records.

Signature:

Back

Environment Canada Environnement Canada

Canada

View Annual Report

Facility: Minto Explorations Limited - Minto Mine (Pelly Crossing, YT)
Final Discharge Point: Mi.W3 - Runoff Main Water Dam
Reporting Period: 2016
Facility Name on Submission:
Submission Tracking ID:

Facility Information

Mine Name: Minto Explorations Limited - Minto Mine (Pelly Crossing, YT)
Mine Operator: Capstone Mining Corporation
Address: Suite 2100 510 West Georgia Street, Vancouver, BC, V6B 0M3
Telephone: 604-759-4634
E-mail: ryanh@mintomine.com

Location of Final Discharge Point

Name: Mi.W3 - Runoff Main Water Dam

Latitude: 62º 37' 32" N

Longitude: 137º 12' 11" W

Monthly Mean Concentrations, pH Range and Volume of Effluent (Generated)

Month	As (mg/L)	Cu (mg/L)	CN (mg/L)	Pb (mg/L)	Ni (mg/L)	Zn (mg/L)	TSS (mg/L)	Ra 226 (Bq/L)	Lowest pH	Highest pH	Effluent Volume (m^3)
January	0.000278	0.002642	NMR	0.0001	0.00074	0.00336	1.36	NMR	8.1	8.23	8035
February	0.000308	0.004903	NMR	0.000128	0.0005	0.0025	6.9	NMR	8.01	8.43	9647
March	0.000362	0.005384	NMR	0.000122	0.000814	0.00408	8.6	0.005	7.84	8.39	10178
April	0.000383	0.012148	NMR	0.000089	0.00129	0.002	5	NMR	7.99	8.28	3180
May	0.0003	0.011244	NMR	0.000025	0.00121	0.0015	3.66	NMR	7.99	8.32	775
June	0.000275	0.00809	NMR	0.000025	0.00108	0.0015	3	NMR	8.03	8.15	873
July	0.000303	0.006233	NMR	0.000025	0.001133	0.0015	3.425	NMR	7.98	8.39	1083
August	0.000325	0.009388	NMR	0.000025	0.000973	0.0015	3	NMR	7.93	8.31	1260
September	0.000223	0.007303	NMR	0.00005	0.00054	0.0015	3	0.005	7.86	8.1	3692
October	0.000304	0.010898	NMR	0.000092	0.000828	0.00182	3	0.005	8.15	8.27	59547
November	0.000264	0.003292	NMR	0.000025	0.00099	0.0015	3.24	NMR	7.88	8.46	6661
December	0.000248	0.004775	NMR	0.000032	0.000965	0.001875	3.875	NMR	7.81	8.35	6596

Results of Acute Lethality Tests and Daphnia magna Monitoring Tests (Generated)

Date Sample Collected	Results for Rainbow Trout Acute Lethality Tests (mean percentage mortality in 100% effluent test concentration)	Results for Daphnia magna Monitoring Tests (mean percentage mortality in 100% effluent test concentration)
2016-03-24	0	0
2016-06-23		0
2016-06-23		
2016-07-12		
2016-07-12	0	0
2016-09-06	0	0
2016-10-03		
2016-10-23	10	0

2016-10-23		

Non-Compliance Information

If effluent was non-compliant with the authorized limits set out in Schedule 4, indicate the cause(s) of non-compliance and remedial measures planned or implemented in response to the failure of acute lethality tests.

Notes:
Notification was provided to Environment Canada on July 7, 2016 that the Q2 quarterly toxicity sample for FDP – W3 was not conducted, partially due to a lab error. There was a resample collected early in the following quarter 7/12/2016 and results were forwarded to the Minto Enforcement Officer. The resample results passed with no mortalities. Site procedure and lab follow up was revised to prevent a reoccurrence. The Q3 sample was collected and tested as scheduled. All sample results will be included in the annual report submission

Ra226 was also sampled on 6/23/2016 and rendered results of <0.0100 Bq/L. The sample was not submitted during the second quarter. However, the results will be submitted during the annual report submission.

Date Modified: 2014-03-27

Close

Data Submitted

Your data has been successfully submitted.

Facility Name:	Minto Explorations Limited - Minto Mine (Pelly Crossing, YT)
Date and Time Submitted (GMT):	2017-03-15 17:03:34
Tracking ID:	PYmmSCC469-2017-03-15-17-03-34-32042
Reporting Period:	2016

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You may wish to print and retain this receipt for your records.
Signature:

Back

User Information

Site User
User: PYmmSCC469
Region: Pacific-Yukon
Regulation: MMER

Home
Del. Sub. & pH Data
Bioassay Data
EEM
Annual Report
Submission
Regulatory Data - Quarterly Report
EEM - Annual Report
Regulatory Data - Annual Report
Queries & Downloads
Graphs & Tables
Company Information
Password Change
Comments: Submit
Publications
RISS Web Service
Logout

Data Submitted

Your EEM data has been successfully submitted.

Facility Name:	Minto Explorations Limited - Minto Mine (Pelly Crossing, YT)
Date and Time Submitted (GMT):	2017-03-15 23:56:59
Tracking ID:	PYmmSCC469-2017-03-15-23-56-59-65375
Reporting Period:	2016

This is the official receipt of your submission.
You may wish to print and retain this receipt for your records.

Signature:

Station Name		W2	W2	W2	W2
Smpl Date		4/27/2016	6/23/2016	8/17/2016	10/23/2016
Lab Report No		L1761061	L1788244	L1815062	L1847772
Hard-T	mg/L				
Alk-T	mg/L	94.9	158	176	176
Al-T	mg/L	0.103	0.0709	0.0408	0.0294
Cd-T	mg/L	0.0000091	<0.0000050	<0.0000050	<0.0000050
Fe-T	mg/L	0.347	0.136	0.228	0.081
Hg-T	mg/L	0.0000102	<0.0000050	<0.0000050	<0.0000050
Mo-T	mg/L	0.00115	0.00142	0.00169	0.00218
Ammonia	mg/L	<0.0050	<0.0050	0.0061	0.0055
N-NO3	mg/L	0.0717	0.0987	0.221	2.11
As-T	mg/L	0.00053	0.00045	0.00058	0.00045
Cu-T	mg/L	0.00500	0.00252	0.00226	0.00323
Pb-T	mg/L	0.000065	<0.000050	<0.000050	<0.000050
Ni-T	mg/L	0.00152	0.00120	0.00123	0.00084
Zn-T	mg/L	<0.0030	<0.0030	<0.0030	<0.0030
TSS	mg/L	4.0	8.0	<3.0	<3.0
pH-F	pH units	7.95	7.81	8.06	7.87
Temp-F	C	0.2	6.8	7	0
DO	mg/L	14.44	10.79	11.87	13.13
Se-T	mg/L	0.000101	0.000140	0.000170	0.000535
Cond-F	µS/cm	118.1	227	235.1	116.6
Ca-T	mg/L	26.5	48.7	51.4	52.0
Chloride	mg/L	2.17	2.30	2.10	4.06
Mg-T	mg/L	8.86	14.6	15.8	17.4
Mn-T	mg/L	0.0224	0.0224	0.0132	0.00782
Na-T	mg/L	6.45	10.1	9.95	11.5
Tl-T	mg/L	<0.000010	<0.000010	<0.000010	<0.000010
C-DOC	mg/L	15.9	8.72	11.0	8.34
P-T	mg/L	<0.050	<0.050	<0.050	<0.050
U-T	mg/L	0.000703	0.00182	0.00163	0.00176

Station Name	W7	W7	W7	W7
Smpl Date	4/28/2016	6/23/2016	8/17/2016	10/23/2016
Lab Report No	L1762258	L1789096	L1816249	L1847772
Hard-T				
Alk-T	69.5	134	157	164
Al-T	0.0730	0.535	0.255	0.0139
Cd-T	0.0000091	0.0000058	<0.0000050	<0.0000050
Fe-T	0.311	0.703	0.467	0.152
Hg-T	0.0000123	<0.0000050	<0.0000050	<0.0000050
Mo-T	0.000731	0.00158	0.00164	0.00132
Ammonia	0.0069	0.0150	0.0156	0.0266
N-NO3	0.0063	0.151	0.0883	0.171
As-T	0.00043	0.00059	0.00057	0.00049
Cu-T	0.00400	0.00201	0.00175	0.00116
Pb-T	<0.000050	0.000263	0.000140	<0.000050
Ni-T	0.00145	0.00184	0.00169	0.00088
Zn-T	<0.0030	<0.0030	<0.0030	<0.0030
TSS	3.3	19.8	10.0	<3.0
pH-F	7.72	7.62	7.81	7.68
Temp-F	0.1	3.1	4.5	-0.1
DO	15.44	11.36	11.78	12.02
Se-T	0.000087	0.000180	0.000118	0.000158
Cond-F	75.6	162.7	178.2	170.4
Ca-T	18.1	36.5	37.7	39.3
Chloride	<0.50	<0.50	<0.50	0.52
Mg-T	6.51	12.8	12.9	14.2
Mn-T	0.0340	0.0437	0.0424	0.0681
Na-T	4.06	7.64	7.66	7.88
Tl-T	<0.000010	<0.000010	<0.000010	<0.000010
C-DOC	18.6	7.44	9.96	7.19
P-T	<0.050	<0.050	<0.050	<0.050
U-T	0.000374	0.00157	0.00126	0.00153

Station Name	W3	W3	W3	W3
Smpl Date	**3/24/2016**	**4/26/2016**	**6/23/2016**	**7/12/2016**
Lab Report No	**B622605**	**L1761061**	**L1788244**	**L1797520**
Hard-T	276	223	217	242
Alk-T	234	187	180	214
Al-T	0.119	0.0553	0.0087	0.0076
Cd-T	<0.000010	<0.0000050	<0.0000050	<0.0000050
Fe-T	0.268	0.120	0.026	0.017
Hg-T	<0.000010	<0.0000050	<0.0000050	<0.0000050
Mo-T	0.0041	0.00357	0.00440	0.00491
Ammonia	0.034	0.0961	<0.0050	<0.0050
N-NO3	0.201	0.772	1.25	0.291
As-T	0.00031	0.00032	0.00030	0.00028
Cu-T	0.00449	0.0121	0.00702	0.00394
Pb-T	<0.00020	0.000053	<0.000050	<0.000050
Ni-T	<0.0010	0.00100	0.00105	0.00105
Zn-T	0.0095	<0.0030	<0.0030	<0.0030
TSS	2.5	<3.0	<3.0	<3.0
pH-F	7.38	7.63		7.87
Temp-F	0.3	1.7		4.3
DO	10.3	13.63		10.74
Se-T	0.0003	0.000365	0.000534	0.000333
Cond-F	282.5	266.3		299.6
Ca-T	50.3	56.5	51.5	56.1
Chloride	5.9	9.11	5.22	5.17
Mg-T	26.4	18.8	20.3	24.4
Mn-T	0.0933	0.0644	0.0171	0.0256
Na-T	16.6	15.9	15.2	18.0
Tl-T	<0.000050	<0.000010	<0.000010	<0.000010
C-DOC	3.01	8.47	8.17	6.16
P-T	0.026	<0.050	<0.050	<0.050
U-T	0.00246	0.00165	0.00175	0.00220

Station Name	W3	W3	W3
Smpl Date	8/17/2016	9/6/2016	10/23/2016
Lab Report No	L1815062	L1825910	L1847772
Hard-T	227	126	231
Alk-T	183	97.9	180
Al-T	0.0177	0.0146	0.0141
Cd-T	<0.0000050	<0.0000050	<0.0000050
Fe-T	0.039	0.035	0.072
Hg-T	<0.0000050	<0.0000050	<0.0000050
Mo-T	0.00458	0.00296	0.00401
Ammonia	0.0066	0.0114	0.0299
N-NO3	2.03	2.83	4.49
As-T	0.00031	0.00025	0.00034
Cu-T	0.00821	0.00828	0.0125
Pb-T	<0.000050	<0.000050	0.000050
Ni-T	0.00101	0.00050	0.00076
Zn-T	<0.0030	<0.0030	<0.0030
TSS	<3.0	<3.0	<3.0
pH-F	7.79	7.43	7.72
Temp-F	7.9	12.7	2.7
DO	9.71	9.13	12.31
Se-T	0.000651	0.000723	0.00128
Cond-F	310.1	220.6	264.8
Ca-T	57.1	32.7	60.6
Chloride	5.26	3.25	6.10
Mg-T	20.3	10.1	18.8
Mn-T	0.0252	0.0230	0.0477
Na-T	15.4	9.56	13.8
Tl-T	<0.000010	<0.000010	<0.000010
C-DOC	8.78	6.71	10.4
P-T	<0.050	<0.050	<0.050
U-T	0.00160	0.000728	0.00154

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 24-OCT-16
Report Date: 06-DEC-16 12:46 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1847785
Project P.O. #: 220405 (MMER)
Job Reference:
C of C Numbers: 2016-10-24 B
Legal Site Desc:

Comments: Please note, this report contains only Nautilus Environmental and ALS Fort Collins reports (at the end of the attachment).

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1847785-1				
	Description	Water				
	Sampled Date	23-OCT-16				
	Sampled Time	15:50				
	Client ID	W3				
Grouping	**Analyte**					
WATER						
Radiological Parameters	Ra-226 (Bq/L)	<0.0100				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
RA226-MMER-FC	Water	Ra226 by Alpha Scint, MDC=0.01 Bq/L	EPA 903.1

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
FC	ALS ENVIRONMENTAL - FORT COLLINS, COLORADO, USA

Chain of Custody Numbers:

2016-10-24 B

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

MMER Toxicity Testing for ALS Environmental

Sample collected October 23, 2016

Final Report

December 2, 2016

Submitted to: **ALS Environmental**
Burnaby, BC

8664 Commerce Court, Burnaby, BC V5A 4N7

NAUTILUS ENVIRONMENTAL

TABLE OF CONTENTS

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NAUTILUS ENVIRONMENTAL

SIGNATURE PAGE

Report By:	Reviewed By:
Mimi Tran, Dipl. T	Armando Tang, R.P.Bio.
Laboratory Biologist	Senior Reviewer

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

SUMMARY

A summary of sample information and test results from the *Ceriodaphnia dubia*, *Oncorhynchus mykiss*, *Lemna minor*, and *Pseudokirchneriella subcapitata* sub-lethal toxicity tests are provided in the tables below. Testing was initiated on October 25 and 26, 2016 at the Nautilus Environmental laboratory in Burnaby, BC.

Sample and Test Type Information

Sample ID	L1847785-1 W3
Sample collection date	October 23, 2016
Sample receipt date	October 25, 2016
Sample receipt temperature	8.4°C and 9.0°C
Test types	*Ceriodaphnia dubia* survival and reproduction 7-d rainbow trout *(Oncorhynchus mykiss)* embryo viability 7-d *Lemna minor* growth inhibition 72-h *Pseudokirchneriella subcapitata* growth inhibition

Results

Endpoint	L1847785-1 W3 %v/v
C. dubia survival LC50	>100
C. dubia reproduction IC25	>100
C. dubia reproduction IC50	>100
O. mykiss embryo viability EC25	>100
O. mykiss embryo viability EC50	>100
L. minor frond count IC25	>97
L. minor frond count IC50	>97
L. minor dry weight IC25	>97
L. minor dry weight IC50	>97
P. subcapitata growth IC25	>95.2
P. subcapitata growth IC50	>95.2

LC = Lethal Concentration, IC = Inhibition Concentration, EC = Effective Concentration.

1.0 INTRODUCTION

Nautilus Environmental Company Inc. conducted sub-lethal toxicity tests for ALS Environmental as part of their requirements under the Metal Mining Effluent Regulations (MMER) and Environmental Effects Monitoring (EEM) program. Sample L1847785-1 W3 was collected on October 23, 2016 and delivered to the Nautilus Environmental laboratory in Burnaby, BC on October 25, 2016. The sample was transported in seven 20-L plastic containers and five 1-L plastic containers and was received at temperatures of 8.4°C and 9.0°C. The sample was stored in the dark at 4 ± 2°C prior to testing. The following toxicity tests were performed on the sample:

- *Ceriodaphnia dubia* survival and reproduction
- 7-d rainbow trout *(Oncorhynchus mykiss)* embryo viability
- 7-d *Lemna minor* growth inhibition
- 72-h *Pseudokirchneriella subcapitata* growth inhibition

This report describes the results of these toxicity tests. Copies of raw laboratory data sheets and statistical analyses for each test species are provided in Appendices A to D. The chain-of-custody form is provided in Appendix E.

2.0 METHODS

Methods for the toxicity tests are summarized in Tables 1 to 4. Testing was conducted according to procedures described by Environment Canada (2007a, 2007b and 2007c). The rainbow trout embryo viability test followed modified procedures described by Environment Canada (1998) and Canaria et al. (1999). Statistical analyses for all tests were performed using CETIS (Tidepool Scientific Software, 2013).

Table 1. Summary of test conditions: *Ceriodaphnia dubia* survival and reproduction test.

Test species	*Ceriodaphnia dubia*
Organism source	In-house culture
Organism age	<24 hour old neonates, produced within a 12 hour window
Test type	Static-renewal
Test duration	7 ± 1 day
Test vessel	20-mL glass test tube
Test volume	15 mL
Test solution depth	10 cm
Test concentrations	Seven concentrations, plus laboratory control
Test replicates	10 per treatment
Number of organisms	1 per replicate
Control/dilution water	20% Perrier water and 80% deionized water + 5 µg/L Se and 2 µg/L vitamin B12
Test solution renewal	Daily (100% renewal)
Test temperature	25 ± 1°C
Feeding	Daily with *Pseudokirchneriella subcapitata* and YCT (3:1 ratio)
Light intensity	100 to 600 lux at water surface
Photoperiod	16 hours light / 8 hours dark
Aeration	None
Test measurements	Temperature, dissolved oxygen, pH and conductivity measured daily; hardness and alkalinity of undiluted sample measured at test initiation; survival and reproduction checked daily
Test protocol	Environment Canada (2007a), EPS 1/RM/21
Statistical software	CETIS Version 1.8.7
Test endpoints	Survival and reproduction
Test acceptability criteria for controls	≥80% survival; ≥15 young per surviving control producing three broods; ≥60% of controls producing three or more broods; no ephippia present
Reference toxicant	Sodium chloride (NaCl)

Table 2. Summary of test conditions: rainbow trout (*Oncorhynchus mykiss*) embryo viability test.

Test species	*Oncorhynchus mykiss*
Organism source	Hatchery
Organism age	<30 minutes post fertilization, <24 hour old gametes
Test type	Static-renewal
Test duration	7 days
Test vessel	2-L plastic container
Test volume	2 L
Test solution depth	17 cm
Test concentrations	Five concentrations, plus laboratory control
Test replicates	4 per treatment
Number of organisms	30 per replicate
Control/dilution water	Dechlorinated Metro Vancouver municipal tapwater
Test solution renewal	Daily (80% renewal)
Test temperature	14 ± 1°C
Feeding	None
Light intensity	Dark
Photoperiod	24 hours dark
Aeration	Continuous gentle aeration
Test measurements	Temperature, dissolved oxygen, pH and conductivity measured daily; hardness and alkalinity of undiluted sample measured at test initiation; survival checked daily
Test protocol	Environment Canada (1998), EPS 1/RM/28; Canaria et al. (1999)
Statistical software	CETIS Version 1.8.7
Test endpoints	Embryo viability
Test acceptability criteria for controls	Embryo viability ≥70%
Reference toxicant	Sodium dodecyl sulphate (SDS)

Table 3. Summary of test conditions: *Lemna minor* growth inhibition test.

Test species	*Lemna minor*, strain CPCC# 490
Organism source	In-house axenic culture, obtained from Canadian Phycological Culture Centre, and originally isolated from Wainfleet, Stinking Barn, Niagara Peninsula, Ontario, Canada
Organism age	7- to 10-day old culture
Test type	Static
Test duration	7 days
Test vessel	250-mL glass container
Test volume	100 mL
Test solution depth	4 cm
Test concentrations	Seven concentrations, plus laboratory control
Test replicates	4 per treatment
Number of organisms	Two 3-frond plants per replicate
Control/dilution water	Modified APHA media (deionized water plus 1% of each APHA stock solution A, B and C)
Test solution renewal	None
Test temperature	25 ± 2°C
Feeding	None
Light intensity	4000 to 5600 lux
Photoperiod	24 hours light
Aeration	None
Test measurements	Test area temperature measured daily; temperature, pH and conductivity measured in all concentrations at test initiation; dissolved oxygen of highest concentration measured at test initiation; temperature and pH measured at test termination
Test protocol	Environment Canada (2007b), EPS 1/RM/37
Statistical software	CETIS Version 1.8.7
Test endpoints	Number of fronds and dry weight
Test acceptability criteria for controls	≥ 8-fold increase in number of fronds
Reference toxicant	Potassium chloride (KCl)

Table 4. Summary of test conditions: *Pseudokirchneriella subcapitata* growth inhibition test.

Test species	*Pseudokirchneriella subcapitata*, strain UTCC# 37
Organism source	In-house axenic culture, obtained from Canadian Phycological Culture Center, and originally isolated from Nivelta River, Norway.
Organism age	3-to 7-day old culture in logarithmic growth phase
Test type	Static
Test duration	72 hours
Test vessel	Microplate
Test volume	220 µL
Test concentrations	Seven concentrations, plus laboratory control
Test replicates	4 per treatment; 8 for laboratory control
Number of organisms	10,000 cells/mL
Control/dilution water	Deionized water supplemented with nutrients
Test solution renewal	None
Test temperature	24 ± 2°C
Feeding	None
Light intensity	3600 to 4400 lux
Photoperiod	24 hours light
Aeration	None
Test measurements	Test area temperature measured daily; temperature and pH measured at test initiation; pH of two control wells measured at test termination
Test protocol	Environment Canada (2007c), EPS 1/RM/25
Statistical software	CETIS Version 1.8.7
Test endpoints	Algal cell growth inhibition
Test acceptability criteria for controls	>16-fold increase in number of algal cells; CV ≤ 20%; no trend when analyzed using Mann-Kendall test
Reference toxicant	Zinc (added as $ZnCl_2$)

3.0 RESULTS

Results of the toxicity tests are summarized in Tables 5 to 8. There were no adverse effects observed on survival and reproduction of *C. dubia* (Table 5), embryo viability of *O. mykiss* (Table 6), frond growth and dry weight of *L. minor* (Table 7), or cell yield of *P. subcapitata* (Table 8). The LC, EC and IC values were therefore greater than the highest test concentration for each of these endpoints in the toxicity tests. Stimulatory effects were observed for *C. dubia* reproduction and *P.subcapitata* cell yield; percent stimulation ranged from 2.8 to 29.8% and 14.2 to 406.4%, respectively.

Table 5. **Results: *Ceriodaphnia dubia* survival and reproduction test.**

Concentration (% v/v)	Survival (%)	Reproduction (Mean ± SD)	Stimulation (%)
Laboratory Control	100	17.8 ± 5.8	--
1.56	100	18.3 ± 5.3	2.8
3.12	100	20.0 ± 4.5	12.4
6.25	100	15.7 ± 4.1	--
12.5	100	20.3 ± 5.8	14.0
25	100	23.0 ± 3.4*	29.2
50	100	22.0 ± 4.4	23.6
100	100	23.1 ± 4.4*	29.8
Test endpoint (% v/v)			
LC50	>100	--	--
IC25	--	>100	--
IC50	--	>100	--

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration.
* = indicates concentrations that are significantly greater than the laboratory control.

Table 6. Results: rainbow trout (*Oncorhynchus mykiss*) embryo viability test.

Concentration (% v/v)	Embryo Viability (%) (Mean ± SD)
Laboratory Control	100.0 ± 0.0
6.25	98.3 ± 1.9
12.5	98.3 ± 1.9
25	97.5 ± 1.7
50	95.0 ± 1.9
100	97.5 ± 3.2
Test endpoint (% v/v)	
EC25	>100
EC50	>100

SD = Standard Deviation, EC = Effective Concentration.

Table 7. Results: *Lemna minor* growth inhibition test.

Concentration	Frond Growth (No. of Fronds) (Mean ± SD)	Dry Weight (mg) (Mean ± SD)
Laboratory Control	105.8 ± 19.0	8.5 ± 1.3
1.5	110.3 ± 13.2	9.1 ± 1.4
3.0	114.5 ± 15.2	9.4 ± 1.2
6.1	115.5 ± 10.2	9.5 ± 1.3
12.1	109.0 ± 15.4	9.4 ± 1.8
24.2	118.8 ± 17.6	10.2 ± 1.5
48.5	120.5 ± 13.5	10.7 ± 1.2
97	87.0 ± 15.5	8.4 ± 0.9
Test endpoint (% v/v)		
IC25	>97	>97
IC50	>97	>97

SD = Standard Deviation, IC = Inhibition Concentration.

Table 8. **Results: *Pseudokirchneriella subcapitata* growth inhibition test.**

Concentration	Cell Density (x 10^4 cells/mL) (Mean ± SD)	Stimulation (%)
Laboratory Control	29.1 ± 2.2	--
1.5	33.2 ± 1.7	14.2
3.0	40.2 ± 3.0*	38.2
6.0	53.8 ± 4.0*	84.6
11.9	72.0 ± 4.8*	147.2
23.8	118.3 ± 3.6*	306.0
47.6	147.5 ± 5.1*	406.4
95.2	144.3 ± 5.5*	395.3
Test endpoint (% v/v)		
IC25	>95.2	--
IC50	>95.2	--

SD = Standard Deviation, IC = Inhibition Concentration.
* = Indicates cell yield that were significantly greater than the control.

4.0 QA/QC

The health histories of the test organisms used in the exposures were acceptable and met the requirements of the Environment Canada protocols. The tests met all control acceptability criteria and water quality parameters remained within ranges specified in the protocols throughout the tests. Uncertainty associated with these tests is best described by the standard deviations around the mean and/or the confidence limits around the point estimates.

There were no deviations from the test methodologies, with one exception in the rainbow trout embryo toxicity test. Only three out of four sperm sources were used to fertilize the eggs due to a lack of motility observed in the remaining source. However, the control met the acceptability criterion and thus, the deviation did not affect the results of the test.

Results of the reference toxicant tests conducted during the testing program are summarized in Table 9. These tests were performed under the same conditions as the sample tested. Results for these tests fell within the acceptable range for organism performance of mean and two standard deviation range, based on historical results obtained by the laboratory with these tests. Thus, the sensitivity of the organisms used in these tests was appropriate.

Table 9. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
C. dubia	Survival (LC50): 2.0 g/L NaCl	2.0 (1.8 - 2.2)	5	October 13, 2016
	Reproduction (IC50): 1.4 g/L NaCl	1.6 (1.2 - 2.0)	13	
O. mykiss	Viability (EC50): 5.5 mg/L SDS	4.0 (2.1 - 7.4)	37	October 25, 2016
L. minor	No. Fronds (IC50): 3.5 g/L KCl	3.9 (3. 2 - 4.9)	11	October 13, 2016
P. subcapitata	Growth (IC50): 36.9 µg/L Zn	32.6 (24.0 - 44.3)	16	October 14, 2016

SD = Standard Deviation, CV = Coefficient of Variation, LC = Lethal Concentration, IC = Inhibition Concentration, EC = Effect Concentration

5.0 REFERENCES

Canaria, E.C., J.R. Elphick and H.C. Bailey. 1999. A simplified procedure for conducting small-scale short-term embryo toxicity tests with salmonids. Environ Toxicol 14:301-307.

Environment Canada. 1998. Biological test method: toxicity tests using early life stages of salmonid fish (rainbow trout). Environmental Protection Series EPS 1/RM/28. Second Edition, July 1998. Environment Canada, Method Development and Application Section, Environmental Technology Centre, Ottawa, ON. 102 pp.

Environment Canada. 2007a. Biological test method: test of reproduction and survival using the cladoceran *Ceriodaphnia dubia*. Environmental Protection Series. Report EPS 1/RM/21, Second Edition, February 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 74 pp.

Environment Canada. 2007b. Biological test method: tests for measuring the inhibition of growth using the freshwater macrophyte, *Lemna minor*. Environmental Protection Series, Report EPS 1/RM/37. Second Edition. January 2007. Environment Canada, Method Development and Application Section, Environmental Technology Centre, Ottawa, ON. 112 pp.

Environment Canada. 2007c. Biological test method: growth inhibition test using the freshwater alga. Environmental Protection Series, Report EPS 1/RM/25. Second Edition, March 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 53 pp.

Tidepool Scientific Software. 2013. CETIS comprehensive environmental toxicity information system, version 1.8.7.16 Tidepool Scientific Software, McKinleyville, CA. 275 pp.

APPENDIX A – *Ceriodaphnia dubia* Toxicity Test Data

Ceriodaphnia dubia Summary Sheet

Client: ALS / Minto
Work Order No.: 161170

Start Date/Time: Oct26/16 @ 1050
Set up by: EMM

Sample Information:

Sample ID: L1847785-1 WB
Sample Date: Oct 23/16
Date Received: Oct 25/16
Sample Volume: 5X1L

Test Validity Criteria:

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

WQ Ranges:

T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 ; pH = 6.0 to 8.5

Test Organism Information:

Broodstock No.: 101216B
Age of young (Day 0): <24-h (within 12-h)
Avg No. young in first 3 broods of previous 7 d: 39
Mortality (%) in previous 7 d: 15
Individual female # used ≥8 young on test day: 21,24,28,29,31,33

NaCl Reference Toxicant Results:

Reference Toxicant ID: Cd150
Stock Solution ID: 16Na02
Date Initiated: Oct 13/16

7-d LC50 (95% CL): 2.0 (1.9-2.3) g/L NaCL
7-d IC50 (95% CL): 1.4 (1.2-1.7) g/L NaCL

7-d LC50 Reference Toxicant Mean and Historical Range: 2.0 (1.8-2.2) g/L NaCL CV (%): 5
7-d IC50 Reference Toxicant Mean and Historical Range: 1.6 (1.2-2.0) g/L NaCL CV (%): 13

Test Results:

	Survival	Reproduction
LC50 % (v/v) (95% CL)	>100	
IC25 % (v/v) (95% CL)		>100
IC50 % (v/v) (95% CL)		>100

Reviewed by: JGL

Date reviewed: Nov-28/16

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: AI S/minto
Sample ID: MG ~~WS~~ 4847785-1 W3
Work Order #: 161170

Start Date & Time: Oct 26/16 @ 1050
Stop Date & Time: Nov 1/16 @ 2010h
Test Species: *Ceriodaphnia dubia*

Concentration control	Day 0 init.	Day 1 old	Day 1 new	Day 2 old	Day 2 new	Day 3 old	Day 3 new	Day 4 old	Day 4 new	Day 5 old	Day 5 new	Final 6 old	Final 6 new	Day 7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0		
DO (mg/L)	8.0	7.8	8.0	7.6	8.0	7.4	8.2	7.6	8.0	7.5	8.1	7.4		
pH	8.0	7.7	8.0	7.8	8.0	7.7	8.1	7.9	8.1	7.7	8.0	7.7		
Cond. (µS/cm)	222	222		221		220		220		221		224		
Initials	EMM	EMM		EMM		A		MLT		EMM		EMM		

Concentration (v/v) 1.56%	Day 0 init.	Day 1 old	Day 1 new	Day 2 old	Day 2 new	Day 3 old	Day 3 new	Day 4 old	Day 4 new	Day 5 old	Day 5 new	Final 6 old	Final 6 new	Day 7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0		
DO (mg/L)	8.0	7.8	8.1	7.6	8.1	7.5	8.2	7.6	8.0	7.5	8.2	7.4		
pH	8.0	7.8	8.0	7.9	8.0	7.8	7.9	7.9	7.9	7.8	8.0	7.8		
Cond. (µS/cm)	230	229		226		231		228		230		229		
Initials	EMM	EMM		EMM		A		A		EMM		EMM		

Concentration (v/v) 12.5%	Day 0 init.	Day 1 old	Day 1 new	Day 2 old	Day 2 new	Day 3 old	Day 3 new	Day 4 old	Day 4 new	Day 5 old	Day 5 new	Final 6 old	Final 6 new	Day 7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0		
DO (mg/L)	8.0	7.8	8.2	7.6	8.1	7.5	8.2	7.5	8.0	7.5	8.2	7.4		
pH	8.0	7.8	8.0	7.9	8.0	7.9	8.0	7.9	7.9	7.8	8.0	7.9		
Cond. (µS/cm)	263	260		261		263		260		261		269		
Initials	EMM	EMM		EMM		A		MLT		EMM		EMM		

Concentration (v/v) 100%	Day 0 init.	Day 1 old	Day 1 new	Day 2 old	Day 2 new	Day 3 old	Day 3 new	Day 4 old	Day 4 new	Day 5 old	Day 5 new	Final 6 old	Final 6 new	Day 7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0		
DO (mg/L)	8.1	8.0	8.2	7.5	8.1	7.4	8.2	7.5	8.0	7.4	8.1	7.4		
pH	7.8	7.9	7.8	8.2	7.9	8.1	8.0	8.1	8.0	8.1	7.9	8.0		
Cond. (µS/cm)	508	512		512		510		512		512		510		
Initials	EMM	EMM		EMM		A		MLT		EMM		EMM		

Thermometer: 4 **DO meter:** 2/1 **pH meter:** 2/1 **Conductivity meter:** 2/1

	Control	100% (v/v)		
Hardness*	100	330		
Alkalinity*	98	182		

* mg/L as CaCO3

Analysts: EMM, MLT, JS, MG, AW
Reviewed by: JGL
Date reviewed: Nov-25/16

Sample Description: clear, yellow, odourless, no particulates.

Comments: **Broodboard Used:** 101216B

Version 1.3 Issued May 22, 2015

Nautilus Environmental Company Inc.

Chronic Freshwater Toxicity Test
***C. dubia* Reproduction Data**

Client: ALS/Minto
Sample ID: ~~WD/W3~~ L1847785-1 W3
Work Order: 161170

Start Date & Time: Oct 21/16 @ 1050h
Stop Date & Time: Nov 1/16 @ 2010h
Set up by: EMM

% (v/v)

Concentration: control

Days	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EMM
2	/	/	/	/	/	/	/	/	/	/	EMM
3	/	/	/	/	/	/	/	/	/	/	A
4	4	✓	4	3	3	3	4	2	3	4	MG
5	✓	3	8	8	7	6	8	7	7	8	EMM
6	8	9	10	13	13	12	✓	✓	11	10	EMM
7											
8											
Total	12	12	22	24	23	21	12	9	21	22	EMM

Concentration: 1.56

Days	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EMM
2	/	/	/	/	/	/	/	/	/	/	EMM
3	/	/	/	/	/	/	/	/	/	/	A
4	✓	4	4	4	3	3	4	4	✓	3	MG
5	4	6	8	8	9	9	6	8	4	6	EMM
6	6	13	7	11	13	✓	12	✓	14	10	EMM
7											
8											
Total	10	23	19	23	25	12	22	12	18	19	EMM

Concentration: 3.12

Days	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EMM
2	/	/	/	/	/	/	/	/	/	/	EMM
3	/	/	/	/	/	/	/	/	/	/	A
4	3	4	✓	2	4	3	4	4	4	4	MG
5	8	8	4	8	9	4	8	7	7	8	EMM
6	14	11	8	10	✓	10	10	11	11	12	EMM
7											
8											
Total	25	23	12	20	13	17	22	22	22	24	EMM

Concentration: 6.25

Days	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EMM
2	/	/	/	/	/	/	/	/	/	/	EMM
3	/	/	/	/	/	/	/	/	/	/	A
4	3	3	✓	✓	✓	2	✓	4	4	4	MG
5	7	6	5	5	4	4	6	8	9	8	EMM
6	11	11	10	9	9	8	6	11	✓	✓	EMM
7											
8											
Total	21	20	15	14	13	~~15~~ 14 MG	12	23	13	12	EMM

Concentration: 12.5

Days	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EMM
2	/	/	/	/	/	/	/	/	/	/	EMM
3	/	/	/	/	/	/	/	/	/	/	A
4	✓	2	4	✓	5	4	✓	3	2	3	MG
5	4	8	6	4	10	8	6	8	8	9	EMM
6	11	13	12	10	13	13	10	✓	13	14	EMM
7											
8											
Total	15	23	22	14	28	25	16	11	23	26	EMM

Concentration: 25

Days	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EMM
2	/	/	/	/	/	/	/	/	/	/	EMM
3	/	/	/	/	/	/	/	/	/	/	A
4	3	✓	3	3	3	4	4	3	3	4	MG
5	9	4	9	9	8	8	10	9	9	10	EMM
6	13	10	13	12	12	12	10	10	11	12	EMM
7											
8											
Total	25	14	25	24	23	24	24	22	23	26	EMM

Concentration: 50

Days	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EMM
2	/	/	/	/	/	/	/	/	/	/	EMM
3	/	/	/	/	/	/	/	/	/	/	A
4	3	3	4	4	✓	3	4	3	4	✓	MG
5	7	9	6	6	4	8	4	8	9	4	EMM
6	13	14	16	14	10	14	11	12	12	11	EMM
7											
8											
Total	23	26	26	24	14	25	19	23	25	15	EMM

Concentration: 100

Days	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	EMM
2	/	/	/	/	/	/	/	/	/	/	EMM
3	/	/	/	/	/	/	/	/	/	/	A
4	4	3	2	3	3	3	4	4	3	3	MG
5	9	9	8	8	9	10	10	8	9	9	EMM
6	13	14	14	✓	13	12	10	12	11	11	EMM
7											
8											
Total	26	26	24	11	25	25	24	24	23	23	EMM

Concentration:

Days	A	B	C	D	E	F	G	H	I	J	Init
1											
2											
3											
4											
5											
6											
7											
8											
Total											

Notes: X = mortality.

Sample Description: See water quality datasheet
Comments: Total # Young only based on the first 3 Broods. Fourth and subsequent broods not included in total count.

Reviewed by: JGL
Date reviewed: Nov. 25/16

CETIS Analytical Report

Nautilus Environmental

Ceriodaphnia 7-d Survival and Reproduction Test

Analysis ID:	21-3522-8998	Endpoint:	6d Survival Rate	CETIS Version:	CETISv1.8.7
Analyzed:	17 Nov-16 12:48	Analysis:	Linear Interpolation (ICPIN)	Official Results:	Yes

Batch ID:	01-3066-1325	Test Type:	Reproduction-Survival (7d)	Analyst:	Mimi Tran
Start Date:	26 Oct-16 10:50	Protocol:	EC/EPS 1/RM/21	Diluent:	20% Perrier Water
Ending Date:	01 Nov-16 20:10	Species:	Ceriodaphnia dubia	Brine:	
Duration:	6d 9h	Source:	In-House Culture	Age:	<24h

Sample ID:	13-9712-4239	Code:	53466C8F	Client:	ALS
Sample Date:	23 Oct-16	Material:	Water Sample	Project:	
Receive Date:	25 Oct-16 14:15	Source:	ALS		
Sample Age:	83h (8.4 °C)	Station:	L1847785-1 W3		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1080417	200	Yes	Two-Point Interpolation

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
EC5	>100	N/A	N/A	<1	NA	NA
EC10	>100	N/A	N/A	<1	NA	NA
EC15	>100	N/A	N/A	<1	NA	NA
EC20	>100	N/A	N/A	<1	NA	NA
EC25	>100	N/A	N/A	<1	NA	NA
EC40	>100	N/A	N/A	<1	NA	NA
EC50	>100	N/A	N/A	<1	NA	NA

6d Survival Rate Summary

			Calculated Variate(A/B)								
C-%	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0	Negative Control	10	1	1	1	0	0	0.0%	0.0%	10	10
1.56		10	1	1	1	0	0	0.0%	0.0%	10	10
3.12		10	1	1	1	0	0	0.0%	0.0%	10	10
6.25		10	1	1	1	0	0	0.0%	0.0%	10	10
12.5		10	1	1	1	0	0	0.0%	0.0%	10	10
25		10	1	1	1	0	0	0.0%	0.0%	10	10
50		10	1	1	1	0	0	0.0%	0.0%	10	10
100		10	1	1	1	0	0	0.0%	0.0%	10	10

6d Survival Rate Detail

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	1	1	1	1	1	1	1	1	1	1
1.56		1	1	1	1	1	1	1	1	1	1
3.12		1	1	1	1	1	1	1	1	1	1
6.25		1	1	1	1	1	1	1	1	1	1
12.5		1	1	1	1	1	1	1	1	1	1
25		1	1	1	1	1	1	1	1	1	1
50		1	1	1	1	1	1	1	1	1	1
100		1	1	1	1	1	1	1	1	1	1

Analyst:_______ QA: JGle Nov. 28/16

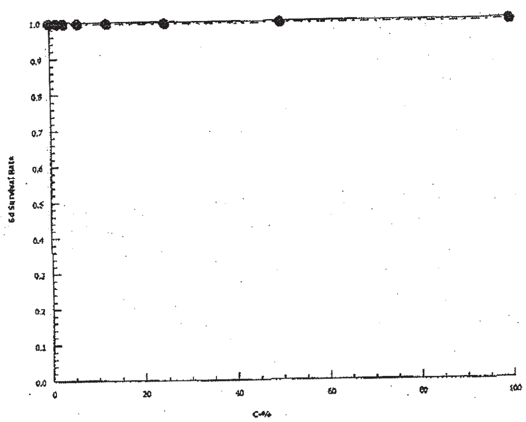
Ceriodaphnia 7-d Survival and Reproduction Test

Analysis ID:	21-3522-8998	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-16 12:48	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

6d Survival Rate Binomials

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.56		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
3.12		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
6.25		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
12.5		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
25		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
50		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
100		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

Graphics



CETIS Analytical Report

Ceriodaphnia 7-d Survival and Reproduction Test — Nautilus Environmental

Analysis ID:	13-9673-2707	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-16 12:49	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	01-3066-1325	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Mimi Tran
Start Date:	26 Oct-16 10:50	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	20% Perrier Water
Ending Date:	01 Nov-16 20:10	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 9h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	13-9712-4239	**Code:**	53466C8F	**Client:**	ALS
Sample Date:	23 Oct-16	**Material:**	Water Sample	**Project:**	
Receive Date:	25 Oct-16 14:15	**Source:**	ALS		
Sample Age:	83h (8.4 °C)	**Station:**	L1847785-1 W3		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1268593	200	Yes	Two-Point Interpolation

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	>100	N/A	N/A	<1	NA	NA
IC10	>100	N/A	N/A	<1	NA	NA
IC15	>100	N/A	N/A	<1	NA	NA
IC20	>100	N/A	N/A	<1	NA	NA
IC25	>100	N/A	N/A	<1	NA	NA
IC40	>100	N/A	N/A	<1	NA	NA
IC50	>100	N/A	N/A	<1	NA	NA

Reproduction Summary

			Calculated Variate						
C-%	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	10	17.8	9	24	1.825	5.77	32.41%	0.0%
1.56		10	18.3	10	25	1.674	5.293	28.92%	-2.81%
3.12		10	20	12	25	1.43	4.522	22.61%	-12.36%
6.25		10	15.7	12	23	1.283	4.057	25.84%	11.8%
12.5		10	20.3	11	28	1.838	5.813	28.63%	-14.04%
25		10	23	14	26	1.065	3.367	14.64%	-29.21%
50		10	22	14	26	1.406	4.447	20.21%	-23.6%
100		10	23.1	11	26	1.386	4.383	18.97%	-29.78%

Reproduction Detail

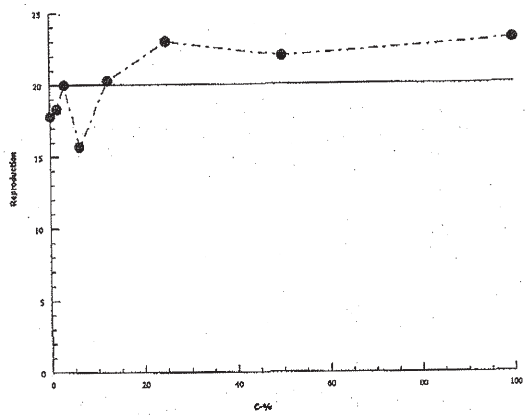
C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	12	12	22	24	23	21	12	9	21	22
1.56		10	23	19	23	25	12	22	12	18	19
3.12		25	23	12	20	13	17	22	22	22	24
6.25		21	20	15	14	13	14	12	23	13	12
12.5		15	23	22	14	28	25	16	11	23	26
25		25	14	25	24	23	24	24	22	23	26
50		23	26	26	24	14	25	19	23	25	15
100		26	26	24	11	25	25	24	24	23	23

Ceriodaphnia 7-d Survival and Reproduction Test

Nautilus Environmental

Analysis ID:	13-9673-2707	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-16 12:49	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	28 Nov-16 10:31 (p 1 of 2)
Test Code:	161170 | 02-5747-8933

Ceriodaphnia 7-d Survival and Reproduction Test — Nautilus Environmental

Analysis ID:	15-4738-0447	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	28 Nov-16 10:28	**Analysis:**	Nonparametric-Control vs Treatments	**Official Results:**	Yes
Batch ID:	01-3066-1325	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Mimi Tran
Start Date:	26 Oct-16 10:50	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	20% Perrier Water
Ending Date:	01 Nov-16 20:10	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 9h	**Source:**	In-House Culture	**Age:**	<24h
Sample ID:	13-9712-4239	**Code:**	53466C8F	**Client:**	ALS
Sample Date:	23 Oct-16	**Material:**	Water Sample	**Project:**	
Receive Date:	25 Oct-16 14:15	**Source:**	ALS		
Sample Age:	83h (8.4 °C)	**Station:**	L1847785-1 W3		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C < T	NA	NA	28.6%	50	100	70.71	2

Steel Many-One Rank Sum Test

Control vs	C-%	Test Stat	Critical	Ties	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	1.56	103	74	3	18	0.8329	Asymp	Non-Significant Effect
	3.12	91.5	74	4	18	0.4657	Asymp	Non-Significant Effect
	6.25	112.5	74	3	18	0.9676	Asymp	Non-Significant Effect
	12.5	88	74	2	18	0.3436	Asymp	Non-Significant Effect
	25*	68.5	74	3	18	0.0167	Asymp	Significant Effect
	50	76.5	74	2	18	0.0766	Asymp	Non-Significant Effect
	100*	68.5	74	2	18	0.0167	Asymp	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	489.15	69.87857	7	3.066	0.0070	Significant Effect
Error	1640.8	22.78889	72			
Total	2129.95		79			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	4.027	18.48	0.7767	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9393	0.9579	0.0009	Non-normal Distribution

Reproduction Summary

C-%	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	10	17.8	13.67	21.93	21	9	24	1.825	32.41%	0.0%
1.56		10	18.3	14.51	22.09	19	10	25	1.674	28.92%	-2.81%
3.12		10	20	16.77	23.23	22	12	25	1.43	22.61%	-12.36%
6.25		10	15.7	12.8	18.6	14	12	23	1.283	25.84%	11.8%
12.5		10	20.3	16.14	24.46	22.5	11	28	1.838	28.63%	-14.04%
25		10	23	20.59	25.41	24	14	26	1.065	14.64%	-29.21%
50		10	22	18.82	25.18	23.5	14	26	1.406	20.21%	-23.6%
100		10	23.1	19.96	26.24	24	11	26	1.386	18.97%	-29.78%

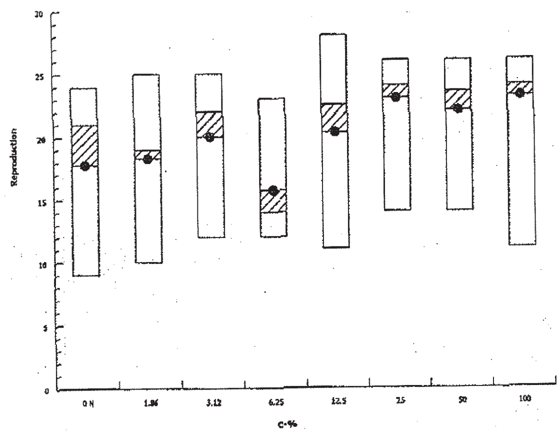
Reproduction Detail

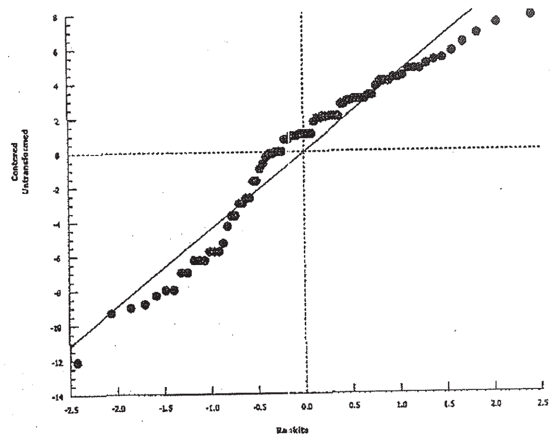
C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	12	12	22	24	23	21	12	9	21	22
1.56		10	23	19	23	25	12	22	12	18	19
3.12		25	23	12	20	13	17	22	22	22	24
6.25		21	20	15	14	13	14	12	23	13	12
12.5		15	23	22	14	28	25	16	11	23	26
25		25	14	25	24	23	24	24	22	23	26
50		23	26	26	24	14	25	19	23	25	15
100		26	26	24	11	25	25	24	24	23	23

Ceriodaphnia 7-d Survival and Reproduction Test

Analysis ID:	15-4738-0447	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	28 Nov-16 10:28	**Analysis:**	Nonparametric-Control vs Treatments	**Official Results:**	Yes

Graphics





Client: ALS

W.O.#: 161170

Hardness and Alkalinity Datasheet

Sample ID	Alkalinity						Hardness			
Sample ID	Subsample Date	Date Measured	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity (mg/L$CaCO_3$)	Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness (mg/L $CaCO_3$)	Technician
L1847785-1 W3	Oct 26/16	Oct 26/16	50	9.3	9.5	182	~~50~~ 10 1	3.3	330	YL
20x perm't	↓	↓	↓	5.0	5.1	98	↓ 50	5.0	100	EMM

Notes: 1 Diluted sample to 100mL w/ D.I. water

Reviewed by: Jon

Date Reviewed: Nov. 25/16

Version 1.1 Issued July 28, 2016

Nautilus Environmental Company Inc.

APPENDIX B – ***Oncorhynchus mykiss*** **Toxicity Test Data**

Rainbow Trout Early Life Stage Summary Sheet

Client: ALS

Work Order No.: 161169

Start Date/Time: Oct25/16 @ 1625h

Test Species: *Oncorhynchus mykiss*

Sample Information:

Sample ID: L1847785-1 W3
Sample Date: Oct 23/16
Date Received: Oct25/16
Sample Volume: 7x20L

Dilution Water:

Type: Dechlorinated Tap Water
Hardness (mg/L $CaCO_3$): 10
Alkalinity (mg/L $CaCO_3$): 4

Test Organism Information:

Batch No.: 102516
Source: Vancouver Island Trout Hatchery
Loading Density: 1.0 g/L

Number of male broodstock used: 3
Number of female broodstock used: ~~?~~ 4
Sperm motility check: Verification of sperm motility using a compound microscope

SDS Reference Toxicant Results:

Reference Toxicant ID: RTE89
Stock Solution ID: 16S02 (1000 mg/L SDS)
Date Initiated: Oct25/16
7-d EC50 (95% CL): 5.5 (5.2 - 5.8) mg/L SDS

Reference Toxicant Mean and Range: 4.0 (2.1 - 7.4) mg/L SDS
Reference Toxicant CV (%): 37

Test Results:

	Sample ID		
	L18477851 W3		
EC25 % (v/v) (95% CL)	>100		
EC50 % (v/v) (95% CL)	>100		

Reviewed by: JGh

Date reviewed: Nov. 9/16

Issued: October 4, 2016; Ver. 1.2

Nautilus Environmental Company Inc.

7-d Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: ALS
Sample ID: L1847785-1 W3
Work Order #: 161169

Start Date & Time: Oct 25 /16 @ 1625h
Stop Date & Time: Nov 1/16 @ 1045h
Test Species: *Oncorhynchus mykiss*

Concentration % (v/v) control	Days 0	1		2		3		4		5		6		7
	init	new	old	new	old	new	old	new	old	new	old	new	old	final
Temperature (°C)	14.5	14.5	14.0	14.0	14.0	14.5	14.0	14.6	14.8	14.6	14.0	14.5	14.0	14.0
DO (mg/L)	9.9	10.1	10.0	10.0	10.0	10.0	10.0	10.1	9.9	10.1	9.9	10.0	9.9	10.2
pH	7.1	6.9	6.9	7.0	6.9	6.9	6.8	6.8	7.1	6.8	7.1	6.9	6.9	6.9
Cond. (µS/cm)	28	28		28		28		28		28		28		30
Initials	KL	KL		KL		KL		A		A		KL		KL

Concentration 6.25	Days 0	1		2		3		4		5		6		7
	init	new	old	new	old	new	old	new	old	new	old	new	old	final
Temperature (°C)	14.5	14.0	14.0	14.5	14.0	14.5	14.0	14.5	14.0	14.5	14.0	14.0	14.0	14.0
DO (mg/L)	9.8	10.2	10.1	10.1	10.0	10.1	10.0	10.1	9.8	10.0	9.8	10.0	10.0	10.2
pH	7.1	7.3	7.4	7.2	7.3	7.3	7.3	7.2	7.3	7.3	7.4	7.2	7.2	7.3
Cond. (µS/cm)	70	60		59		58		57		56		60		60
Initials	KL	KL		KL		KL		A		A		KL		KL

Concentration 25	Days 0	1		2		3		4		5		6		7
	init	new	old	new	old	new	old	new	old	new	old	new	old	final
Temperature (°C)	13.5	14.5	14.0	14.5	14.0	14.5	14.0	14.5	14.0	14.5	14.0	14.0	14.0	14.0
DO (mg/L)	9.9	10.1	10.1	10.1	10.0	10.1	10.0	10.1	9.9	10.0	9.8	10.0	10.0	10.2
pH	7.4	7.5	7.6	7.6	7.6	7.7	7.6	7.7	7.8	7.8	7.5	7.7	7.7	7.6
Cond. (µS/cm)	162	159		169		169		165		167		165		163
Initials	KL	KL		KL		KL		A		A		KL		KL

Concentration ~~50~~ 100	Days 0	1		2		3		4		5		6		7
	init	new	old	new	old	new	old	new	old	new	old	new	old	final
Temperature (°C)	14.0	14.5	14.0	14.5	14.0	14.5	14.0	14.5	14.0	14.5	14.0	14.0	14.0	14.0
DO (mg/L)	10.1	10.1	10.1	10.1	10.1	10.1	10.0	10.1	9.8	10.0	9.8	10.0	10.0	10.2
pH	8.0	7.9	8.3	7.8	8.3	7.9	8.3	7.9	8.2	7.9	8.3	8.0	8.4	8.3
Cond. (µS/cm)	514	508		516		509		510		508		508		505
Initials	KL	KL		KL		KL		A		A		KL		KL

Thermometer: Temp-3 DO meter: DO-2 pH meter: pH-1 Conductivity meter: C-2

	Control	100%		
Hardness*	10	252		
Alkalinity*	4	174		

* mg/L as CaCO3

Analysts: AWO, KL
Reviewed by: JGL
Date reviewed: Nov-9/16

Sample Description: Clear, yellow, no odour, no particulates.

Comments:

Version 1.1 Issued May 22, 2015

Nautilus Environmental Company Inc.

Embryo Toxicity Test
Daily Mortality

Client: ALS
Sample ID: L1847785-1 W3
Work Order #: 161169

Start Date & Time: Oct 25/16 @ 1625h
Stop Date & Time: Nov 1/16 @ 1045h
Test Species: *Oncorhynchus mykiss*

Concentration % (v/v)	Rep	Day of Test - No. of Mortalities 1	2	3	4	5	6	7	Total Dead Eggs	Total Undeveloped	Total No. Embryo	Total Exposed
control	1	0	0	0	0	0	0	0	0	0	30	30
	2									0	30	30
	3									0	30	30
	4									0	30	30
6.25	1									0	30	30
	2									1	29	30
	3									0	30	30
	4									1	29	30
12.5	1						1	0	1	0	29	30
	2						0	0	0	0	30	30
	3									0	30	30
	4									1	29	30
25	1									1	29	30
	2									1	29	30
	3									0	30	30
	4						1	0	1	0	29	30
50	1						0	0	0	1	29	30
	2						1	0	1	1	28	30
	3					1	1	0	2	0	28	30
	4					0	0	0	0	1	29	30
100	1						0	0		0	30	30
	2						0	0		0	30	30
	3						0	~~0~~ 1	1	0	~~29~~ 29	30
	4						2	~~2~~ 0	2	0	28	30
	1											
	2											
	3											
	4											
	1											
	2											
	3											
	4											
Tech Initials		K	K	K	A	A	K	K	K	K	K	K

Comments:

Reviewed by: JCk

Date reviewed: Nov. 9/16

Version 1.0 Issued June 26, 2006

Nautilus Environmental Company Inc.

CETIS Analytical Report

Nautilus Environmental

Salmonid Embryo Survival and Development Test

Analysis ID:	20-2346-9604	**Endpoint:**	Proportion Normal	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Nov-16 16:47	**Analysis:**	Linear Regression (MLE)	**Official Results:**	Yes
Batch ID:	19-1929-1377	**Test Type:**	Development	**Analyst:**	Kania Lywe
Start Date:	25 Oct-16 16:25	**Protocol:**	EC/EPS 1/RM/28	**Diluent:**	Dechlorinated Tap Water
Ending Date:	01 Nov-16 10:45	**Species:**	Oncorhynchus mykiss	**Brine:**	
Duration:	6d 18h	**Source:**	Vancouver Island Trout Hatchery	**Age:**	
Sample ID:	13-9712-4239	**Code:**	53466C8F	**Client:**	ALS
Sample Date:	23 Oct-16	**Material:**	Water Sample	**Project:**	
Receive Date:	25 Oct-16 14:15	**Source:**	ALS		
Sample Age:	64h (9 °C)	**Station:**	L1847785-1 W3		

Linear Regression Options

Model Function	Threshold Option	Threshold	Optimized	Pooled	Het Corr	Weighted
Log-Angle [Asin(P^0.5)=A+B*log(X)]	Control Threshold	0.0000001	Yes	No	No	Yes

Regression Summary

Iters	LL	AICc	BIC	Mu	Sigma	Adj R2	F Stat	Critical	P-Value	Decision(α:5%)
6	-73.15	153.5	155.8	-1.544		0.3565	0.4137	3.16	0.7452	Non-Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
EC5	348	N/A	N/A	0.2874	NA	NA
EC10	19280	N/A	N/A	0.005187	NA	NA
EC15	458300	N/A	N/A	0.0002182	NA	NA
EC20	7176000	N/A	N/A	0.0000139	NA	NA
EC25	87510000	N/A	N/A	0.0000011	NA	NA
EC40	726300000	N/A	N/A	0.0000000	NA	NA
EC50	484400000	N/A	N/A	0.0000000	NA	NA

u

>100

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
Threshold	9.898E-08	2.872E-05	-5.62E-05	5.639E-05	0.003446	0.9973	Non-Significant Parameter
Slope	0.0552	0.04795	-0.03878	0.1492	1.151	0.2626	Non-Significant Parameter
Intercept	0.08523	0.07007	-0.0521	0.2226	1.216	0.2373	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	7.171578	7.171578	1	14.74	0.0010	Significant
Lack of Fit	0.65891	0.2196366	3	0.4137	0.7452	Non-Significant
Pure Error	9.555876	0.530882	18			
Residual	10.21479	0.4864184	21			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Goodness-of-Fit	Pearson Chi-Sq GOF	10.21	32.67	0.9760	Non-Significant Heterogenity
	Likelihood Ratio GOF	14.53	32.67	0.8458	Non-Significant Heterogenity
Variances	Mod Levene Equality of Variance	3.498	2.773	0.0220	Unequal Variances
Distribution	Shapiro-Wilk W Normality	0.9378	0.9169	0.1454	Normal Distribution
	Anderson-Darling A2 Normality	0.6195	2.492	0.1076	Normal Distribution

Proportion Normal Summary

			Calculated Variate(A/B)								
C-%	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0	Negative Control	4	1	1	1	0	0	0.0%	0.0%	120	120
6.25		4	0.9833	0.9667	1	0.009622	0.01924	1.96%	1.67%	118	120
12.5		4	0.9833	0.9667	1	0.009622	0.01924	1.96%	1.67%	118	120
25		4	0.975	0.9667	1	0.008333	0.01667	1.71%	2.5%	117	120
50		4	0.95	0.9333	0.9667	0.009622	0.01924	2.03%	5.0%	114	120
100		4	0.975	0.9333	1	0.01596	0.03191	3.27%	2.5%	117	120

Salmonid Embryo Survival and Development Test — Nautilus Environmental

Analysis ID:	20-2346-9604	**Endpoint:**	Proportion Normal	**CETIS Version:**	CETISv1.8.7
Analyzed:	04 Nov-16 16:47	**Analysis:**	Linear Regression (MLE)	**Official Results:**	Yes

Proportion Normal Detail

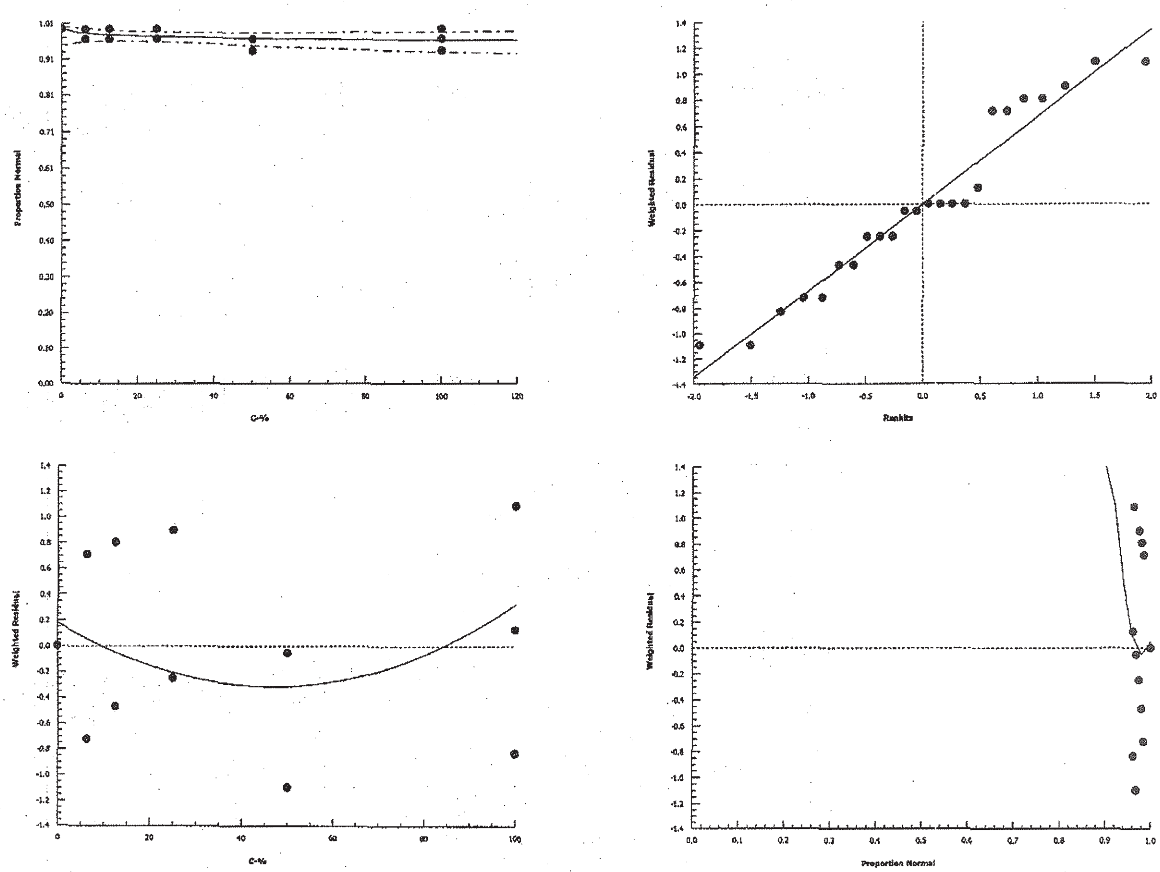
C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Negative Control	1	1	1	1
6.25		1	0.9667	1	0.9667
12.5		0.9667	1	1	0.9667
25		0.9667	0.9667	1	0.9667
50		0.9667	0.9333	0.9333	0.9667
100		1	1	0.9667	0.9333

Proportion Normal Binomials

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Negative Control	30/30	30/30	30/30	30/30
6.25		30/30	29/30	30/30	29/30
12.5		29/30	30/30	30/30	29/30
25		29/30	29/30	30/30	29/30
50		29/30	28/30	28/30	29/30
100		30/30	30/30	29/30	28/30

Graphics

Log-Angle [Asin(P^0.5)=A+B*log(X)]



Client: ALS

W.O.#: 161169

Hardness and Alkalinity Datasheet

Sample ID	Alkalinity: Subsample Date	Alkalinity: Date Measured	Alkalinity: Sample Volume (mL)	Alkalinity: (mL) 0.02N HCL/H_2SO_4 used to pH 4.5	Alkalinity: (mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Alkalinity: Total Alkalinity (mg/L $CaCO_3$)	Hardness: Sample Volume (mL)	Hardness: Volume of 0.01M EDTA Used (mL)	Hardness: Total Hardness (mg/L $CaCO_3$)	Technician
Dechlor	Oct 25/16	Oct 25/16	100	0.5	0.6	~~100.5~~ 4	100	1.0	10	[illegible]
L1847785-1 W3	Oct 23/16	Oct 25/16	50	9.0	9.3	174	50	12.6	252	

Notes:

Reviewed by: JCh

Date Reviewed: Nov. 9/16

APPENDIX C – *Lemna minor* Toxicity Test Data

Lemna minor Summary Sheet

Client: ALS / Minto
Work Order No.: 161171

Start Date: October 26, 2016
Set up by: JW

Sample Information:

Sample ID: ~~W3~~ JW L1847785-1 W3
Sample Date: October 23, 2016
Date Received: October 25, 2016
Sample Volume: 5 x 1L

Test Organism Information:

Culture Date: 101916
Age of culture (Day 0): 7 days
>8X growth in APHA?: Y (38 fronds)

KCl Reference Toxicant Results:

Reference Toxicant ID: Lm 138
Date Initiated: October 13, 2016

7-d No. of Fronds IC50 (95% CL): 3.5 (3.2 - 3.9) g/L KCl

7-d No. Fronds IC50 Reference Toxicant Mean (2 SD Range): 3.9 (3.2 - 4.9) g/L KCl CV (%): 11

Test Results:

	Number of Fronds	Dry Weight
IC25 %(v/v) (95% CL)	>97	>97
IC50 %(v/v) (95% CL)	>97	>97

Reviewed by: JGu Date reviewed: Nov. 25/16

Plant Growth Inhibition Toxicity Test
Water Quality Measurements

Client : ALS / Minto

Sample ID: ~~W3~~ JW L1847785-1 W3

Work Order No.: 161171

Culture Source: CPCC # 490

Test Culture Age: 7 days

Light Intensity Range: 4210 - 4840 lux

Setup by: JW

Test Date: October 26, 2016

Test Species: *Lemna minor*

> 8X Growth? (Y/N): Y (38 fronds)

Date Measured: October 26, 2016

Day	0	1	2	3	4	5	6	7
Shelf Temp (°C)	25.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Initials	JW	JW	JW	A	A	JW	JW	JW

Sample Characteristics: Initial Water Quality

Temperature (°C): 25.0

DO (mg/L): 9.0

pH: 7.8

Conductivity (µS): 506

Aeration?: 20 min

Nutrients added?[1]: Y

Adjusted Water Quality: 25.0 / 8.4 / 7.9 / 1297

[1] 10 mL of each APHA stock (A,B and C) added to 970 mL sample.

Concentration % (v/v)	Temperature (°C)		pH		Conductivity (µS)
	Day 0	Day 7	Day 0	Day 7	0 h
Control	25.5	25.5	8.3	8.4	889
1.5	25.5	25.5	8.1	8.4	906
3	25.5	25.5	8.2	8.6	914
6.1	25.5	25.5	8.2	8.6	926
12.1	25.5	25.5	8.1	8.5	951
24.2	25.5	25.5	8.1	8.6	1002
48.5	25.0	25.5	8.0	8.7	1099
97	25.0	25.5	7.9	8.8	1297
Initials	JW	JW	JW	JW	JW

Thermometer: 4 Cond. Meter: 2 pH meter: 1 Light meter: 1.

Sample Description: clear, ~~colorless~~ JW yellow, odorless, ~~some black~~ JW no particulates present.

Comments:

Reviewed: JOh

Date Reviewed: Nov. 25/16

Lemna minor Toxicity Test Data Sheet - 7-d Frond Counts

Client: ALS / Minto
Sample ID: JW ~~W3~~ L1847785-1 W3
Work Order #: 161171

Start Date: October 26, 2016
Termination Date: November 2, 2016
Test set up by: JW

Concentration % (v/v)	Rep	No. of fronds Day 0	No. of fronds Day 7	Chlorosis	Necrosis	Yellow	Abnormal size	Gibbosity	Single fronds	Root destruction	Loss of buoyancy	Comments	Initials
control	A	6	132										JW
	B	6	86										
	C	6	115										
	D	6	114										
1.5	A	6	132										
	B	6	100										
	C	6	114										
	D	6	119										
3.0	A	6	142										
	B	6	120										
	C	6	112										
	D	6	108										
6.1	A	6	127										
	B	6	114										
	C	6	112										
	D	6	133										
12.1	A	6	131										
	B	6	99										
	C	6	105										
	D	6	125										
24.2	A	6	123										
	B	6	111										
	C	6	150										
	D	6	115										

Comments:

Reviewed by: JGb

Date Reviewed: Nov. 25/16

Lemna minor Toxicity Test Data Sheet - 7-d Frond Counts

Client: ALS / Minto
Sample ID: JW ~~W3~~ L1847785-1 W3
Work Order #: 161171

Start Date: October 26, 2016
Termination Date: November 2, 2016
Test set up by: JW

Concentration % (v/v)	Rep	No. of fronds Day 0	No. of fronds Day 7	Chlorosis	Necrosis	Yellow	Abnormal size	Gibbosity	Single fronds	Root destruction	Loss of buoyancy	Comments	Initials
48.5	A	6	118										JW
	B	6	125										
	C	6	146										
	D	6	117										
97	A	6	72										
	B	6	109										
	C	6	93										
	D	6	98										
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												

Comments:

Reviewed by: JGv

Date Reviewed: Nov. 25/16

7-d *Lemna minor* Weight Data Sheet

Client: ALS / Minto
Sample ID: ~~W3~~ JW L 1847785 - 1 W3
WO #: 161171

Start Date: October 26, 2016
Termination Date: November 2, 2016
Balance ID: Bal - 1

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
% (v/v)		W3 - Black			
control	A	1	1016.47	1026.08	JW / JW
	B	2	1017.39	1024.07	
	C	3	1013.80	1023.14	
	D	4	1010.12	1018.66	
1.5	A	5	1003.88	1014.85	
	B	6	1003.15	1010.70	
	C	7	998.52	1007.48	
	D	8	996.86	1005.78	
3.0	A	9	1001.00	1011.98	
	B	10	1015.76	1025.40	
	C	11	996.32	1004.83	
	D	12	1002.73	1011.07	
6.1	A	13	1031.86	1041.22	
	B	14	1007.41	1015.95	
	C	15	1009.54	1018.17	
	D	16	1010.47	1021.78	
12.1	A	17	1015.75	1027.19	
	B	18	1025.06	1032.65	
	C	19	1030.04	1038.28	
	D	20	1023.70	1034.01	
24.2	A	21	995.56	1005.33	
	B	22	1004.79	1013.65	
	C	23	995.98	1008.35	
	D	24	1019.87	1029.51	
48.5	A	25	1034.30	1044.07	
	B	26	1014.3~~8~~3 JW	1024.95	
	C	27	1007.67	1020.11	
	D	28	1002.68	1012.82	↓

Comments: 10% Re-weigh : # 1. 1026.06 # 23. 1008.17
(mg) # 11. 1004.66 #. 32 : 1013.96

Reviewed by: JGL

Date Reviewed: Nov. 28/16

7-d *Lemna minor* Weight Data Sheet

Client: ALS / Minto
Sample ID: JW ~~W3~~ L1847785-1 W3
WO #: 161171

Start Date: October 26, 2016
Termination Date: November 2, 2016
Balance ID: Bal - 1

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
% (V/V)		W3 - Black			
	A	29	1027.90	1035.68	JW / JW
	B	30	1006.86	1016.64	
97	C	31	999.49	1007.44	
	D	32	1005.76	1013.92	
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				

Comments:

Reviewed by: [signature] Date Reviewed: Nov. 25/16

CETIS Analytical Report

Report Date: 16 Nov-16 09:59 (p 1 of 2)
Test Code: 161171 | 08-7741-5097

Nautilus Environmental

Lemna Growth Inhibition Test

Analysis ID:	18-2914-4333	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 9:57	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes
Batch ID:	05-9803-4038	**Test Type:**	Lemna Growth	**Analyst:**	Jeslin Wijaya
Start Date:	26 Oct-16	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	Modified APHA
Ending Date:	02 Nov-16	**Species:**	Lemna minor	**Brine:**	
Duration:	7d 0h	**Source:**	CPCC#490	**Age:**	7d
Sample ID:	13-9712-4239	**Code:**	53466C8F	**Client:**	ALS
Sample Date:	23 Oct-16	**Material:**	Water Sample	**Project:**	
Receive Date:	25 Oct-16 14:15	**Source:**	ALS		
Sample Age:	72h ~~(9 °C)~~ JW (8.4 °C)	**Station:**	L1847785-1 W3		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
7	-99.17	207.8	212.2	0.2598	Yes	0.2954	2.776	0.8780	Non-Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	80.35	N/A	108.3	1.245	0.9234	NA
IC10	86.05	N/A	108	1.162	0.9258	NA
IC15	91.32	N/A	106.9	1.095	0.9351	NA
IC20	96.35	83.04	108.9	1.038	0.918	1.204
IC25	~~101.3~~	~~83.6~~	118.8	0.9872	0.8415	1.196
IC40	116.5	N/A	~~216.4~~	~~0.8587~~	0.4622	NA
IC50	127.7	N/A	N/A	0.783	NA	~~NA~~ JW

} > 97 % (v/v)

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	109.6	4.211	101.4	117.9	26.03	<0.0001	Significant Parameter
C	3.735	4.368	-4.826	12.3	0.8552	0.3997	Non-Significant Parameter
D	127.7	43.19	43.06	212.4	2.957	0.0062	Significant Parameter
E	0.003165	0.004231	-0.005128	0.01146	0.7479	0.4607	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	2869.311	2869.311	1	13.88	0.0009	Significant
Lack of Fit	271.658	67.91449	4	0.2954	0.8780	Non-Significant
Pure Error	5517.25	229.8854	24			
Residual	5788.908	206.7467	28			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance	1.285	14.07	0.9888	Equal Variances
	Mod Levene Equality of Variance	0.1037	2.423	0.9976	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9832	0.9338	0.8852	Normal Distribution
	Anderson-Darling A2 Normality	0.2383	2.492	0.8100	Normal Distribution

Lemna Growth Inhibition Test — Nautilus Environmental

Analysis ID:	18-2914-4333	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 9:57	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Frond Count Summary

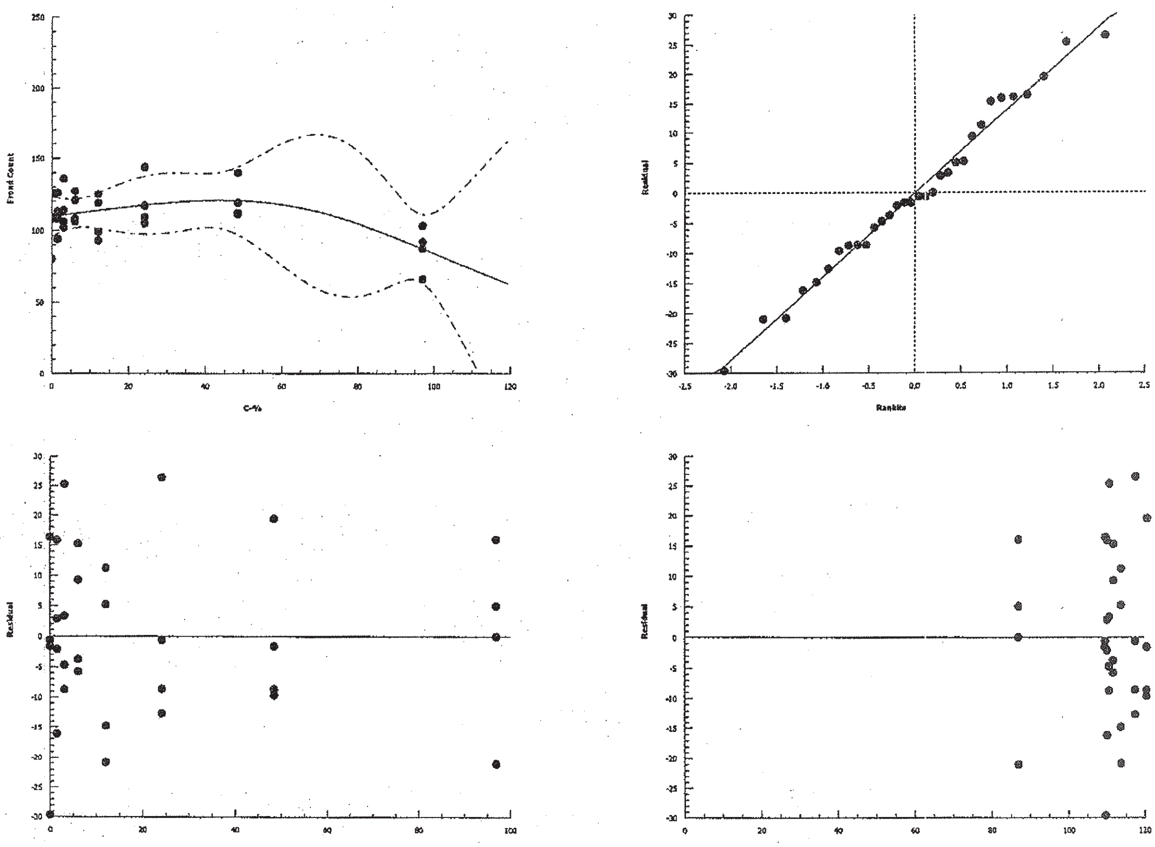
C-%	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
			Calculated Variate						
0	Negative Control	4	105.8	80	126	9.525	19.05	18.01%	0.0%
1.5		4	110.3	94	126	6.613	13.23	12.0%	-4.26%
3.1		4	114.5	102	136	7.588	15.18	13.25%	-8.27%
6.1		4	115.5	106	127	5.074	10.15	8.79%	-9.22%
12.1		4	109	93	125	7.703	15.41	14.13%	-3.07%
24.2		4	118.8	105	144	8.779	17.56	14.78%	-12.29%
48.5		4	120.5	111	140	6.739	13.48	11.19%	-13.95%
97		4	87	66	103	7.757	15.51	17.83%	17.73%

Frond Count Detail

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Negative Control	126	80	109	108
1.5		126	94	108	113
3.1		136	114	106	102
6.1		121	108	106	127
12.1		125	93	99	119
24.2		117	105	144	109
48.5		112	119	140	111
97		66	103	87	92

Graphics

4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]



CETIS Analytical Report

Report Date:	16 Nov-16 09:59 (p 1 of 2)		
Test Code:	161171 | 08-7741-5097		

Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	18-4757-3102	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 9:59	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes
Batch ID:	05-9803-4038	**Test Type:**	Lemna Growth	**Analyst:**	Jeslin Wijaya
Start Date:	26 Oct-16	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	Modified APHA
Ending Date:	02 Nov-16	**Species:**	Lemna minor	**Brine:**	
Duration:	7d 0h	**Source:**	CPCC#490	**Age:**	7d
Sample ID:	13-9712-4239	**Code:**	53466C8F	**Client:**	ALS
Sample Date:	23 Oct-16	**Material:**	Water Sample	**Project:**	
Receive Date:	25 Oct-16 14:15	**Source:**	ALS		
Sample Age:	72h ~~(9 °C)~~ JW (8.4 °C)	**Station:**	L1847785-1 W3		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C < T	NA	NA	25.2%	97	>97	NA	1.031

Dunnett Multiple Comparison Test

Control vs	C-%	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	1.5	0.4197	2.482	26.61	6	0.7398	CDF	Non-Significant Effect
	3.1	0.8161	2.482	26.61	6	0.5669	CDF	Non-Significant Effect
	6.1	0.9094	2.482	26.61	6	0.5232	CDF	Non-Significant Effect
	12.1	0.3031	2.482	26.61	6	0.7833	CDF	Non-Significant Effect
	24.2	1.213	2.482	26.61	6	0.3843	CDF	Non-Significant Effect
	48.5	1.376	2.482	26.61	6	0.3157	CDF	Non-Significant Effect
	97	-1.749	2.482	26.61	6	0.9992	CDF	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	3140.969	448.7098	7	1.952	0.1050	Non-Significant Effect
Error	5517.25	229.8854	24			
Total	8658.219		31			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	1.285	18.48	0.9888	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9693	0.9081	0.4811	Normal Distribution

Frond Count Summary

C-%	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	4	105.8	75.44	136.1	108.5	80	126	9.525	18.01%	0.0%
1.5		4	110.3	89.21	131.3	110.5	94	126	6.613	12.0%	-4.26%
3.1		4	114.5	90.35	138.6	110	102	136	7.588	13.25%	-8.27%
6.1		4	115.5	99.35	131.6	114.5	106	127	5.074	8.79%	-9.22%
12.1		4	109	84.49	133.5	109	93	125	7.703	14.13%	-3.07%
24.2		4	118.8	90.81	146.7	113	105	144	8.779	14.78%	-12.29%
48.5		4	120.5	99.05	141.9	115.5	111	140	6.739	11.19%	-13.95%
97		4	87	62.31	111.7	89.5	66	103	7.757	17.83%	17.73%

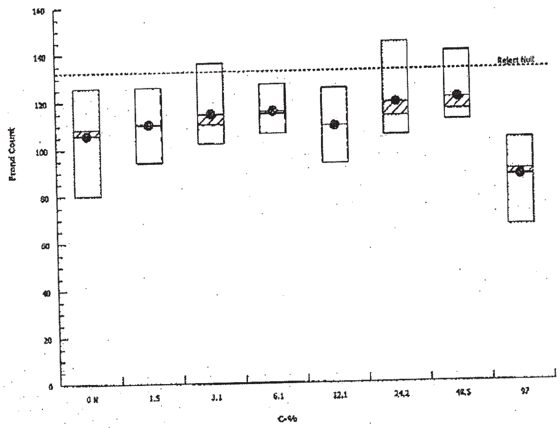
Frond Count Detail

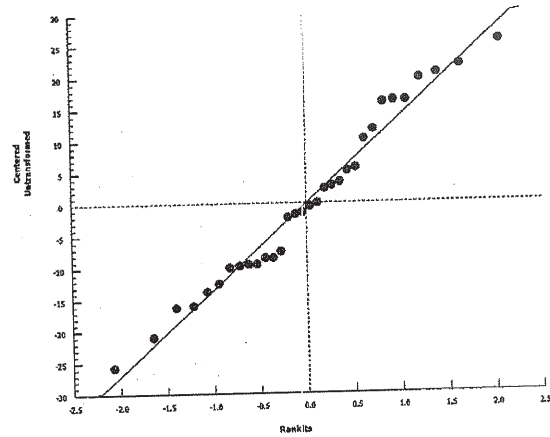
C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Negative Control	126	80	109	108
1.5		126	94	108	113
3.1		136	114	106	102
6.1		121	108	106	127
12.1		125	93	99	119
24.2		117	105	144	109
48.5		112	119	140	111
97		66	103	87	92

Lemna Growth Inhibition Test

Analysis ID:	18-4757-3102	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 9:59	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Graphics





CETIS Analytical Report

Report Date: 16 Nov-16 09:59 (p 1 of 2)
Test Code: 161171 | 08-7741-5097

Lemna Growth Inhibition Test — Nautilus Environmental

Analysis ID:	13-4365-0332	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 9:59	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes
Batch ID:	05-9803-4038	**Test Type:**	Lemna Growth	**Analyst:**	Jeslin Wijaya
Start Date:	26 Oct-16	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	Modified APHA
Ending Date:	02 Nov-16	**Species:**	Lemna minor	**Brine:**	
Duration:	7d 0h	**Source:**	CPCC#490	**Age:**	7d
Sample ID:	13-9712-4239	**Code:**	53466C8F	**Client:**	ALS
Sample Date:	23 Oct-16	**Material:**	Water Sample	**Project:**	
Receive Date:	25 Oct-16 14:15	**Source:**	ALS		
Sample Age:	72h ~~(9 °C)~~ JW (8.4 °C)	**Station:**	L1847785-1 W3		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
2P Exponential EV [Y=A*exp(log(0.5)*X/D)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
8	-26.22	56.86	59.38		Yes	1.513	2.508	0.2165	Non-Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	345.2	N/A	5598	0.2897	0.01786	NA
IC10	709	N/A	N/A	0.141	NA	NA
IC15	1094	N/A	N/A	0.09144	NA	NA
IC20	1502	N/A	N/A	0.06659	NA	NA
IC25	1936	N/A	N/A	0.05165	NA	NA
IC40	3438	N/A	N/A	0.02909	NA	NA
IC50	4665	N/A	N/A	0.02144	NA	NA

JW

> 97 % (v/v)

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	9.432	0.3169	8.811	10.05	29.76	<0.0001	Significant Parameter
D	4665	26870	-48010	57340	0.1736	0.8634	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	0.0650514	0.0650514	1	0.03219	0.8588	Non-Significant
Lack of Fit	16.63542	2.772571	6	1.513	0.2165	Non-Significant
Pure Error	43.99018	1.832924	24			
Residual	60.62561	2.020854	30			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance	1.376	14.07	0.9863	Equal Variances
	Mod Levene Equality of Variance	0.3406	2.423	0.9270	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9744	0.9338	0.6270	Normal Distribution
	Anderson-Darling A2 Normality	0.3384	2.492	0.5057	Normal Distribution

Total Dry Weight-mg Summary

			Calculated Variate						
C-%	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	4	8.542	6.68	9.61	0.6611	1.322	15.48%	0.0%
1.5		4	9.1	7.55	10.97	0.7042	1.408	15.48%	-6.53%
3.1		4	9.368	8.34	10.98	0.61	1.22	13.02%	-9.66%
6.1		4	9.46	8.54	11.31	0.6434	1.287	13.6%	-10.74%
12.1		4	9.395	7.59	11.44	0.8949	1.79	19.05%	-9.98%
24.2		4	10.16	8.86	12.37	0.7636	1.527	15.03%	-18.94%
48.5		4	10.74	9.77	12.44	0.592	1.184	11.02%	-25.75%
97		4	8.418	7.78	9.78	0.4608	0.9215	10.95%	1.46%

CETIS Analytical Report

Report Date:	16 Nov-16 09:59 (p 2 of 2)
Test Code:	161171 | 08-7741-5097

Nautilus Environmental

Lemna Growth Inhibition Test

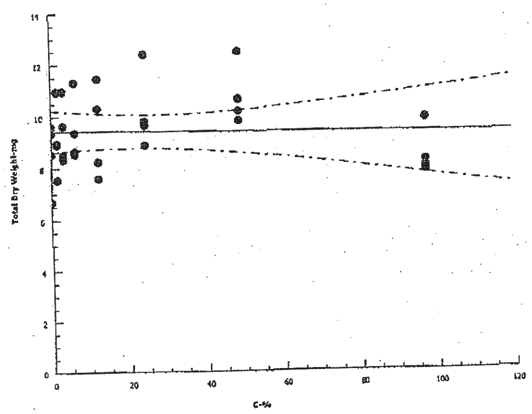
Analysis ID:	13-4365-0332	Endpoint:	Total Dry Weight-mg	CETIS Version:	CETISv1.8.7
Analyzed:	16 Nov-16 9:59	Analysis:	Nonlinear Regression	Official Results:	Yes

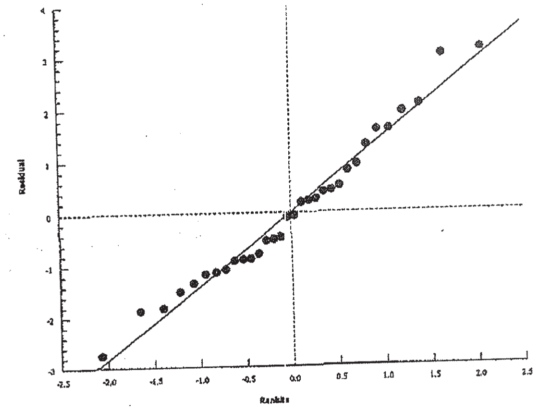
Total Dry Weight-mg Detail

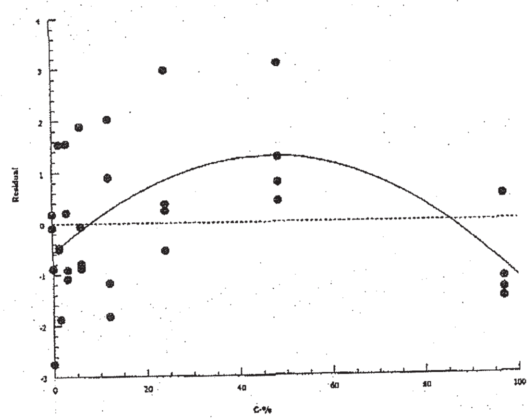
C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Negative Control	9.61	6.68	9.34	8.54
1.5		10.97	7.55	8.96	8.92
3.1		10.98	9.64	8.51	8.34
6.1		9.36	8.54	8.63	11.31
12.1		11.44	7.59	8.24	10.31
24.2		9.77	8.86	12.37	9.64
48.5		9.77	10.62	12.44	10.14
97		7.78	9.78	7.95	8.16

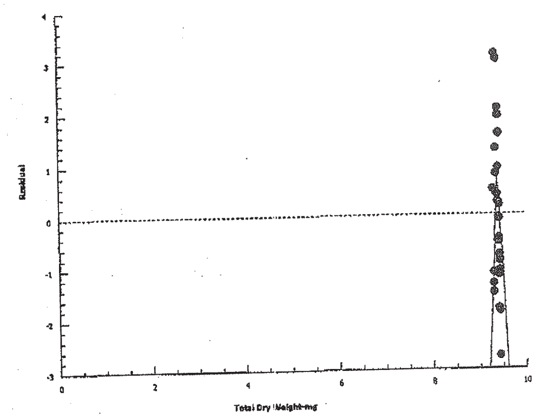
Graphics

2P Exponential EV [Y=A*exp(log(0.5)*X/D)]









CETIS Analytical Report

Report Date: 16 Nov-16 09:59 (p 1 of 2)
Test Code: 161171 | 08-7741-5097

Lemna Growth Inhibition Test — Nautilus Environmental

Analysis ID:	04-0736-2865	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 9:59	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes
Batch ID:	05-9803-4038	**Test Type:**	Lemna Growth	**Analyst:**	Jeslin Wijaya
Start Date:	26 Oct-16	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	Modified APHA
Ending Date:	02 Nov-16	**Species:**	Lemna minor	**Brine:**	
Duration:	7d 0h	**Source:**	CPCC#490	**Age:**	7d
Sample ID:	13-9712-4239	**Code:**	53466C8F	**Client:**	ALS
Sample Date:	23 Oct-16	**Material:**	Water Sample	**Project:**	
Receive Date:	25 Oct-16 14:15	**Source:**	ALS		
Sample Age:	72h ~~(9 °C)~~ JW (8.4°C)	**Station:**	L1847785-1 W3		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C < T	NA	NA	27.8%	97	>97	NA	1.031

Dunnett Multiple Comparison Test

Control	vs	C-%	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		1.5	0.5824	2.482	2.376	6	0.6726	CDF	Non-Significant Effect
		3.1	0.8618	2.482	2.376	6	0.5455	CDF	Non-Significant Effect
		6.1	0.9584	2.482	2.376	6	0.5003	CDF	Non-Significant Effect
		12.1	0.8905	2.482	2.376	6	0.5321	CDF	Non-Significant Effect
		24.2	1.69	2.482	2.376	6	0.2039	CDF	Non-Significant Effect
		48.5	2.298	2.482	2.376	6	0.0717	CDF	Non-Significant Effect
		97	-0.1305	2.482	2.376	6	0.9046	CDF	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	16.70048	2.385782	7	1.302	0.2919	Non-Significant Effect
Error	43.99018	1.832924	24			
Total	60.69066		31			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	1.376	18.48	0.9863	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.934	0.9081	0.0506	Normal Distribution

Total Dry Weight-mg Summary

C-%	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	4	8.542	6.439	10.65	8.94	6.68	9.61	0.6611	15.48%	0.0%
1.5		4	9.1	6.859	11.34	8.94	7.55	10.97	0.7042	15.48%	-6.53%
3.1		4	9.368	7.426	11.31	9.075	8.34	10.98	0.61	13.02%	-9.66%
6.1		4	9.46	7.412	11.51	8.995	8.54	11.31	0.6434	13.6%	-10.74%
12.1		4	9.395	6.547	12.24	9.275	7.59	11.44	0.8949	19.05%	-9.98%
24.2		4	10.16	7.73	12.59	9.705	8.86	12.37	0.7636	15.03%	-18.94%
48.5		4	10.74	8.858	12.63	10.38	9.77	12.44	0.592	11.02%	-25.75%
97		4	8.418	6.951	9.884	8.055	7.78	9.78	0.4608	10.95%	1.46%

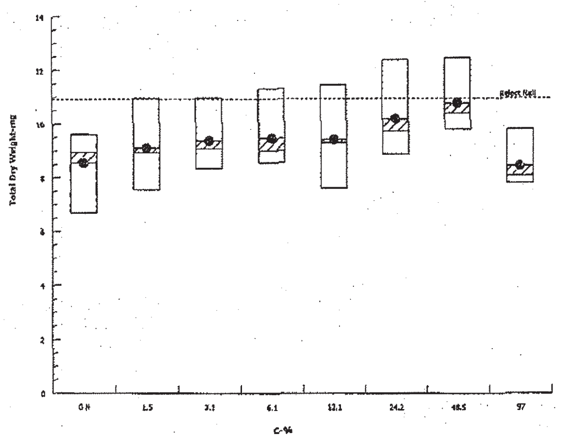
Total Dry Weight-mg Detail

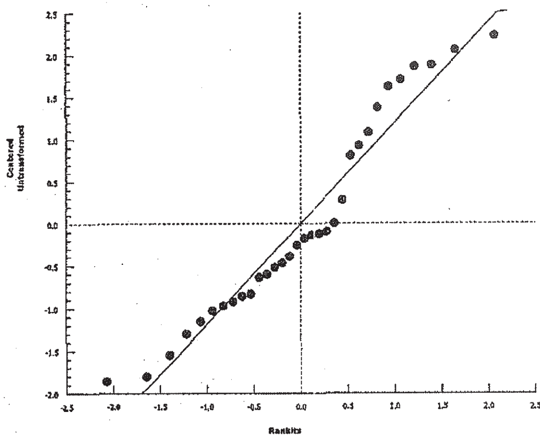
C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Negative Control	9.61	6.68	9.34	8.54
1.5		10.97	7.55	8.96	8.92
3.1		10.98	9.64	8.51	8.34
6.1		9.36	8.54	8.63	11.31
12.1		11.44	7.59	8.24	10.31
24.2		9.77	8.86	12.37	9.64
48.5		9.77	10.62	12.44	10.14
97		7.78	9.78	7.95	8.16

Lemna Growth Inhibition Test | **Nautilus Environmental**

Analysis ID:	04-0736-2865	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 9:59	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Graphics





APPENDIX D – *Pseudokirchneriella subcapitata* Toxicity Test Data

Pseudokirchneriella subcapitata Summary Sheet

Client: ALS/minto

Work Order No.: 161172

Start Date: Oct 25/16

Set up by: MLT

Sample Information:

Sample ID: L1847785-1 W3

Sample Date: Oct 23/16

Date Received: Oct 25/16

Sample Volume: 5×1L

Test Organism Information:

Culture Date: Oct 21/16

Age of culture (Day 0): 4d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC150

Stock Solution ID: 16Zn01

Date Initiated: Oct 14/16

72-h IC50 (95% CL): 36.9 (31.6-41.0) ug/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.6 (24.0-44.3) ug/L Zn CV (%): 16

Test Results:

	Algal Growth
IC25 %(v/v) (95% CL)	>95.2
IC50 %(v/v) (95% CL)	>95.2

Reviewed by: ____________________

Date reviewed: ____________________

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client : ALS / Minto

Setup by: MLT

Sample ID: L1847785-1 W3

Test Date/Time: Oct 25/16 @ 1645h

Work Order No.: 161172

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: oct 21/16

Age of Culture: 4d

Culture Health: Good

Culture Count: 1 290 2 310

Average: 300

Culture Cell Density (c1): 300x10^4 cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 300x10^4 cells/ml = 7.33mL

Time Zero Counts: 1 22 2 23

Average: 22.5

No. of Cells/mL: 22.5x10^4

Initial Density: # cells/mL ÷ 220 µL x 10 µL = 10227 cells/mL

Concentration %(v/v)	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control	6.8	22.5	25.0	25.0	25.0	25.0	✓	✓	✓	✓
1.5	6.8	22.5	↓	↓	↓	↓	✓	✓	✓	✓
3.0	6.8	22.5					✓	✓	✓	✓
6.0	6.9	22.5					✓	✓	✓	✓
11.9	7.1	22.5					✓	✓	✓	✓
23.8	7.3	22.5					✓	✓	✓	✓
47.6	7.5	22.5					✓	✓	✓	✓
95.2	7.8	22.5					✓	✓	✓	✓
Initials	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT	MLT

Initial control pH: Well 1: 6.8 Well 2: 6.8

Final control pH: Well 1: 6.7 Well 2: 6.7

Light intensity (lux): 4210

Date measured: oct 25/16

Instruments: Thermometer 4 pH meter 2 Light meter 1

Sample Description: clear, yellow, odourless, no particulates

Comments:

Reviewed: JCh

Date reviewed: Nov. 25/16

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: ALS/Minto
Work Order #: 161172
Sample ID: L1847785-1 W3

Start Date/Time: Oct 25/16 @ 1645h
Termination Date: Oct 28/16 @ 1645h
Test set up by: MLT

%(v/v) Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	34					MLT
	B	30					
	C	27					
	D	29					
	E	31					
	F	28					
	G	30					
	H	32					
1.5	A	36					
	B	32					
	C	34					
	D	35					
3.0	A	38					
	B	42					
	C	45					
	D	40					
6.0	A	55					
	B	49					
	C	57					
	D	58					
11.9	A	70					
	B	78					
	C	76					
	D	68					
23.8	A	116					
	B	124					
	C	117					
	D	120					
47.6	A	155					
	B	145					
	C	150					
	D	144					
95.2	A	150					
	B	144					
	C	138					
	D	149					

Comments:

Reviewed by: JCh Date Reviewed: Nov-25/16

Pseudokirchneriella subcapitata Algal Counts

Client: ALS/Minto
WO#: 161172
Sample ID: L1847785-1 W3

Start Date/Time: 25-Oct-16 @ 1645h
Termination Date/Time: 28-Oct-16 @ 1645h

Initial Cell Density: 10227 cell/mL

225000
0.22
0.01
10227.27

Concentration %(v/v)	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	34				34	33.0	mean	29.1
	B	30				30	29.0	SD	2.232071
	C	27				27	26.0	CV	7.66975
	D	29				29	28.0		
	E	31				31	30.0		
	F	28				28	27.0		
	G	30				30	29.0		
	H	32				32	31.0		
1.5	A	36				36	35.0		
	B	32				32	31.0		
	C	34				34	33.0		
	D	35				35	34.0		
3	A	38				38	37.0		
	B	42				42	41.0		
	C	45				45	44.0		
	D	40				40	39.0		
6	A	55				55	54.0		
	B	49				49	48.0		
	C	57				57	56.0		
	D	58				58	57.0		
11.9	A	70				70	69.0		
	B	78				78	77.0		
	C	76				76	75.0		
	D	68				68	67.0		
23.8	A	116				116	115.0		
	B	124				124	123.0		
	C	117				117	116.0		
	D	120				120	119.0		
47.6	A	155				155	154.0		
	B	145				145	144.0		
	C	150				150	149.0		
	D	144				144	143.0		
95.2	A	150				150	149.0		
	B	144				144	143.0		
	C	138				138	137.0		
	D	149				149	148.0		

Reviewed by: JCh

Date reviewed: Nov-25/16

CETIS Analytical Report

EC Alga Growth Inhibition Test — Nautilus Environmental

Analysis ID:	16-9355-3746	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 16:09	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	16-0340-6709	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	25 Oct-16 16:45	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water
Ending Date:	28 Oct-16 16:45	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	13-9712-4239	**Code:**	53466C8F	**Client:**	ALS
Sample Date:	23 Oct-16	**Material:**	Water Sample	**Project:**	
Receive Date:	25 Oct-16 14:15	**Source:**	ALS		
Sample Age:	65h ~~(9°C)~~ 8.4°C	**Station:**	L1847785-1 W3		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1832257	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			1.0000	Non-significant Trend in Controls

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	>95.2	N/A	N/A	<1.05	NA	NA
IC10	>95.2	N/A	N/A	<1.05	NA	NA
IC15	>95.2	N/A	N/A	<1.05	NA	NA
IC20	>95.2	N/A	N/A	<1.05	NA	NA
IC25	>95.2	N/A	N/A	<1.05	NA	NA
IC40	>95.2	N/A	N/A	<1.05	NA	NA
IC50	>95.2	N/A	N/A	<1.05	NA	NA

Cell Yield Summary

			Calculated Variate						
C-%	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	29.13	26	33	0.7892	2.232	7.66%	0.0%
1.5		4	33.25	31	35	0.8539	1.708	5.14%	-14.16%
3		4	40.25	37	44	1.493	2.986	7.42%	-38.2%
6		4	53.75	48	57	2.016	4.031	7.5%	-84.55%
11.9		4	72	67	77	2.38	4.761	6.61%	-147.2%
23.8		4	118.3	115	123	1.797	3.594	3.04%	-306.0%
47.6		4	147.5	143	154	2.533	5.066	3.44%	-406.4%
95.2		4	144.3	137	149	2.75	5.5	3.81%	-395.3%

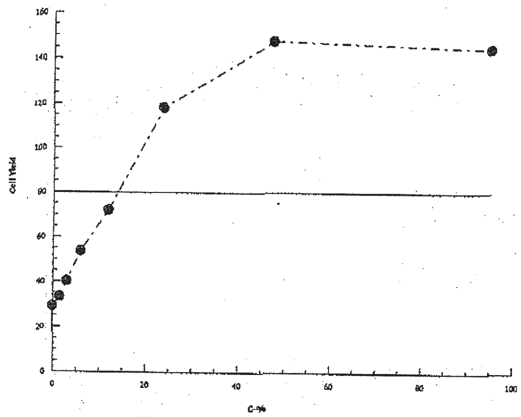
Cell Yield Detail

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	33	29	26	28	30	27	29	31
1.5		35	31	33	34				
3		37	41	44	39				
6		54	48	56	57				
11.9		69	77	75	67				
23.8		115	123	116	119				
47.6		154	144	149	143				
95.2		149	143	137	148				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	16-9355-3746	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 16:09	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



EC Alga Growth Inhibition Test | **Nautilus Environmental**

Analysis ID:	20-4273-3668	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 16:09	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes
Batch ID:	16-0340-6709	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	25 Oct-16 16:45	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water
Ending Date:	28 Oct-16 16:45	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d
Sample ID:	13-9712-4239	**Code:**	53466C8F	**Client:**	ALS
Sample Date:	23 Oct-16	**Material:**	Water Sample	**Project:**	
Receive Date:	25 Oct-16 14:15	**Source:**	ALS		
Sample Age:	65h (~~6~~ 8.4 °C)	**Station:**	L1847785-1 W3		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C < T	NA	NA	19.9%	1.5	3	2.121	66.67

Dunnett Multiple Comparison Test

Control vs	C-%	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	1.5	1.797	2.526	5.8	10	0.1990	CDF	Non-Significant Effect
	3*	4.845	2.526	5.8	10	0.0001	CDF	Significant Effect
	6*	10.73	2.526	5.8	10	<0.0001	CDF	Significant Effect
	11.9*	18.67	2.526	5.8	10	<0.0001	CDF	Significant Effect
	23.8*	38.82	2.526	5.8	10	<0.0001	CDF	Significant Effect
	47.6*	51.56	2.526	5.8	10	<0.0001	CDF	Significant Effect
	95.2*	50.14	2.526	5.8	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			1.0000	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	78145.38	11163.63	7	794.1	<0.0001	Significant Effect
Error	393.625	14.05804	28			
Total	78539		35			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	6.833	18.48	0.4465	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9845	0.9166	0.8833	Normal Distribution

Cell Yield Summary

C-%	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	29.13	27.26	30.99	29	26	33	0.7892	7.66%	0.0%
1.5		4	33.25	30.53	35.97	33.5	31	35	0.8539	5.14%	-14.16%
3		4	40.25	35.5	45	40	37	44	1.493	7.42%	-38.2%
6		4	53.75	47.34	60.16	55	48	57	2.016	7.5%	-84.55%
11.9		4	72	64.42	79.58	72	67	77	2.38	6.61%	-147.2%
23.8		4	118.3	112.5	124	117.5	115	123	1.797	3.04%	-306.0%
47.6		4	147.5	139.4	155.6	146.5	143	154	2.533	3.44%	-406.4%
95.2		4	144.3	135.5	153	145.5	137	149	2.75	3.81%	-395.3%

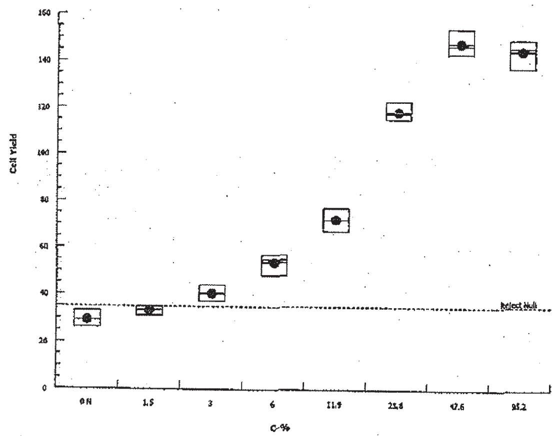
EC Alga Growth Inhibition Test — **Nautilus Environmental**

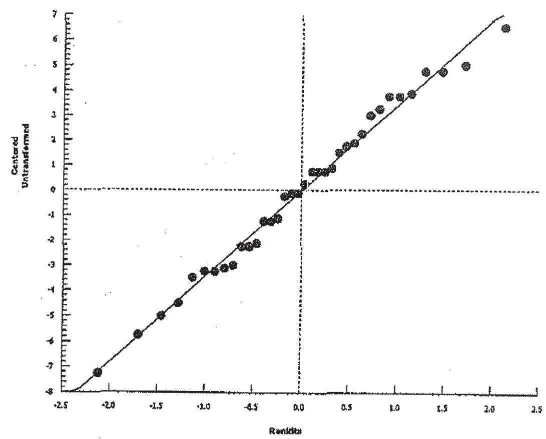
Analysis ID:	20-4273-3668	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-16 16:09	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	33	29	26	28	30	27	29	31
1.5		35	31	33	34				
3		37	41	44	39				
6		54	48	56	57				
11.9		69	77	75	67				
23.8		115	123	116	119				
47.6		154	144	149	143				
95.2		149	143	137	148				

Graphics





APPENDIX E – Chain-of-Custody Forms

ALS Environmental

L1847785

VANCOUVER

Subcontract Request Form

Subcontract To:

NAUTILUS ENVIRONMENTAL
8664 COMMERCE COURT
BURNABY,BC V5A 4N7

NOTES: Please reference on final report and invoice: PO# L1847785
ALS requires QC data to be provided with your final results. See attached email!

Please see enclosed 1 **sample(s) in** 12 **Container(s)**

SAMPLE NUMBER	ANALYTICAL REQUIRED	DATE SAMPLED / DUE DATE	Priority Flag
L1847785-1 W3	Special Request- Nautilus Environmental (SPECIAL REQUEST-NL 14)	10/23/2016 / 11/1/2016	

Subcontract Info Contact: Walter Lin (604) 253-4188

Analysis and reporting info contact: Ariel McDonnell, B.Sc.
8081 LOUGHEED HWY
SUITE 100
BURNABY,BC V5A 1W9
Phone: (604) 253-4188 Email: Ariel.McDonnell@alsglobal.com

Please email confirmation of receipt to: **Ariel.McDonnell@alsglobal.com**

Shipped By: AS Date Shipped: Oct 25, 2016

Received By: Nautilus Date Received: Oct 25/16 @ 14:15

Verified By: NY- Nai Yamamoto Date Verified:

Temperature: 9.0°C — 7x20L

Sample Integrity Issues: 8.4°C — 5x1L

Sample desc- clear, yellow, no odour, no particulates

ondav. October 24, 2016 3:29 PM

Ariel McDonnell

From: Ariel McDonnell
Sent: Monday, October 17, 2016 4:47 PM
To: 'Krysta Pearcy'
Subject: RE: Minto tests next week
Attachments: RE: W3 Sublethal Next Week

Hi Krysta,

Ok so next week W3 will be in for the below tests:

- 96-hr Rainbow Trout LC50 161173
- 48-hr Daphnia Magna LC50 161174
- **Table 3: Sublethal Toxicity testing Requirements.**

Site	Frequency	Samples Taken	Volume	WO #
W3	Annually	7-day Rainbow Trout embryo toxicity	100L	161169
W3	Annually	7-day Ceriodaphnia	7L	161170
W3	Annually	7-day Lemna minor	1L	161171
W3	Annually	72-hr Alga growth	1L	161172

Preliminary sampling schedule and delivery date is in the attached email. Let me know if you need more info. I will keep you updated as I receive info from Minto I guess.

Thanks,

Ariel

Ariel McDonnell
Account Manager, Environmental
Burnaby Laboratory

T +1 604 253 4188 D +1 778 370 3247
F +1 604 253 6700
ariel.mcdonnell@alsglobal.com
8081 Lougheed Highway
Burnaby, BC V5A 1W9

From: Ariel McDonnell
Sent: Monday, October 17, 2016 4:29 PM
To: 'Krysta Pearcy' <krysta@nautilusenvironmental.ca>
Subject: *RE: Minto tests next week*

END OF REPORT

Wednesday, November 30, 2016

Ariel McDonnell
ALS Environmental
8081 Lougheed Hwy, Suite 100
Burnaby, BC V5A 1W9

Re: ALS Workorder: 1610482
Project Name:
Project Number: L1847785

Dear Ms. McDonnell:

One water sample was received from ALS Environmental, on 10/26/2016. The sample was scheduled for the following analysis:

Radium-226

The results for these analyses are contained in the enclosed reports.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Thank you for your confidence in ALS Environmental. Should you have any questions, please call.

Sincerely,

ALS Environmental
Shiloh J. Summy
Project Manager

ALS Environmental – Fort Collins is accredited by the following accreditation bodies for various testing scopes in accordance with requirements of each accreditation body. All testing is performed under the laboratory management system, which is maintained to meet these requirement and regulations. Please contact the laboratory or accreditation body for the current scope testing parameters.

ALS Environmental – Fort Collins	
Accreditation Body	License or Certification Number
AIHA	214884
Alaska (AK)	UST-086
Alaska (AK)	CO01099
Arizona (AZ)	AZ0742
California (CA)	06251CA
Colorado (CO)	CO01099
Connecticut (CT)	PH-0232
Florida (FL)	E87914
Idaho (ID)	CO01099
Kansas (KS)	E-10381
Kentucky (KY)	90137
L-A-B (DoD ELAP/ISO 170250)	L2257
Louisiana (LA)	05057
Maryland (MD)	285
Missouri (MO)	175
Nebraska(NE)	NE-OS-24-13
Nevada (NV)	CO000782008A
New York (NY)	12036
North Dakota (ND)	R-057
Oklahoma (OK)	1301
Pennsylvania (PA)	68-03116
Tennessee (TN)	2976
Texas (TX)	T104704241
Utah (UT)	CO01099
Washington (WA)	C1280

1610482

Radium-226:
The sample was prepared and analyzed according to the current revision of SOP 783.

All acceptance criteria were met.

ALS -- Fort Collins

Sample Number(s) Cross-Reference Table

OrderNum: 1610482
Client Name: ALS Environmental
Client Project Name:
Client Project Number: L1847785
Client PO Number: L1847785

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
L1847785-1	1610482-1		WATER	23-Oct-16	

L1847785

1610482

VANCOUVER

ALS Environmental

Subcontract Request Form

Subcontract To:

ALS ENVIRONMENTAL - FORT COLLINS, COLORADO, USA
225 COMMERCE DRIVE
FORT COLLINS,CO 80524

NOTES:	Please reference on final report and invoice: PO# *L1847785* ALS requires QC data to be provided with your final results.

Please see enclosed 1 **sample(s) in** 1 **Container(s)**

SAMPLE NUMBER	ANALYTICAL REQUIRED	DATE SAMPLED / DUE DATE	Priority Flag
L1847785-1 W3		10/ 23/ 2016	
	Ra226 by Alpha Scint, MDC=0.01 Bq/L (RA226-MMER-FC 1)	11/1/2016	

Subcontract Info Contact: Walter Lin (604) 253-4188

Analysis and reporting info contact: Ariel McDonnell, B.Sc.
8081 LOUGHEED HWY
SUITE 100
BURNABY,BC V5A 1W9
Phone: (604) 253-4188 Email: Ariel.McDonnell@alsglobal.com

Please email confirmation of receipt to: **Ariel.McDonnell@alsglobal.com**

Shipped By: HS Date Shipped: Oct 25, 2016

Received By: [signature] Date Received: 10/26/16 0920

Verified By: Date Verified:

Temperature:

Sample Integrity Issues:

ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: ALS BURNABY Workorder No: 1610482

Project Manager: SJS Initials: M Date: 10/26/16

1. Does this project require any special handling in addition to standard ALS procedures?		YES	NO
2. Are custody seals on shipping containers intact?	NONE	YES	NO
3. Are Custody seals on sample containers intact?	NONE	YES	NO
4. Is there a COC (Chain-of-Custody) present or other representative documents?		YES	NO
5. Are the COC and bottle labels complete and legible?		YES	NO
6. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)		YES	NO
7. Were airbills / shipping documents present and/or removable?	DROP OFF	YES	NO
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	N/A	YES	NO
9. Are all aqueous non-preserved samples pH 4-9?	N/A	YES	NO
10. Is there sufficient sample for the requested analyses?		YES	NO
11. Were all samples placed in the proper containers for the requested analyses?		YES	NO
12. Are all samples within holding times for the requested analyses?		YES	NO
13. Were all sample containers received intact? (not broken or leaking, etc.)		YES	NO
14. Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: ____ < green pea ____ > green pea	N/A	YES	NO
15. Do any water samples contain sediment? Amount Amount of sediment: ____ dusting ____ moderate ____heavy	N/A	YES	NO
16. Were the samples shipped on ice?		YES	NO
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #2 #4	RAD ONLY	YES	NO

Cooler #:	1							
Temperature (°C):	8.9							
No. of custody seals on cooler:	0							
External µR/hr reading:	11							
Background µR/hr reading:	11							

DOT Survey/ Acceptance Information

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? **YES / NO / NA** (If no, see Form 008.)

Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EXCEPT #1 AND #16.

If applicable, was the client contacted? **YES / NO / NA** Contact: ________ Date/Time: ________

Project Manager Signature / Date: ________

*IR Gun #2: Oakton, SN 29922500201-0066
*IR Gun #4: Oakton, SN 2372220101-0002

Form 201r24.xls (06/04/2012)

DEFINITIONS: On the Air Waybill 'We', 'Our', 'us' and 'FedEx' refer to Federal Express Corporation, its subsidiaries and branches and their respective employees, agents and independent contractors. 'You' and 'your' refer to the shipper, its employees, principals and agents. If your shipment originates outside the United States, your contract of carriage is with the Federal Express subsidiary, branch or independent contractor who originally accepts the shipment from you. 'Package' means any container or envelope that is accepted by us for delivery, including any such items tendered by you utilizing our automated systems, meters, manifests or waybills. 'Shipment' means all packages, which are tendered to and accepted by us on a single Air Waybill.
AGREEMENT TO TERMS. By giving us your shipment, you agree, regardless of whether you sign the front of this Air Waybill, for yourself and as agent for and on behalf of any other person having an interest in this shipment, to all terms on this NON-NEGOTIABLE Air Waybill. In any applicable tariff, and in our current Service Guide or Standard Conditions of Carriage, copies of which are available upon request. If there is a conflict between this Air Waybill and either the tariff, Service Guide or Standard Conditions then in effect, the tariff and the terms of any customer automation agreement between the shipper and Federal Express will control(the Service Guide or Standard Conditions have secondary priority). No one is authorized to alter or modify the terms of our agreement. This Air Waybill shall be binding on us when the shipment is accepted.
YOUR OBLIGATIONS: You warrant that each article in the shipment is properly described on this Air Waybill and is acceptable for transport by us, and that the shipment is properly marked, addressed (including postal codes) and packaged to ensure safe transportation with ordinary care in handling.
NOTE CONCERNING LIMITATIONS OF LIABILITY. Air Carriage Notice. If the carriage of your shipment by air involves an ultimate destination or stop in a country other than the country of departure, the Warsaw Convention, an international treaty relating to international carriage by air, may be applicable, which treaty would then govern and in most cases limit our liability for loss or delay of or damage to your shipment. In the U.S. the Warsaw Convention limits our liability to U.S. $9.07 per pound (U.S. $20.38 per kilogram). Unless you declare a higher value for carriage as described below. The interpretation of the Warsaw Convention liability limits may vary in other countries. There are no stopping places which are agreed at the time of tender of the shipment and we reserve the right to route shipments in any way we deem appropriate.
Road Transport Notice. Shipments transported partly or solely by road be it explicit agreement to do so or not-in, to, from a country which is party to the Convention on the Contract for the International Carriage of Goods by Road (the 'CMR') are subject to the terms and conditions of the CMR, notwithstanding any other provisions of this Agreement to the contrary. For these shipments transported solely by road, if a conflict arises between the provisions of the CMR and this Air Waybill the terms of the CMR shall prevail.
Limitation of Liability, if not governed by the Warsaw Convention or the CMR as described above, our maximum liability for loss, damage or delay is limited by this Air Waybill to U.S. $100 per shipment or U.S. $9.07 per pound (U.S. $20.38 per kilo) (or equivalent local currency), whichever is greater, unless you declare a higher value for carriage as described below. FedEx does not provide cargo liability or all-risk insurance, but you may pay an additional charge to each additional U.S. $100 (or equivalent local currency) of described value for carriage. If a higher value for carriage is declared and the additional charge is paid, FedEx maximum liability will be the lesser of the declared value for carriage or your actual damages.
LIABILITIES NOT ASSUMED. IN ANY EVENT, WE WON'T BE LIABLE FOR ANY DAMAGES WHETHER DIRECT , INCIDENTAL, SPECIAL OR CONSEQUENTIAL , IN EXCESS OF THE DECLARED VALUE FOR CARRIAGE (INCLUDING BUT NOT LIMITED TO LOSS OF INCOME OR PROFITS) WHETHER OR NOT WE HAD ANY KNOWLEDGE THAT SUCH DAMAGES MIGHT BE INCURRED, UNLESS SUCH DAMAGES WERE CAUSED BY OUR OWN WILLFUL MICONDUCT OR GROSS NEGLIGENCE.
We won't be liable for your actions or omissions, including but not limited to incorrect declaration of cargo, improper or insufficient packing, securing, marking or addressing of the shipment, or for the acts or omissions of the recipient or anyone else with an interest in the shipment. Also we won't be liable if you (or) the recipient violate any of the terms of our agreement. We won't be liable for loss of or damage to shipments of cash, currency or other prohibited items. We won't be liable for loss, damages or delay caused by events we cannot control, including but not limited to acts of God, perils of the air, weather conditions mechanical delays, acts of public enemies, war, strikes, civil commotions, or acts or omissions of public authorities (including customs and health officials) with actual or apparent authority.
NO WARRANTIES. We make no warranties, express or implied.
CLAIM FOR LOSS, DAMAGE FOR DELAY. ALL CLAIMS MUST BE NOTIFIED TO US WITHIN 15 DAYS AFTER DELIVERY OF THE SHIPMENT FAILING WHICH NO ACTION FOR DAMAGES MAY BE BROUGHT. All claims for loss, non-delivery or mis-delivery must be received by us within 90 days after the shipment is accepted by us. The right to damages against us shall be extinguished unless an action is brought within two years from the date of delivery of the shipment or from date on which the shipment should have been delivered. Within 30 days after notification to us (of) the claim, it must be documented by sending us all relevant information about it. We are not obligated to act on any claim until all transportation charges have been paid; the claim amount may not be deducted from those charges. If the recipient accepts the shipment without noting any damage on the delivery record, we will assume the shipment was delivered in good condition. In order for us to consider a claim for damages, the content(s), original shipping cartons, and packing must be available to us for inspection.
RIGHT TO INSPECT. Your shipment may, at our option or at the request of governmental authorities, be opened and inspected by us or such authorities or us at any time.
CUSTOMS CLEARANCE. It is your responsibility to provide proper customs documentation and confirmation, where required.
EXPORT CONTROL. You authorize Federal Express to act as forwarding agent for you for export control and customs purposes. You hereby certify that all statements and information contained in this air waybill relating to exportation are true and correct. Furthermore, you understand that civil and criminal penalties, including forfeiture and sale, may be imposed for making false or fraudulent statements or for the violation of any United States laws on exportation, including but not limited to, 13 USC Sec. 305; 22 USC Sec 401; 18 USC Sec. 1001; 50 USC app. 2410.
MANDATORY LAW. Insofar as any provision contained or referred to in this air Waybill may be contrary to any applicable international treaty, law government regulations, orders or requirements such provision shall remain in effect as a part of our agreement to the extent that it is not overridden. The invalidity or unenforceability of any provision shall not affect any other part of this Air Waybill. Unless otherwise indicated the Sender's address indicated on the face of this Waybill is the place of execution and the place of departure, and Recipient's address listed on the face of this Waybill is the place of destination. Unless otherwise indicated Federal Express Corporation, P.O. Box 727, Memphis, TN 38194 USA is the first carrier of this shipment.

After printing this label:
CONSIGNEE COPY - PLEASE PLACE IN FRONT OF POUCH
1. Fold the printed page along the horizontal line.
2. Place label in shipping pouch and affix it to your shipment.

1610482

ORIGIN ID:YBYA (604) 253-4188
MELISSA YAGI
ALS ENVIRONMENTAL LAB GROUP
8081 LOUGHEED HIGHWAY
SUITE 100
BURNABY, BC V5A1W9
CANADA CA

SHIP DATE: 25OCT16
ACTWGT: 10.00 LB MAN
CAD: 0347419/CAFE3009

BILL SENDER

TO **SAMPLE RECEVING**
ALS ENVIRONMANTAL
225 COMMERCE DRIVE

FORT COLLINS CO 80524 (US)
(970) 490-1511 REF: SUBLET
DEPT: SUBLET

540C3/FB42/727F

FedEx Express

E

J161016072602uv

10:30A
TRK# 0430 **7012 5069 0412**
INTL PRIORITY

XH FTCA \\ -0
8.9°
80524
CO-US **DEN**

Client:	ALS Environmental		**Date:**	*30-Nov-16*
Project:	L1847785		**Work Order:**	1610482
Sample ID:	L1847785-1		**Lab ID:**	1610482-1
Legal Location:			**Matrix:**	WATER
Collection Date:	10/23/2016		**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Radium-226 by Radon Emanation - Method 903.1		**PAI 783**		Prep Date: **11/16/2016**		PrepBy: **CDJ**
Ra-226	ND (+/- 0.0027)	U	0.0041	BQ/l	NA	11/29/2016 17:11
Carr: BARIUM	*80.1*		*40-110*	*%REC*	DL = NA	11/29/2016 17:11

Client:	ALS Environmental	**Date:**	*30-Nov-16*
Project:	L1847785	**Work Order:**	1610482
Sample ID:	L1847785-1	**Lab ID:**	1610482-1
Legal Location:		**Matrix:**	WATER
Collection Date:	10/23/2016	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed

Explanation of Qualifiers

Radiochemistry:

U or ND - Result is less than the sample specific MDC.
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
Y2 - Chemical Yield outside default limits.
W - DER is greater than Warning Limit of 1.42
* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'.
# - Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'.
G - Sample density differs by more than 15% of LCS density.
D - DER is greater than Control Limit
M - Requested MDC not met.
LT - Result is less than requested MDC but greater than achieved MDC.
M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.
L - LCS Recovery below lower control limit.
H - LCS Recovery above upper control limit.
P - LCS, Matrix Spike Recovery within control limits.
N - Matrix Spike Recovery outside control limits
NC - Not Calculated for duplicate results less than 5 times MDC
B - Analyte concentration greater than MDC.
B3 - Analyte concentration greater than MDC but less than Requested MDC.

Inorganics:

B - Result is less than the requested reporting limit but greater than the instrument method detection limit (MDL).
U or ND - Indicates that the compound was analyzed for but not detected.
E - The reported value is estimated because of the presence of interference. An explanatory note may be included in the narrative.
M - Duplicate injection precision was not met.
N - Spiked sample recovery not within control limits. A post spike is analyzed for all ICP analyses when the matrix spike and or spike duplicate fail and the native sample concentration is less than four times the spike added concentration.
Z - Spiked recovery not within control limits. An explanatory note may be included in the narrative.
* - Duplicate analysis (relative percent difference) not within control limits.
S - SAR value is estimated as one or more analytes used in the calculation were not detected above the detection limit.

Organics:

U or ND - Indicates that the compound was analyzed for but not detected.
B - Analyte is detected in the associated method blank as well as in the sample. It indicates probable blank contamination and warns the data user.
E - Analyte concentration exceeds the upper level of the calibration range.
J - Estimated value. The result is less than the reporting limit but greater than the instrument method detection limit (MDL).
A - A tentatively identified compound is a suspected aldol-condensation product.
X - The analyte was diluted below an accurate quantitation level.
* - The spike recovery is equal to or outside the control criteria used.
+ - The relative percent difference (RPD) equals or exceeds the control criteria.
G - A pattern resembling gasoline was detected in this sample.
D - A pattern resembling diesel was detected in this sample.
M - A pattern resembling motor oil was detected in this sample.
C - A pattern resembling crude oil was detected in this sample.
4 - A pattern resembling JP-4 was detected in this sample.
5 - A pattern resembling JP-5 was detected in this sample.
H - Indicates that the fuel pattern was in the heavier end of the retention time window for the analyte of interest.
L - Indicates that the fuel pattern was in the lighter end of the retention time window for the analyte of interest.
Z - This flag indicates that a significant fraction of the reported result did not resemble the patterns of any of the following petroleum hydrocarbon products:
- gasoline
- JP-8
- diesel
- mineral spirits
- motor oil
- Stoddard solvent
- bunker C

ALS -- Fort Collins

Date: *11/30/2016 9:15*

Client: ALS Environmental

Work Order: 1610482

Project: L1847785

QC BATCH REPORT

Batch ID: **RE161116-1-1** Instrument ID: **Alpha Scin** Method: **Radium-226 by Radon Emanation**

LCS Sample ID: **RE161116-1** Units: **BQ/l** Analysis Date: **11/29/2016 17:11**

Client ID: Run ID: **RE161116-1A** Prep Date: **11/16/2016** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	1.72 (+/- 0.429)	0.00739	1.673		103	67-120					P
Carr: BARIUM	12600		16270		77.4	40-110					

LCSD Sample ID: **RE161116-1** Units: **BQ/l** Analysis Date: **11/29/2016 17:42**

Client ID: Run ID: **RE161116-1A** Prep Date: **11/16/2016** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	1.54 (+/- 0.383)	0.00747	1.673		91.8	67-120		1.72	0.32	2.13	P
Carr: BARIUM	14700		16270		90.4	40-110		12600			

MB Sample ID: **RE161116-1** Units: **BQ/l** Analysis Date: **11/29/2016 17:11**

Client ID: Run ID: **RE161116-1A** Prep Date: **11/16/2016** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref Value	DER	DER Limit	Qual
Ra-226	ND	0.0067									U
Carr: BARIUM	11100		16270		67.9	40-110					

The following samples were analyzed in this batch: 1610482-1

ALS Environmental
ATTN: Ariel McDonnell
Suite 100-8081 Lougheed Hwy.
Burnaby, BC
V5A 1W9

Report Date: November 4, 2016
Work Order: 161173 - 161174

Data Report

Species: **Rainbow trout (*Oncorhynchus mykiss*)**
Protocol: **EPS 1/RM/13 (Second Ed. 2000 with 2007 & 2016 amendments)**

Species: ***Daphnia magna***
Protocol: **EPS 1/RM/14 (Second Ed. 2000 with 2016 amendments)**

Table 1. Results for the 96-h rainbow trout acute LC50 toxicity test.

Sample ID	Collection Date and Time	96-h LC50 (%v/v)
L1847785-1 W3	October 23, 2016 @ N/A	>100

N/A = Not Available.

Table 2. Results for the 48-h *Daphnia magna* acute LC50 toxicity test.

Sample ID	Collection Date and Time	48-h LC50 (%v/v)
L1847785-1 W3	October 23, 2016 @ N/A	>100

N/A = Not Available.

The tests met performance criteria and there were no deviations from the test methods. The results relate only to the sample tested.

Yvonne Lam, B.Sc.
Laboratory Biologist

Reviewed By:
Edmund Canaria, R.P.Bio
Senior Reviewer

Rainbow Trout Summary Sheet

Client: ALS

Start Date/Time: October 27, 2016 @ 1145h

Work Order No.: ~~161115~~ 161173

Test Species: *Oncorhynchus mykiss*

Test Validity Criteria:

≥ 90% control survival

WQ Ranges:

T (°C) = 15 ± 1; DO (mg/L) = 7.0 to 10.3; pH = 5.5 to 8.5

Sample Information:

Sample ID: L1847785-1 W3
Sample Date: October 23, 2016
Date Received: October 25, 2016
Sample Volume: 7x20L, 5x1L
Other: —

Dilution Water:

Type: Dechlorinated Municipal Tap Water
Hardness (mg/L $CaCO_3$): 10
Alkalinity (mg/L $CaCO_3$): 11

Test Organism Information:

Batch No.: 101116
Source: Miracle Springs
No. Fish/Volume (L): 10 / 12 L
Loading Density (g/L): 0.31
Mean Length ± SD (mm): 33 ± 2 Range: 28 – 36
Mean Weight ± SD (g): 0.37 ± 0.08 Range: 0.22 – 0.48

Zinc Reference Toxicant Results:

Reference Toxicant ID: RTZn52
Stock Solution ID: 16Zn02
Date Initiated: October 26, 2016
96-h LC50 (95% CL): 35.4 (28.3 – 44.2) µg/L Zn

Reference Toxicant Mean and Historical Range: 65.0 (25.8 – 163.6) µg/L Zn
Reference Toxicant CV (%): 59

Test Results: The 96-hr LC50 is > 100% (v/v)

Reviewed by: [signature]

Date reviewed: NOV. 3, 2016

96-Hour Rainbow Trout Toxicity Test Data Sheet

Client/Project#: ALS
Sample I.D. 11847785-1-W3
W.O. # 161173
RBT Batch #: 101116
Date Collected/Time: Oct 23/16 @ Not available
Date Setup/Time: Oct 27/16 @ 1145h
Sample Setup By: EC

Number Fish/Volume: 10/12 L
7-d % Mortality: 1.2
Total Pre-aeration Time (mins): 30
Aeration rate adjusted to 6.5 ± 1 mL/min/L? (Y/N): Y

Thermometer: CER#2 **D.O. meter:** 2
Cond./Salinity: 2 **pH meter:** 1

Undiluted Sample WQ			
Parameters	Initial WQ	Adjustment	30 min WQ
Temp °C	15.0		15.0
D.O. (mg/L)	9.9		9.9
pH	7.7		7.7
Cond. (µS/cm)	509		509
Salinity (ppt)	0.2		0.2

Concentration	# Survivors							Temperature (°C)					Dissolved Oxygen (mg/L)					pH					Conductivity (µS/cm)	
(% v/v)	1	2	4	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	96
Ctl				10	10	10	10	15.0	15.0	16.0	16.0	15.0	10.0	9.9	9.8	9.9	9.6	7.0	7.0	6.9	7.0	7.0	28	38
6.25				10	10	10	10	15.0	15.0	16.0	16.0	15.0	10.0	9.9	9.9	9.8	9.7	7.2	6.9	7.1	7.1	7.2	41	56
12.5				10	10	10	10	15.0	15.0	16.0	16.0	15.0	9.9	9.9	9.8	9.8	9.7	7.2	7.0	7.2	7.3	7.5	98	109
25				10	10	10	10	15.0	15.0	16.0	16.0	15.0	10.0	9.8	9.8	9.7	9.7	7.3	7.2	7.4	7.5	7.7	159	165
50				10	10	10	10	15.0	15.0	16.0	16.0	15.0	10.0	9.8	9.9	9.8	9.6	7.4	7.7	7.8	7.7	7.9	274	281
100				10	10	10	9	15.0	15.0	16.0	16.0	15.0	9.9	9.8	9.9	9.8	9.7	7.7	8.1	8.2	8.1	8.3	509	508
Initials				EL	AM	AM	MWC	EC	EL	AM	AM	MWC	EL	EL	AM	AM	MWC	EL	EN	AM	AM	MWC	EL	MWC

Sample Description/Comments: Yellow, clear, odourless, No particulates

Fish Description at 96 h: Surviving fish appear normal Number of Stressed Fish at 96 h: Ø

Other Observations:

Reviewed by: [signature] Date Reviewed: Nov. 3, 2016

Daphnia magna Summary Sheet

Client: ALS
Work Order No.: 161174

Start Date/Time: October 26, 2016 @ 1105h
Test Species: *Daphnia magna*
Set up by: YHL

Test Validity Criteria:

≥ 90% mean control survival and/or mobility and ≤2 daphnids exibit immobility and/or mortality in any single control replicate.

WQ Ranges:

T (°C) = 20 ± 2; DO (mg/L) = 3.6 to 9.4; pH = 6 to 8.5

Sample Information:

Sample ID: L1847785-1 W3
Sample Date: October 23, 2016
Date Received: October ~~26~~ 25, 2016
Sample Volume: 5x1L

Test Organism Information:

Broodstock No.: 101216B
Age of young (Day 0): <24 h
Avg No. young per brood in previous 7 d: 16
Mortality (%) in previous 7 d: 0
Days to first brood: 8

NaCl Reference Toxicant Results:

Reference Toxicant ID: DMTC40
Stock Solution ID: 16Na02
Date Initiated: October 12, 2016
48-h LC50 (95% CL): 4.2 (3.7-4.8) g/LNaCL

Reference Toxicant Mean and Historical Range: 4.1 (3.0-5.4) g/L NaCL
Reference Toxicant CV (%): 16

Test Results: The 48h LC50 is estimated to be >100% (v/v)

Reviewed by: [signature]

Date reviewed: Nov. 3, 2016

Freshwater Acute
48 Hour Toxicity Test Data Sheet

Client: ALS
Sample ID: L1847785-1 W3
Work Order No.: 161174

Start Date/Time: October 26, 2016 @ 1105h
No. Organisms/volume: 10/200mL
Test Organism: *D.magna*
Set up by: YYC

Thermometer: temp-11 DO meter: DO-2/3 pH meter: pH-113 Cond./Salinity: C-2/3

Concentration (% v/v)	Rep	Number of Live Organisms 24	48	No. Immobilized 48	Temperature (°C) 0	24	48	Dissolved oxygen (mg/L) 0	24	48	pH 0	24	48	Conductivity (µS/cm) 0	48
Control	A	10	10	0	19.0	19.0	19.5	8.6	8.3	8.4	7.6	7.5	7.6	356	356
	B														
	C														
	D														
6.25	A	10	10	0	19.0	19.0	19.5	8.6	8.2	8.3	7.6	7.6	7.6	364	369
	B														
	C														
	D														
12.5	A	10	10	0	19.0	19.0	18.5	8.6	8.2	8.2	7.6	7.6	7.6	369	374
	B														
	C														
	D														
25	A	10	10	0	19.0	19.0	18.5	8.6	8.3	8.4	7.6	7.7	7.6	391	394
	B														
	C														
	D														
50	A	10	10	0	19.0	19.0	18.8	8.6	8.3	8.3	7.6	7.8	7.7	429	432
	B														
	C														
	D														
100	A	10	10	0	19.0	19.0	18.5	8.4	8.2	8.3	7.6	7.8	7.8	514	514
	B														
	C														
	D														
Technician Initials		MM	YM	YM	YYC	YM	YM	YYC	YYC	YM	YYC	YM	YYC	YYC	YYC

	Hardness*	Alkalinity*
Concentration	*(mg/L as CaCo3)	
Control (MHW)	94	64
Highest conc.	330	182
Hardness adjusted	—	—

	Initial WQ	Adjustment	Adjusted WQ
Temp (°C)	19.0		
DO (mg/L)	8.4		
pH	7.6		
Cond (µS/cm)	514		
Salinity (ppt)	0.2		

Comments: ______ Mortality: Heartbeat checked under microscope not req'd

Sample Description: Clear, yellow, no odour, no particulates.

Batch#: 101216B 7-d previous # young/brood: 16 Previous 7-d Mortality (%): 0 Day of 1st Brood: 8

Reviewed by: [signature] Date reviewed: Nov. 3, 2016

Client: ALS

W.O.#: 161174

Hardness and Alkalinity Datasheet

	Alkalinity						Hardness			
Sample ID	Subsample Date	Date Measured	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity (mg/L$CaCO_3$)	Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness (mg/L $CaCO_3$)	Technician
L1847785-1	Oct.26/16	Oct.26/16	50	9.3	9.5	182	10①	3.3	330	YKC
W3										
MHW	Oct.26/16	Oct.26/16	50	3.3	3.4	64	50	4.7	94	YKC

Notes: ① Diluted to 100 mL w/ DI water.

Reviewed by: [signature] Date Reviewed: Nov. 3, 2016

ALS Environmental

L1847785

VANCOUVER

Subcontract Request Form

Subcontract To:

NAUTILUS ENVIRONMENTAL
8664 COMMERCE COURT
BURNABY,BC V5A 4N7

NOTES: Please reference on final report and invoice: PO# *L1847785*
ALS requires QC data to be provided with your final results. See attached email!

Please see enclosed 1 **sample(s) in** 12 **Container(s)**

SAMPLE NUMBER	ANALYTICAL REQUIRED	DATE SAMPLED / DUE DATE	Priority Flag
L1847785-1 W3	Special Request- Nautilus Environmental (SPECIAL REQUEST-NL 14)	10/ 23/ 2016 11/1/2016	

Subcontract Info Contact: Walter Lin (604) 253-4188
Analysis and reporting info contact: Ariel McDonnell, B.Sc.
8081 LOUGHEED HWY
SUITE 100
BURNABY,BC V5A 1W9
Phone: (604) 253-4188 Email: Ariel.McDonnell@alsglobal.com

Please email confirmation of receipt to: **Ariel.McDonnell@alsglobal.com**

Shipped By: AS Date Shipped: Oct 25, 2016
Received By: Nautilus Date Received: Oct 25/16 @ 14:15
Verified By: NY - Nai Yamamoto Date Verified:
Temperature: 9.0°C — 7x20L
Sample Integrity Issues: 8.4°C — 5x 1L

sample desc - clear, yellow, no odour, no particulates

ondav. October 24, 2016 3:29 PM

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1847785-COFC

COC Number: 2016-10-24 A

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: 220405 (MMER)

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact:

Sampler: SR/SB

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	96hr LC50 RainbowTrout	48hr - LC50 Daphnia	7day - RainbowTroutEmbryoToxicity	7day - Ceriodaphnia	7day - Lemma minor	Alga 72-h Growth Inhibition	7day - Flathead Minnow	Ra-226	Number of Containers
	W3	23-Oct-16	15:50	Water	R	R	R	R	R	R	R	R	13

RUSH

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 8

FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Shaun Roberts	Date: 2016-10-24	Time: 9:00	Received by: Jenny Mey	Date: Oct-24-16	Time: 1:20pm	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

OCTOBER 2015 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Appendix L – Minto Creek Sediment, Periphyton and Benthic Invertebrate Community Assessment 2016 Update

Minto Creek Sediment, Periphyton and Benthic Invertebrate Community Assessment - 2016

Report Prepared For:
Capstone Mining Corp. Minto Mine
13-151 Industrial Road
Whitehorse, YT
Y1A 2V3

Prepared By:
Minnow Environmental Inc.
101-1025 Hillside Ave.
Victoria, BC
V8T 2A2

March 2017

Minto Creek Sediment, Periphyton and Benthic Invertebrate Community Assessment - 2016

Report Prepared for:

Capstone Mining Corp.
Minto Mine
13 - 151 Industrial Rd.
Whitehorse, YT
Y1A 2V3

Report Prepared by:

Minnow Environmental Inc.
101 - 1025 Hillside Ave.
Victoria, BC
V8T 2A2

March 2017

Minto Creek Sediment, Periphyton and Benthic Invertebrate Community Assessment - 2016

Report Prepared for:

Capstone Mining Corp. Minto Mine

Report Prepared by:

Minnow Environmental Inc.

Lisa Bowron, M.Sc.
Project Manager

Pierre Stecko, M.Sc., EP, RPBio
Project Principal

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1.0 INTRODUCTION

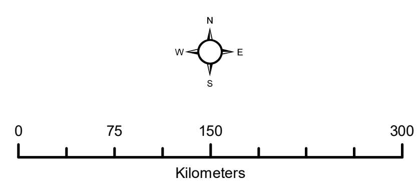
1.1 Site Description

The Minto Mine is a high-grade copper mine located within Selkirk First Nation (SFN) Category A Settlement Land Parcel R-6A approximately 240 km northwest of Whitehorse, Yukon Territory (62°37'N latitude and 137°15'W longitude; Figure 1.1). It is owned and operated by Minto Explorations Ltd. (MintoEx), a wholly owned subsidiary of Capstone Mining Corporation (Capstone). Mine development was initiated in 1997, commercial operations started in October 2007. The facility is permitted to conduct open pit and underground mining with milling at a rate of 4,200 tonnes of copper/gold/silver ore per day, and produced 36.4 million pounds of copper in 2015. Mill tailings are deposited into both the Main Pit Tailings Management Facility and the Area 2 Pit Tailings Management Facility (Figure 1.2). Mine-impacted seepage from the dry stack Tailings Storage Facility (TSF) and under the Mill Valley Fill Expansion (MVFE) is collected at the Minto Creek Detention Structure at the toe of the MVFE and pumped to the main pit (Figure 1.2). Non-impacted water and treated mine-impacted water are collected in a Water Storage Pond (WSP; Figure 1.2). Effluent from the WSP is periodically discharged to Minto Creek under conditions specified in Water Use Licence (WUL) QZ14-031 (August 2015). Minto Creek, in turn, discharges to the Yukon River approximately 7.7 km south-east of the WSP (Figure 1.2).

1.2 Background

Under the WUL, the Minto Mine implements an Environmental Monitoring, Surveillance and Reporting Plan (EMSRP) that includes a routine water quality surveillance program in Minto Creek and reference tributaries at sampling frequencies that vary from weekly to monthly during the ice-free period (typically from April to October or November). In accordance with the WUL, the Minto Mine submits water quality data to the Yukon Water Board as original laboratory reports and monthly summary reports within 30-days of month-end. Water quality monitoring data have indicated that total suspended solids (TSS) concentrations can increase dramatically during high flow events and that concentrations of a number of metals (including aluminum, chromium, copper and iron) are generally concurrently higher than the Canadian Water Quality Guideline (CWQG) for the protection of aquatic life even under background and reference conditions (e.g., HKP 1994; Minnow 2009a, 2010a,b).

The Minto Mine also implements biological monitoring under the EMSRP, including Environmental Effects Monitoring (EEM) in accordance with federal requirements and an Aquatic Environmental Monitoring Plan (AEMP). Biological monitoring under EEM is



MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 8V
Data Source: Department of Natural Resources Canada

Creation Date: March 2017
Project No. 167202.0080

Map of Canada

Figure 1.1: Location of the Minto Mine

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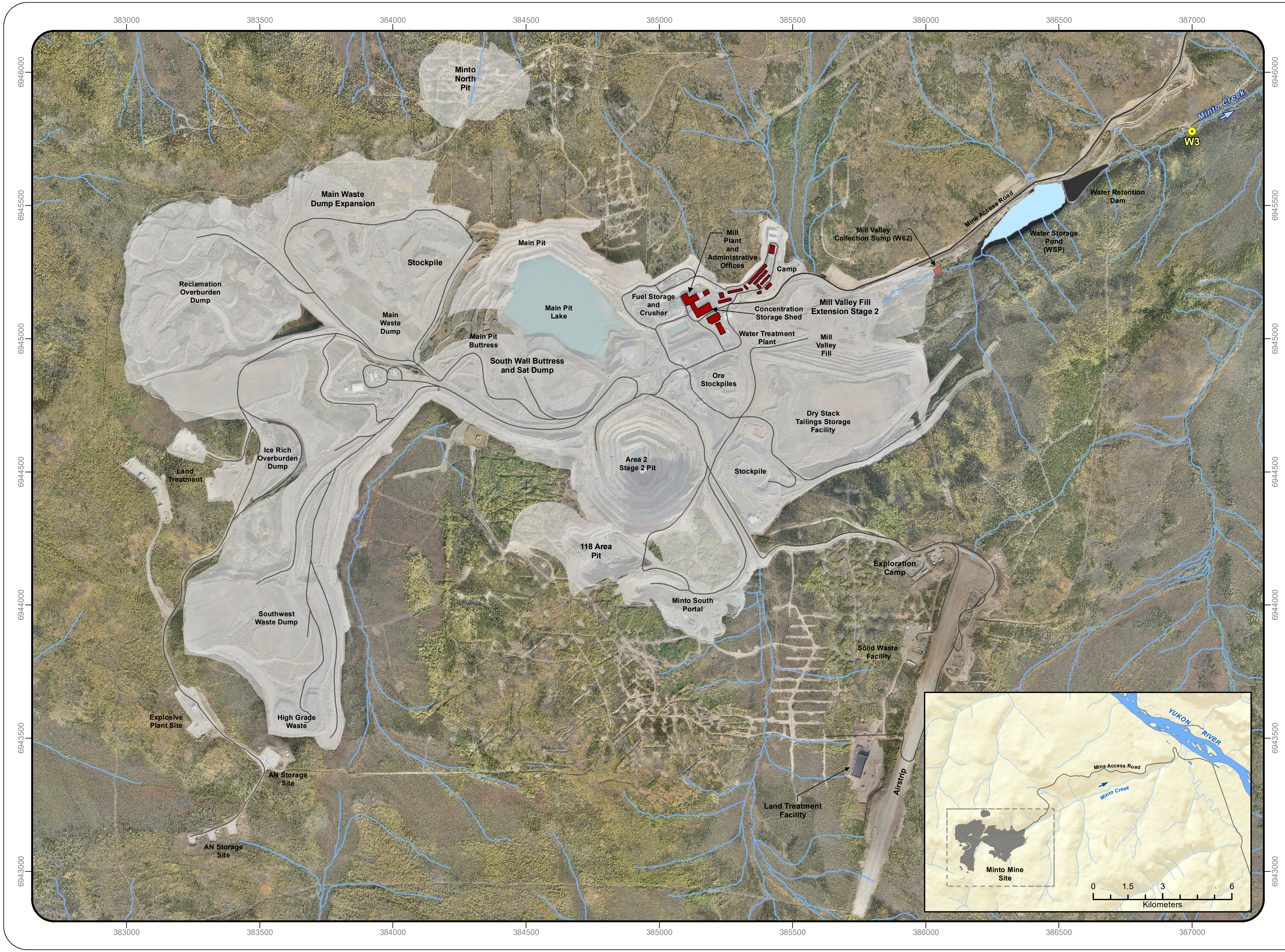
A Tetra Tech Consultants Company



Features

- Final Effluent Discharge Point
- Mine Road
- Watercourse
- Waterbody
- Water Retention Dam
- Minto Creek Detention Structure
- Building
- Mine Footprint
- Water Flow Direction

0 187.5 375 750
Meters

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 8V
Data Source: National Topographic Data Base (NTDB) compiled by Department of Natural Resources Canada at a scale of 1:50,000. All rights reserved.

Mine infrastructure data provided by Access Mining Consultants Inc.
Mine site contours derived from 2012 aerial imagery obtained from Challenger Geomatics.

Creation Date: March 2017
Project No. 167202.0080

Figure 1.2: Minto Mine Site Layout and Receiving Environment

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implemented every three years, the study design has been completed for Cycle 4 of the EEM (Minnow 2016a). The field work has been completed but the interpretive report is in progress. The most recent completed EEM was implemented in 2014 and was an Investigation of Cause (IOC) study into differences in benthic invertebrate community structure of upper Minto Creek (relative to reference) observed in the first two EEM studies (Minnow 2015a). Some mine influence on Minto Creek water quality was documented in the IOC study. Conductivity, hardness, nitrate, arsenic and copper were higher in Minto Creek than at reference areas but analytes were below CWQG for the protection of aquatic life, except for copper. Concentrations of nitrate were most strongly associated with the release of water from the Water Storage Pond, but remained below the CWQG. Despite the differences in water quality, a Reference Condition Approach (RCA) benthic invertebrate community survey indicated that the benthic invertebrate community of upper Minto Creek was within reference condition (Minnow 2015a).

Biological monitoring under the AEMP is implemented annually, and includes monitoring of water, sediment, periphyton, benthic invertebrates, fish and fish habitat. The biological monitoring program has been modified over time, but data from 1994 (baseline) and 2006-2015 have been reported previously (e.g., Minnow 2016b). AEMP water quality monitoring has indicated there were no analytes that had concentrations greater than WUL water quality objectives. Analytes that were above guidelines were also elevated at reference areas in apparent association with suspended solids/turbidity. Concentrations of copper in Minto Creek were greater than the Interim Sediment Quality Guidelines (ISQGs) for the protection of aquatic life and the reference areas. These concentrations were observed to be similar to several previous years. In 2015, the periphyton community at lower Minto Creek had lower density/biomass indicating lower production and had a different community composition compared to lower Wolverine Creek. Within year differences between lower Minto Creek and lower Wolverine Creek periphyton community summary metrics and composition were observed in previous years indicating temporal variability. Benthic invertebrate community composition of lower Minto Creek differed from both reference areas, lower Wolverine and lower Big creeks. Lower Minto Creek differed from references on the basis of density (higher), Simpson's Diversity (lower), Simpson's Evenness (lower), Bray-Curtis index (higher), percent Chironomids (higher at lower Wolverine Creek only), and CA Axis-1 (higher). High temporal variability has been observed presumably due to inter-annual variability in environmental conditions.

1.3 Objectives

The objectives of this study and report are to characterize and interpret current (2016) sediment quality, periphyton community, benthic invertebrate community and benthic invertebrate tissue quality of Minto Creek relative to reference conditions and conditions documented in previous years. Additional data on the quality of periphyton tissues and supporting environmental data are also reported.

1.4 Report Overview

This report is presented in nine sections, the first of which is this introduction (Section 1.0). Section 2.0 provides the methods used in sample collection, sample analysis and data analysis. Section 3.0 provides a description of the sampling areas and a summary of supporting physical and chemical data collected in the field. Sediment, periphyton community, benthic invertebrate community, and tissue chemistry results are presented in Sections 4.0–7.0, respectively. Conclusions and recommendations of the study are provided in Section 8.0. All the references cited throughout this report are listed in Section 9.0.

2.0 METHODS

Minnow Environmental Inc. implemented the Minto Creek sediment, periphyton and benthic invertebrate assessment from September 22nd to 28th, 2016 with the assistance of Minto Mine staff. The study was completed in accordance with specifications of the Minto Mine WUL (QZ14-031). In response to recent additions to the WUL (Clause 101), additional sampling was completed in 2016. This included sediment toxicity testing and benthic invertebrate tissue chemistry analysis. Sediment sampling was undertaken in upper Minto Creek, lower Minto Creek and corresponding reference areas (Table 2.1; Figure 2.1). Toxicity tests were run on sediment from lower Minto and lower Wolverine creeks (Table 2.1; Figure 2.1). Periphyton and benthic invertebrate community sampling were undertaken in erosional habitat of lower Minto Creek and their corresponding reference areas (Table 2.1; Figure 2.1). Tissue sampling (periphyton and benthic invertebrate) was also undertaken in lower Minto Creek and corresponding reference areas (Table 2.1; Figure 2.1). Supporting measures (e.g., field meter measures, water quality samples, depth, flow, habitat observations) were collected at all sampling stations.

2.1 Supporting Measures

2.1.1 Field Collection

A number of environmental variables were measured to support the sediment quality, periphyton community, benthic invertebrate community, and tissue chemistry data collected for the Minto Creek assessment. The location of each station was recorded using a handheld Geographic Positioning System (GPS) with coordinates recorded in Universal Transverse Mercator (UTM) units (using the North American Datum of 1983).

Supporting measures collected concurrent with sediment sampling (i.e., at depositional areas) included: core penetration depth (lower creek areas only), sample texture, and the presence or absence of organic detritus. *In situ* measurements, including temperature, dissolved oxygen, conductivity, and pH were taken at each station using either a YSI 650 MDS (Multiparameter Display System) field meter equipped with a YSI 6600 Sonde (Yellow Springs Instruments, Yellow Springs, OH) or a Hanna 4M multiparameter meter (Woonsocket, RI).

At each periphyton and benthic invertebrate station (community and tissue samples), *in situ* water quality measurements were taken using a field meter (described above), water depth was measured using a meter stick and water velocity was measured using a HACH FH950 handheld flow meter (HACH Company, Loveland, CO). Creek wetted and bankfull widths were measured at each sampling station using a tape measure or a range finder. Additional data

Table 2.1: Minto Mine Water Use Licence sediment, periphyton and benthic invertebrate monitoring program overview - September 2016.

Area Type	Area	Station	Minto Mine Water Use Licence (QZ14-031)								Selenium	
			Water	Sediment by Spoon[1]	Sediment by Hand Corer/Petite Ponar[2]	Sediment Toxicity Testing	Periphyton Chlorophyll 'a'	Periphyton Community	Benthic Community by Hess Sampler[3]	Benthic Invertebrate Tissue	Periphyton Tissue[4]	Benthic Invertebrate Tissue[4]
Upper Creek Areas	Upper McGuinty Creek (Reference)	URC-1	✓	✓								
		URC-2		✓								
		URC-3		✓								
		URC-4		✓								
		URC-5		✓								
	Upper Minto Creek (Exposed)	UMC-1	✓	✓								
		UMC-2		✓								
		UMC-3		✓								
		UMC-4		✓								
		UMC-5		✓								
Lower Creek Areas	Lower Wolverine Creek (Reference)	LWC-1	✓		✓	✓	✓	✓	✓	✓	Target 5 periphyton tissue samples	Target 5 benthic invertebrate tissue samples
		LWC-2			✓	✓	✓	✓	✓	✓		
		LWC-3			✓	✓	✓	✓	✓	✓		
		LWC-4			✓	✓	✓	✓	✓	✓		
		LWC-5			✓	✓	✓	✓	✓	✓		
	Lower Big Creek (Reference)	LBC-1	✓						✓		Target 5 periphyton tissue samples	Target 5 benthic invertebrate tissue samples
		LBC-2							✓			
		LBC-3							✓			
		LBC-4							✓			
		LBC-5							✓			
	Lower Minto Creek (Exposed)	LMC-1	✓		✓	✓	✓	✓	✓	✓	Target 5 periphyton tissue samples	Target 5 benthic invertebrate tissue samples
		LMC-2			✓	✓	✓	✓	✓	✓		
		LMC-3			✓	✓	✓	✓	✓	✓		
		LMC-4			✓	✓	✓	✓	✓	✓		
		LMC-5			✓	✓	✓	✓	✓	✓		

[1] Top 2 centimeters collected; minimum 3-grab composite.

[2] Top 2 centimeters collected; 3-grab composite.

[3] 500 µm mesh; 3-grab composite.

[4] Productivity permitting; in some cases, replication (of 5) may not be achieved with reasonable effort.

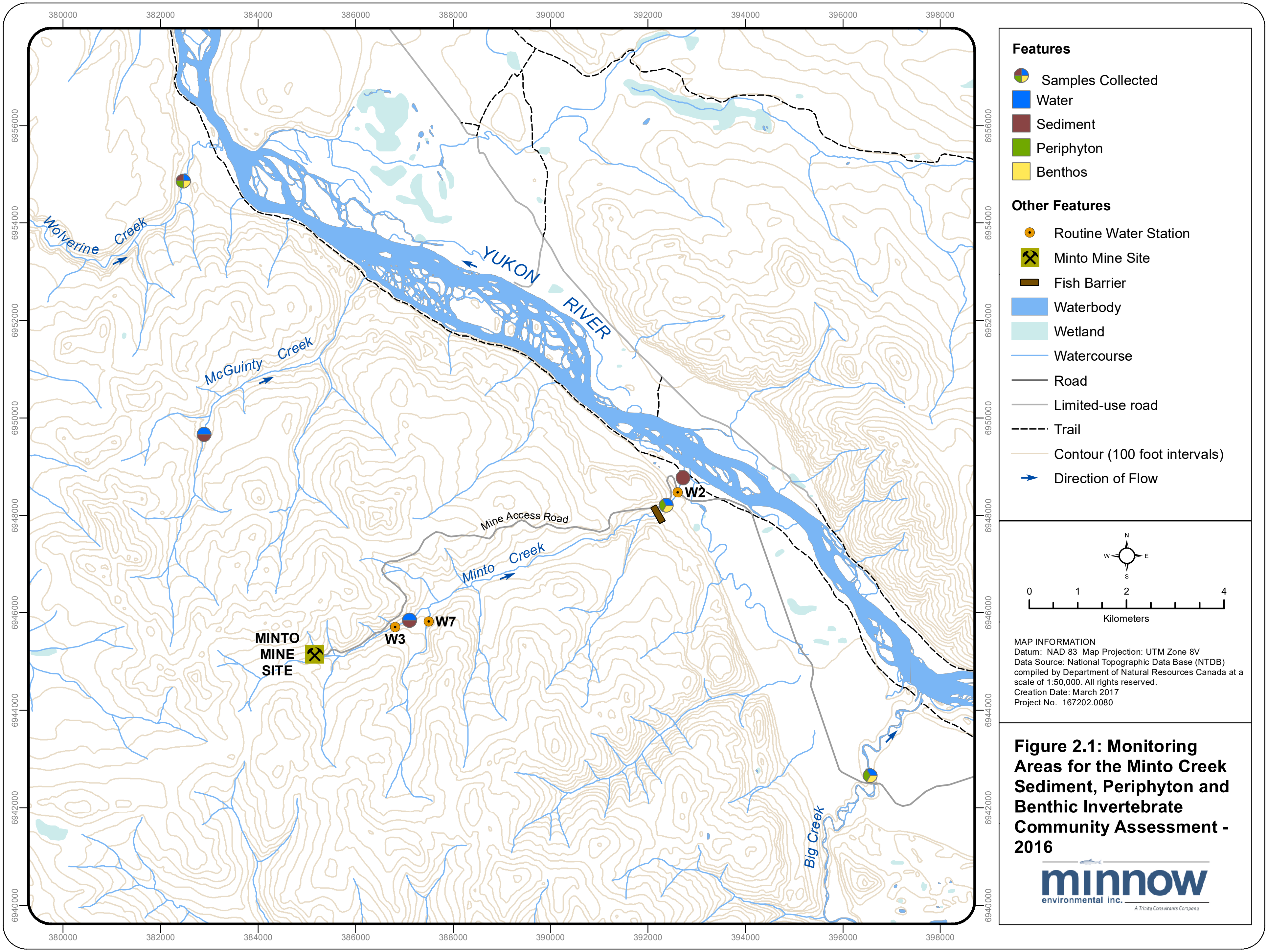

Figure 2.1: Monitoring Areas for the Minto Creek Sediment, Periphyton and Benthic Invertebrate Community Assessment - 2016

collected to characterize each periphyton and benthic invertebrate sampling station included: elevation, gradient, water appearance, creek morphology, bank condition, substrate texture, instream cover, instream features, overhead canopy, aquatic vegetation, riparian vegetation, surrounding land use and anthropogenic disturbance. In addition, at each benthic invertebrate station, the intermediate axis lengths were measured and recorded for 100 rocks that were washed during the benthic invertebrate sampling, and the percent embeddedness of ten randomly selected rocks were evaluated and recorded. This type of substrate characterization is similar to that recommended under the Canadian Aquatic Biomonitoring Network (CABIN) protocol (CABIN 2012) for characterizing benthic invertebrate habitat and provided additional information to assess and standardize habitat conditions among sampling stations and areas. Summary statistics of intermediate axis lengths (including the median and geometric mean) and median embeddedness were calculated for each station as per CABIN protocol.

Water samples for chemical analysis were collected at each periphyton and benthic invertebrate sampling area. Samples were collected using a master bottle from which the collected water was poured into pre-labeled sample bottles. Preservatives were added to the sample bottles, as required. A duplicate sample was collected from one site by using a split sample method; water from the master bottle was poured into one bottle and then into a duplicate bottle. Water samples for dissolved organic carbon (DOC) and for dissolved ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrophotometry) metals were filtered in the field using 0.45 μm polypropylene filters. Immediately after collection, water samples were placed in a cooler, and later placed in a refrigerator at approximately 4°C. They were later submitted to ALS Environmental in Whitehorse, YT, for analysis of alkalinity by auto titration, anions by ion chromatography, total and dissolved organic carbon by combustion, total inorganic carbon by CO_2 purge, total cyanide by Continuous Flow Analyzer (CFA), conductivity by electrode, hardness by calculation, total and dissolved mercury by Cold Vapour Atomic Fluorescence Spectrophotometry (CVAFS [low]), total and dissolved metals by Collision Cell Mass Spectrometry (CCMS) and ICP-OES, total and dissolved phosphorus by colour, total dissolved and suspended solids by gravimetrics, pH and turbidity by meter, and ammonia by fluorescence.

The productivity of lower Minto Creek and lower Wolverine Creek was evaluated using measurements of chlorophyll *α* in periphyton. Chlorophyll *α* is the primary photosynthetic pigment of all oxygen-evolving photosynthetic organisms (Wetzel 2001) and therefore provides an indicator of the standing stock of photosynthetic organisms representing the lowest trophic level. Since Minto Creek is a lotic system, measuring chlorophyll *α* in periphyton was considered to be more representative of productivity than measuring it in water. A stainless steel razor blade was used to scrape periphyton from five rocks. The sample was transferred on to filter paper and placed in a pre-labeled opaque sampling jar. The surface area sampled was measured and recorded. All samples were maintained in coolers with ice packs during transport and then kept frozen on site until submission to ALS Environmental (Whitehorse, YT).

2.1.2 Data Analysis

The quality of the data was evaluated by comparing laboratory method detection limits (MDL) to target detection limits, which are ideally ≤ 1/10th of guideline values. On a subset of samples the laboratory conducted Quality Assurance/Quality Control (QA/QC) analysis, including method blanks, laboratory duplicates, matrix spikes, spiked blanks and certified reference materials. Field duplicates were also collected and analyzed. These QA/QC samples were evaluated to characterize data quality in a formal Data Quality Assessment (DQA; Appendix A). Water quality of Minto Creek was evaluated relative to WUL objectives, concentrations measured at reference areas, applicable water quality guidelines, and historical water quality.

Supporting field measures (temperature, dissolved oxygen, pH and specific conductivity) and chlorophyll *α* results were tested for differences between lower Minto Creek and reference areas (lower Wolverine and lower Big creeks) using t-tests. Prior to the t-test, data were tested for normality and homogeneity of variance (equal variance). Data that were not found to be normal were log, square root or inverse transformed. If, after transformation, data could not be normalized, a non-parametric Mann-Whitney U-test was applied. The significant p-value was set at 0.050 for all tests of supporting field measures. Statistical comparisons were conducted using SPSS software (SPSS 2003). Chlorophyll *α* was also compared to British Columbia water quality guidelines. Creek productivity was also characterized by comparing chlorophyll *α* concentration to the Dodds et al. (1998) productivity classification system for temperate streams.

2.2 Sediment Quality

2.2.1 Sample Collection and Laboratory Analysis

Sediment samples were collected for particle size and chemical analysis at depositional areas within Minto Creek and reference creeks (Table 2.1; Figure 2.1). At lower Minto Creek and lower Wolverine Creek, sediment samples for particle size analysis were collected using a 15.24 cm x 15.24 cm (6” x 6”) stainless steel petite ponar grab sampler (0.023 m^2 sampling area). A composite sample was created by collecting the surficial two centimeters of sediment from each of three acceptable grabs (i.e., full to each edge of the sampler) using a stainless steel spoon. Each sample that was collected to form the composite were placed into a tote and mixed. Sediment samples for physical characterization were then placed into pre-labeled glass sampling jars. Sediment samples for chemical analyses were collected using a 4.7 cm (2”; inside diameter) Lexan™ core tube, which was carefully inserted into sediment deposits, capped using a fitted plastic cap and retrieved by hand. From each acceptable core (i.e., each core containing an intact, representative sediment-water interface), the surficial two centimeters of sediment was manually extruded upwards into a graded core collar, cut with a stainless steel core knife, and placed into a pre-labeled glass sampling jar. Samples from three cores treated in this manner were composited to form a single sample from each station. At upper Minto Creek and upper McGinty Creek, sediment deposits were rare and were typically very shallow (i.e., deposits were less than three centimeters in depth). Accordingly, collection by ponar or by coring, as described above, was not effective in the upper creek areas and sediments were collected using a stainless steel spoon. Specifically, at locations of sediment deposition, surficial sediment was carefully collected by slowly spooning the sediment into a pre-labeled glass jar, with care taken to avoid the loss of fine material. In order to be as consistent as possible with the sediment collected in the lower creek areas, samples included no more than the top 2 centimeters of deposited sediment. Immediately after collection, sediment samples were placed in a cooler and later placed in a refrigerator at approximately 4°C. They were later submitted to ALS Environmental in Burnaby, BC or Whitehorse, YT, for analysis of particle size by dry and wet sieving and pipette sedimentation method, total organic carbon and loss on ignition by combustion, inorganic carbon was derived from a calculation, metals by collision/reaction cell - inductively coupled plasma mass spectrometry (CRC ICP-MS), mercury by CVAFS, total Kjeldahl nitrogen by colorimetric analysis and pH by probe.

Two sediment toxicity tests that measured survival and growth were added to the 2016 monitoring program; a 10 day *Chironomus dilutus* test and a 14 day *Hyalella azteca* test (Environment Canada 1997, 2013). At lower Minto Creek and lower Wolverine Creek, sediment was collected using a 15.24 cm x 15.24 cm (6” x 6”) stainless steel petite ponar grab sampler (0.023 m^2 sampling area). The top 2 cm from three grabs were collected as a composite from each of five stations (which form the replicates in the toxicity tests). Samples from each station were placed into a pre-labeled 1L jar and mixed with a stainless steel spoon. Immediately after collection, samples were placed in a cooler, then later transferred to a refrigerator and stored at approximately 4°C until they were submitted to Nautilus Environmental Inc. in Burnaby, BC for sediment toxicity testing.

2.2.2 Data Analysis

The MDLs achieved by the laboratory were compared to target limits, generally ≤1/10th guideline values. Laboratory QA/QC analysis included method blanks, laboratory duplicates, spiked blanks and certified reference materials (Appendix A). Sediment quality data were evaluated relative to sediment quality guidelines (SQGs) for the protection of aquatic life (e.g., CCME 1999) and reference concentrations to identify metals with the potential to adversely affect aquatic life and/or whose concentrations may be elevated due to mine activity. Sediment quality data were also compared to results obtained in previous years of sampling (1994 and 2006-2015). Interpretation was conducted with careful consideration of a significant methodological change made in 2010 and carried through to 2016 (sediments collected as described in Section 2.2.1) relative to previous years. Sediments collected in all years previous to 2010 were collected within the active channel of the creek using an aluminum or Teflon scoop. Samples were submitted whole for analysis of particle size distribution, which generally included significant quantities of gravel and sand. Only material passing through a 230 mesh sieve (< 63 µm; silt and clay) was digested and analyzed for metals. While this approach does result in the analysis of geochemically-relevant fine sediment (e.g., Horowitz 1991), it represents an impediment to the interpretation of the biological significance of sediment chemistry as organisms are exposed to whole sediment (not just fines) and SQGs for the protection of aquatic life (e.g., CCME 1999) apply to whole sediment. Due in part to these methodological changes, relationships between analytes of concern and percent TOC were investigated. Analytes of concern were also normalized to percent TOC and lithium concentrations to help bridge the gap between these methodological changes. If values were less than MDL, calculations were calculated by substituting the detection limit (i.e., if value was < 0.10 mg/kg, the value 0.10 mg/kg was used).

The laboratory performed QA/QC on the sediment toxicity tests by comparing results to reference toxicant tests. Ammonia was monitored in lower Wolverine Creek treatments to ensure that the concentrations did not exceed 0.20 mg/L of un-ionized ammonia (as N). Sediment from lower Minto Creek was compared to lower Wolverine Creek sediment, laboratory control sediment. Results were also compared to previous sediment toxicity testing conducted in 2011 and 2015 (Minnow 2012, 2016b). Statistical analysis were conducted and summarized in a report by Nautilus Environmental (Appendix C).

2.3 Periphyton Community

2.3.1 Sample Collection and Laboratory Analysis

Periphyton is the assemblage of algae, bacteria, fungi, and meiofauna attached to submerged substrate in freshwaters. However, periphyton communities are generally characterized on the basis of the attached alga community. Attached algal communities are representative of the lowest trophic level and are indicators of primary productivity. Periphyton community samples were collected in erosional habitat of lower Minto Creek, lower Wolverine Creek and lower Big Creek (Table 2.1; Figure 2.1). Periphyton was collected from five replicate stations per area, with each sample collected from five randomly selected rocks with the use of a stainless steel razor blade. The area sampled was measured and recorded. After preservation, samples were placed in pre-labeled sampling jars and preserved with Lugol's iodine solution. Samples were placed in a cooler, then later transferred to a refrigerator and stored at approximately 4 °C until they were shipped to Plankton R Us Inc. (Winnipeg, MB) for analysis to species level.

2.3.2 Data Analysis

Laboratory duplicate samples were collected on 10% of the periphyton community samples and are described in the DQA (Appendix A). Periphyton communities were evaluated using summary metrics including number of cells per unit area (density), biomass per unit area, number of taxa, Simpson's Diversity, Simpson's Evenness and Bray-Curtis index (Environment Canada 2012). Additional non-statistical comparisons were made on the basis of percent community composition of dominant taxa (calculated as the abundance of each respective dominant taxon group relative to the total number of organisms in the sample).

Total organism density (cells/cm^2) and biomass (µg/cm^2) were calculated for periphyton community samples. The diversity metric "number of taxa" (also known as taxon richness) included all separate taxa identified to the species level. Simpson's Diversity and Simpson's Evenness indices were computed according to formulae presented by Smith and Wilson (1996) and recommended by Environment Canada (2012). These indices take into account both the relative abundance of taxa, and the number of taxa, with values ranging from 0 (low diversity or evenness) to 1 (high diversity or evenness). The Bray-Curtis index was also calculated according to Environment Canada (2012). This metric takes into account the abundance of each taxon at each station compared to the median abundance computed from the reference stations (lower Wolverine Creek), to compute an index of the relative "dissimilarity" of each station from the hypothetical reference median station. Larger Bray-Curtis index values indicate greater dissimilarity from reference.

Periphyton community endpoints were summarized by reporting mean, median, minimum, maximum, and standard deviation for each study area. Differences among effluent-exposed and reference areas were tested using ANOVA, with a p-value < 0.10. A p-value of 0.10 was used as per suggested EEM guidelines (Environment Canada 2012). Prior to ANOVA, data were tested for the assumptions of normality and homogeneity of variance. If data were not found to be normal or variances were not equal then data were transformed by either log, square root or inverse transformation. If transformation could not achieve normality, a non-parametric Mann-Whitney U-test was conducted. All statistics were conducted using SPSS (SPSS 2003).

Periphyton data collected in 2016 were compared to data collected in baseline studies (HKP 1994) and in 2011-2015. Due to differences in reporting of periphyton community data in the 1994 baseline report (e.g., taxa were only identified as present, common or dominant), a non-statistical comparison was performed against 1994 data using proportional abundances at the taxonomic level of Phylum.

2.4 Benthic Invertebrate Community

2.4.1 Sample Collection and Laboratory Analysis

Benthic invertebrate community samples were collected in erosional habitat of lower Minto Creek, lower Wolverine Creek and lower Big Creek as required under the WUL (Table 2.1; Figure 2.1). Benthic invertebrate community samples were collected from riffle/run habitat with cobble and gravel substrate using a Hess sampler (0.10 m^2) outfitted with 500 µm mesh. Five replicate samples (stations), consisting of a three grab composite each (0.30 m^2 area in total) were collected at each sampling area. For each grab, the substrate within the sampler was disturbed and scrubbed (by hand and nail brush) with care taken to ensure that all dislodged organic material was swept into the sampler collection net. The substrate was disturbed to a depth of approximately 5 cm over a period of approximately ten minutes. This procedure was repeated for the second and third grab, following which all of the material contained in the collection net was carefully transferred to a pre-labeled 2 L wide-mouth plastic jar using a stainless steel spoon and a wash bottle while working over a plastic tub to avoid any potential loss of organisms. Any organisms that adhered to the sieve bag were removed by hand and added to the sample. All samples were labeled internally (using wooden sticks) and externally with the station number, area identifier, Minnow project number, date and field personnel in order to ensure correct identification at the laboratory. Samples were preserved within six hours of collection using buffered formalin solution to a nominal concentration of 10% in ambient water.

All benthic invertebrate samples were shipped to Cordillera Consulting in Summerland, BC. Each sample was elutriated to remove sand, gravel and clay, and the remaining organic material was preserved in 70% ethanol. Elutriate was examined for any mollusc or trichopteran cases, then each sample was examined to estimate the total number of invertebrates. If the estimated number of organisms were greater than 600, the sample was fine and non-clumping, a subsample was taken using a Folsom Plankton Splitter (Motodo 1959; Van Guelpen et al. 1982). Empty snail or bivalve shells, empty caddisfly cases, invertebrate fragments such as legs, gills, antennae etc. were not removed or counted. When organism fragments were encountered, only the heads were counted towards the total. Larval and pupal exuviae were not counted while terrestrial stages and terrestrial drop-ins were indicated as such and do not contribute to the total count. Benthic invertebrates were identified to the “lowest practicable taxonomic level” (which in most cases were genus) and counted. Following identification and counting, representative specimens of each taxon were preserved in a museum quality vial with a polyseal lid to create a voucher collection. Internal labels were used to identify the taxa, the client, date collected, site code and the project.

2.4.2 Data Analysis

Laboratory QA/QC included an assessment of sub-sampling error and sorting efficiency on at least 10% of the samples (Appendix A). Benthic invertebrate communities were evaluated using summary metrics including invertebrate density (number of organisms per m^2, calculated based on a sample area of 0.30 m^2), number of taxa, Simpson’s Diversity, Simpson’s Evenness and Bray-Curtis index. These endpoints were calculated after the exclusion of either non-benthic organisms, organisms that could not be conclusively identified as separate taxa or taxa smaller than 500 µm in size, including, Ostracods, Nemata and Turbellaria. In some instances, for the purposes of data analysis, invertebrate taxa were combined at a generic taxonomic level in order to incorporate abundance associated with indeterminate taxa. This was only done when there were few species in the genus and indeterminates made up a significant proportion of generic abundance. Total organism density (individuals/m^2), taxon richness, Simpson’s Diversity, Simpson’s Evenness and Bray-Curtis index were calculated in the same manner as periphyton community data (Section 2.3.2). Bray-Curtis index was calculated based on the median of each reference area as well as the combined reference median. The combined reference median was presented within the text as this is the optimal method for determination of potential effluent effects, due to the fact that using a reference median value calculated from only one area biases the outcome toward detecting a difference between two areas regardless of potential anthropogenic stressors. This occurs because the area used to calculate the median was inherently more similar to itself than any other area (Huebert et al. 2011), even if the two areas in question are 'natural-pristine' areas.

The relative proportions of the most abundant taxa were calculated relative to the total number of organisms in the sample. Dominant taxon groups were defined as groups representing greater than 10% of total organism abundance in one or more areas or any groups considered to be important indicators of environmental stress. In this study, relative proportions of the major groups, such as chironomids and EPT taxa (Ephemeroptera [mayfly], Plecoptera [stonefly], Trichoptera [caddisfly] taxa) were examined. It is often possible to relate low relative abundance of sensitive taxonomic groups (e.g., EPT taxa) to environmental stress (e.g., Taylor and Bailey 1997). Similarly, high relative abundance of tolerant taxonomic groups (e.g., oligochaetes) may also indicate higher environmental stress (Chapman et al. 1982a,b).

All benthic invertebrate community endpoints were summarized by reporting mean, median, minimum, maximum, standard deviation, standard error and sample size for each study area. Differences among effluent-exposed and reference areas were tested using ANOVA with a post hoc test, with significance set at a p-value of < 0.10. A p-value of 0.10 was used as per suggested EEM guidelines (Environment Canada 2012). Either the Bonferroni (if equal variance was achieved) or Tamhane's (if data had unequal variance) post hoc tests were used. Prior to ANOVA, all data were transformed (log, square root or inverse transformation) as necessary to meet assumptions of normality and homogeneity of variance. If data failed the assumptions of normality and homogeneity of variance, then a non-parametric Kruskal-Wallis test was conducted. All statistical comparisons were conducted using SPSS software (SPSS 2013). Magnitudes of difference between effluent-exposed and reference area means were calculated for each benthic invertebrate community metric where a significant difference was detected. If a significant difference between areas was not detected, then the minimum effect size that could be detected was calculated.

Benthic invertebrate community data were also evaluated in comparison to results obtained in previous years of sampling (1994, 2006, 2008 and 2010-2015). Summary metrics from earlier years were previously re-calculated (Minnow 2011) to ensure consistency and appropriate comparisons over time.

2.5 Tissue Chemistry

2.5.1 Sample Collection and Laboratory Analysis

Periphyton and benthic invertebrate tissue samples were collected from lower Minto (exposed), lower Wolverine (reference) and lower Big creeks (reference; Table 2.1; Figure 2.1). Periphyton samples were collected by scraping submerged cobble-size rocks using a stainless steel razor blade. Scraped material (periphyton) was placed in pre-labeled sample jars. Benthic invertebrate tissue samples were collected in areas with cobble substrate using a kick-net and by overturning rocks and collecting organisms by hand. Periphyton and benthic invertebrate tissue samples (2-5 grams) were placed into pre-labeled sample jars and Whirl-Pak™ bags, respectively. A total of five periphyton and benthic invertebrate samples were collected at each area. Immediately after collection, all tissue samples were placed in a cooler, and later in a freezer until they were submitted to ALS Environmental in Burnaby, BC. Samples were analyzed for percent moisture and for metals by High-Resolution ICP-MS, and later converted to dry weight using percent moisture.

2.5.2 Data Analysis

Periphyton and benthic invertebrate tissue data were assessed to determine if the data quality were acceptable. The MDLs achieved were compared to the detection limits quoted by the laboratory. Method blanks, laboratory duplicates, spiked blanks and certified reference materials were included in the DQA for both tissue types (Appendix A).

The primary objective of tissue collection was to support a selenium assessment reported under separate cover. Accordingly, data are reported herein for future reference with limited interpretation. Tissue quality data were interpreted by statistically comparing metal concentrations at the exposed area to those collected at the reference areas using ANOVA with post-hoc testing. Either the Bonferroni (if equal variances were achieved) or Tamhane's (if data had unequal variance) post hoc tests were used. Data were first tested for normality and equality of variance and if normality was not achieved, data were transformed by either log, square root, or inverse transformations. Some analytes could not be normalized, and a non-parametric Kruskal-Wallis test was conducted instead. All statistical tests were interpreted using p-values of 0.050.

3.0 SUPPORTING MEASURES

3.1 Field Measures

Mean temperature at the sediment sampling area of upper Minto Creek (7.08°C) was significantly higher than in upper McGinty Creek (0.50°C; Figure 3.1; Appendix Table B.3). Higher temperature in upper Minto Creek was likely due to the mine discharging during sampling. Specific conductance was significantly higher in upper Minto Creek (234 µS/cm) than in lower Minto Creek (120 µS/cm). In both upper and lower Minto Creek, specific conductance was significantly higher than at the respective reference areas (Figure 3.1). Dissolved oxygen was significantly higher at lower Minto Creek (94.7% saturation) than at lower Wolverine Creek (25.6% saturation). Lower dissolved oxygen at lower Wolverine Creek could be attributed to sampling in back eddies, which were the only areas to support sediment deposition, but where dissolved oxygen was expected to be low. Upper Minto Creek had significantly lower dissolved oxygen (88.1%) than upper McGinty Creek (91.9%) but well above guidelines. At lower Minto Creek, pH was significantly higher (7.93) compared to lower Wolverine Creek (6.88) but in all areas pH was well within water quality guidelines and WUL objectives (Figure 3.1; Appendix Table B.3).

Physico-chemical measurements were also taken in erosional areas of lower Minto, lower Wolverine and lower Big creeks in support of benthic invertebrate community sampling. Temperature was significantly higher at lower Minto Creek (3.08°C) compared to lower Wolverine Creek (1.64°C) but did not differ from lower Big Creek (3.48°C; Figure 3.2). Specific conductance was the only measure that was significantly higher at lower Minto Creek (278 µS/cm) compared to both reference areas, lower Wolverine (166 µS/cm) and lower Big (166 µS/cm) creeks, which was consistent with the measures supporting the sediment collections and suggest a mine influence on water quality. All areas were well oxygenated with slightly, but significantly lower dissolved oxygen at lower Minto Creek (98.0% saturation) than at lower Big Creek (103.2% saturation; Figure 3.2; Appendix Table B.4). Lower Minto Creek had significantly higher pH (8.34) than lower Wolverine Creek (8.10) but did not differ from lower Big Creek (8.37). All areas were within the range of the WUL objective for pH.

3.2 Water Chemistry and Chlorophyll *α*

Water chemistry data quality were assessed prior to data analysis and interpretation, and were judged to be of good quality (Appendix A). Fluoride exceeded guidelines in Minto Creek and at associated reference areas, while total iron exceeded guidelines only at upper McGinty Creek (Table 3.1). Total copper concentrations (a metal of particular interest at the Minto

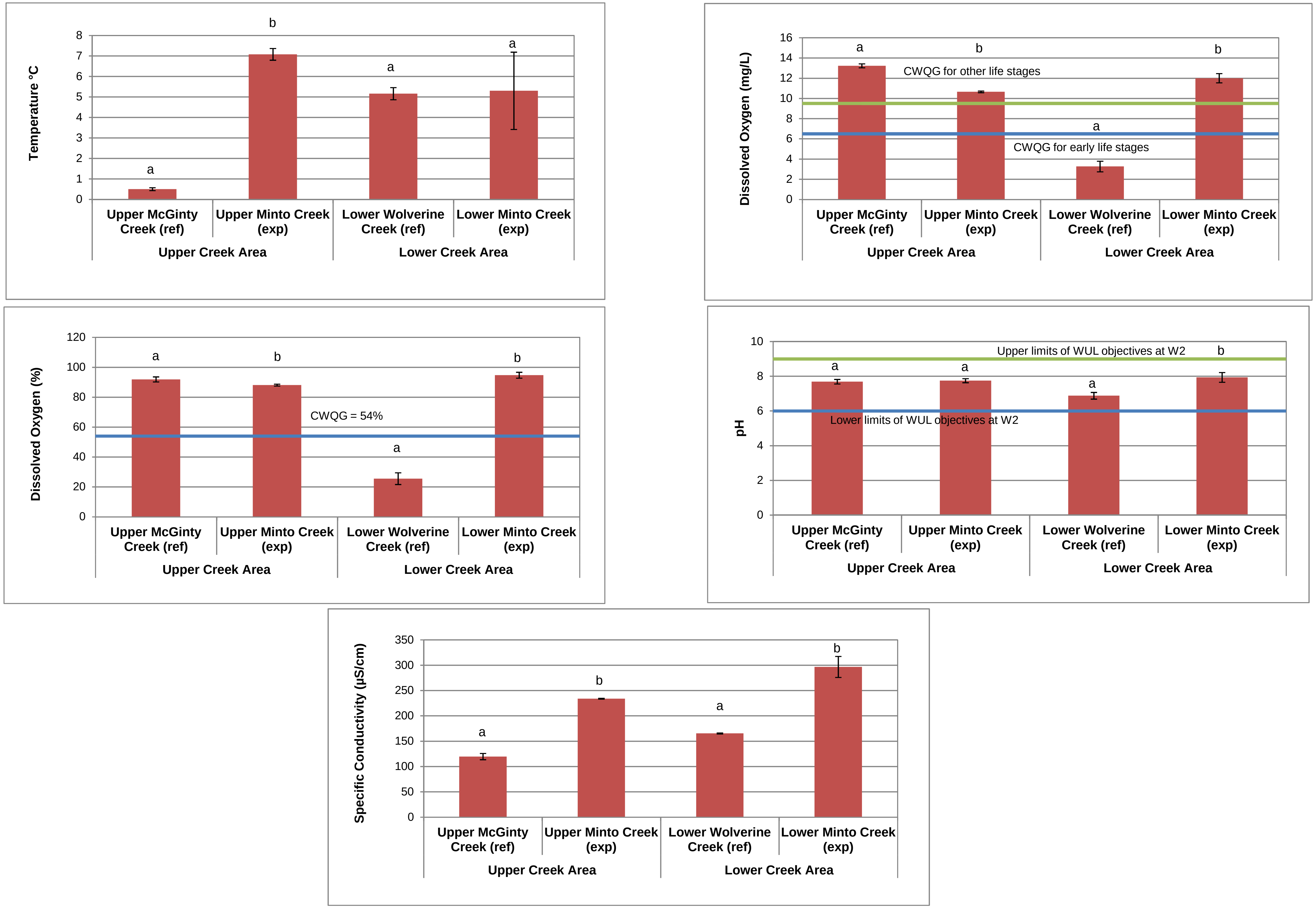

Figure 3.1: Physico-chemical measurements in depositional areas of upper and lower Minto Creek relative to reference areas, Minto Mine, 2016. Data presented as mean ± standard deviation. Sample sizes were n = 5 in all areas. Different letters represent a significant difference between areas within each creek area.

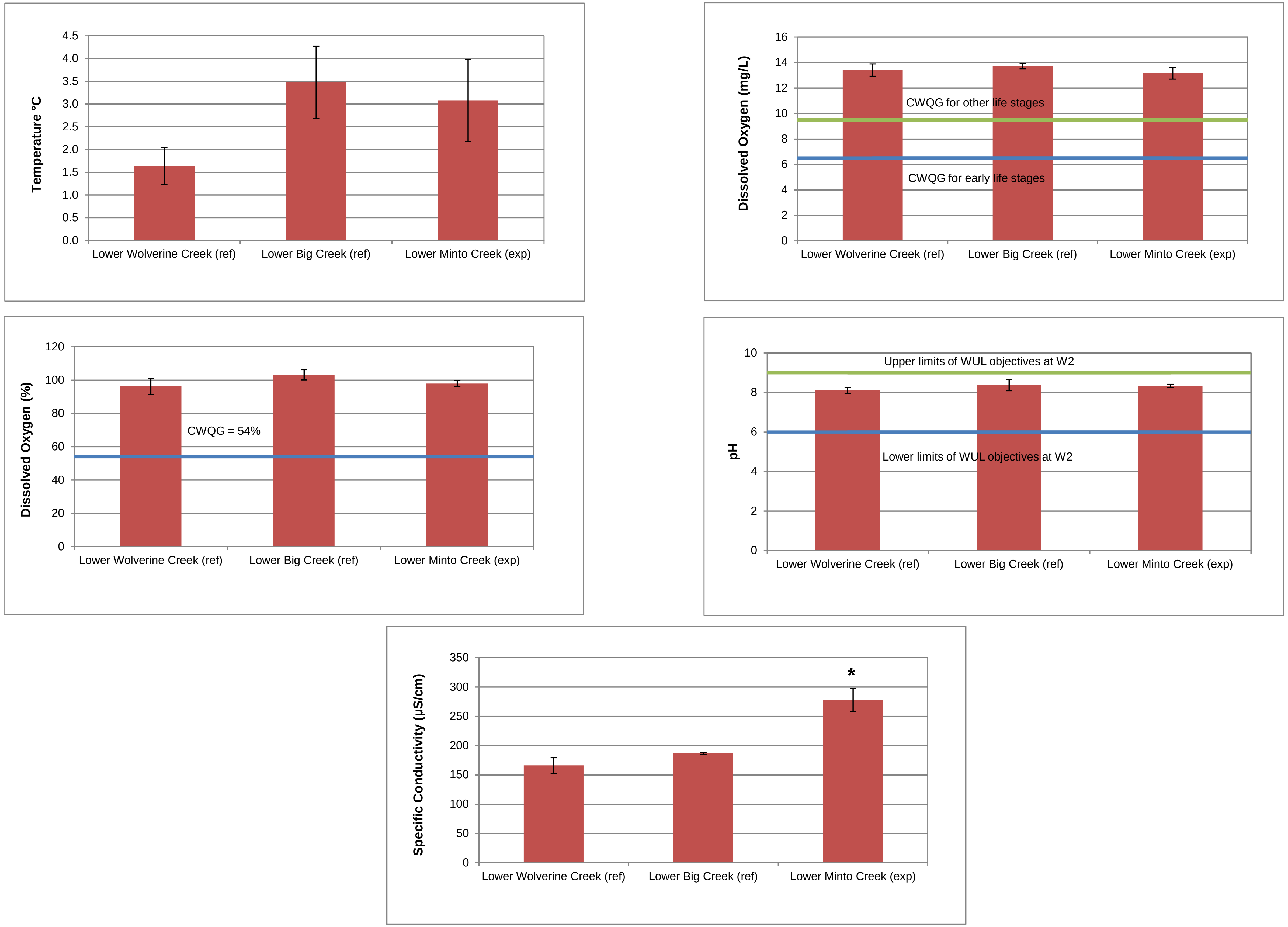

Figure 3.2: Physico-chemical measurements in erosional areas in lower Minto Creek and reference areas, Minto Mine, 2016. Data presented as mean ± standard deviation and n = 5. Asterisk (*) indicate when lower Minto Creek was significantly different from lower Wolverine and lower Big creeks.

Table 3.1: Water quality results at exposure and reference areas, Minto Mine WUL, September 2016.

	Analyte	Units	CCME Water Quality Guidelines[1] 30 Day	CCME Water Quality Guidelines[1] Max	WUL Objectives at W2	Upper McGinty Creek (reference)	Upper Minto Creek (exposure)	Lower Wolverine Creek (reference)	Lower Big Creek (reference)	Lower Minto Creek (exposure)
Physical Tests	Conductivity	µS/cm	-	-	-	142	252	191	207	294
	Hardness (as $CaCO_3$)	mg/L	-	-	-	75	120	98	104	159
	pH	ph Units	6.5 - 9.0	-	6.0 - 9.0	7.88	8.10	8.11	8.24	8.22
	Total Suspended Solids	mg/L	8.0[a]	28[a]	-	< 3.0	< 3.0	< 3.0	< 3.0	3.9
	Total Dissolved Solids	mg/L	-	-	-	101	179	141	148	212
	Turbidity	NTU	3.1[b]	9.1[b]	-	1.6	0.82	1.0	1.1	1.4
Anions and Nutrients	Total Alkalinity	mg/L	-	-	-	68	96	95	99	141
	Total Ammonia (as N)	mg/L	0.41[c]	-	0.25	0.0058	0.0077	0.0051	< 0.0050	< 0.0050
	Bromide (Br)	mg/L	-	-	-	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
	Chloride (Cl)	mg/L	120	640	-	< 0.50	2.9	< 0.50	0.56	2.1
	Fluoride (F)	mg/L	0.12		-	0.25	0.16	0.13	0.13	0.29
	Nitrate (as N)	mg/L	3.0	124	9.1	0.050	2.3	< 0.0050	0.030	0.84
	Nitrite (as N)	mg/L	0.060	-	0.060	< 0.0010	0.0039	< 0.0010	< 0.0010	< 0.0010
	Total dissolved Phosphorus (P)	mg/L	-	-	-	0.014	0.0066	0.0068	0.0035	0.0097
	Total Phosphorus (P)	mg/L	-	-	-	0.018	0.013	0.0069	0.0053	0.012
	Sulfate (SO_4)	mg/L	-	-	-	8.8	31	14	14	21
Other	Total Cyanide	mg/L	-	-	-	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
	Dissolved Organic Carbon	mg/L	-	-	-	15	5.4	17	8.5	9.4
	Total Organic Carbon	mg/L	-	-	-	13	24	21	24	32
	Total Inorganic Carbon	mg/L	-	-	-	14	5.2	17	8.2	9.5
Total Metals	Total Aluminum (Al)	mg/L	0.10[d]	-	-	0.095	0.023	0.060	0.059	0.041
	Total Antimony (Sb)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	0.00018	0.00010
	Total Arsenic (As)	mg/L	0.0050	-	-	0.00065	0.00021	0.00052	0.0010	0.00051
	Total Barium (Ba)	mg/L	-	-	-	0.034	0.039	0.035	0.066	0.058
	Total Beryllium (Be)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Total Bismuth (Bi)	mg/L	-	-	-	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
	Total Boron (B)	mg/L	1.5	2.9	-	< 0.010	0.028	< 0.010	< 0.010	0.012
	Total Cadmium (Cd)	mg/L	0.00013[e]	0.0016[e]	-	0.0000051	0.000015	< 0.0000050	0.0000066	< 0.0000050
	Total Calcium (Ca)	mg/L	-	-	-	21	32	21	25	43
	Total Chromium (Cr)	mg/L	0.0010 Cr(VI)	-	-	0.00058	0.00010	0.00063	0.00031	0.00025
	Total Cobalt (Co)	mg/L	-	-	-	0.00019	< 0.00010	0.00011	< 0.00010	< 0.00010
	Total Copper (Cu)	mg/L	0.0020[e]	-	-	0.0017	0.0066	0.0022	0.0023	0.0023
	Total Iron (Fe)	mg/L	0.30	-	-	0.69	0.046	0.22	0.12	0.20
	Total Lead (Pb)	mg/L	0.0022[e]	-	-	< 0.000050	< 0.000050	< 0.000050	0.000071	< 0.000050
	Total Lithium (Li)	mg/L	-	-	-	< 0.0010	0.0010	0.0016	0.0014	0.0014
	Total Magnesium (Mg)	mg/L	-	-	-	6.1	10	11	10	14
	Total Manganese (Mn)	mg/L	-	-	-	0.050	0.039	0.015	0.017	0.013
	Total Mercury (Hg)	mg/L	0.000026	-	-	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
	Total Molybdenum (Mo)	mg/L	0.073	-	-	0.0010	0.0024	0.00057	0.0014	0.0016
	Total Nickel (Ni)	mg/L	0.077[e]	-	-	0.0014	0.00053	0.0021	0.0013	0.0011
	Total Phosphorus (P)	mg/L	-	-	-	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
	Total Potassium (K)	mg/L	-	-	-	0.47	1.8	0.63	0.86	1.4
	Total Selenium (Se)	mg/L	0.0010	-	-	0.00027	0.00059	0.00011	0.000055	0.00022
	Total Silicon (Si)	mg/L	-	-	-	7.1	2.3	6.0	6.5	5.4
	Total Silver (Ag)	mg/L	0.00025		-	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Total Sodium (Na)	mg/L	-	-	-	4.2	12	7.3	7.9	9.9
	Total Strontium (Sr)	mg/L	-	-	-	0.13	0.33	0.19	0.27	0.36
	Total Thallium (Tl)	mg/L	0.00080	-	-	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Total Tin (Sn)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Total Titanium (Ti)	mg/L	-	-	-	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
	Total Uranium (U)	mg/L	0.015	0.033	-	0.00043	0.00074	0.00068	0.0027	0.0010
	Total Vanadium (V)	mg/L	-	-	-	0.0011	< 0.00050	0.0012	0.0011	0.00075
	Total Zinc (Zn)	mg/L	0.030	-	-	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Dissolved Metals	Dissolved Aluminum (Al)	mg/L	-	-	0.10	0.029	0.0017	0.027	0.017	0.0052
	Dissolved Antimony (Sb)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	0.00014	< 0.00010
	Dissolved Arsenic (As)	mg/L	-	-	0.0050	0.00053	0.00018	0.00046	0.00075	0.00047
	Dissolved Barium (Ba)	mg/L	-	-	-	0.032	0.038	0.036	0.066	0.058
	Dissolved Beryllium (Be)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Dissolved Bismuth (Bi)	mg/L	-	-	-	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
	Dissolved Boron (B)	mg/L	-	-	-	< 0.010	0.027	< 0.010	< 0.010	0.012
	Dissolved Cadmium (Cd)	mg/L	-	-	0.00018[f]	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
	Dissolved Calcium (Ca)	mg/L	-	-	-	20	32	21	25	42
	Dissolved Chromium (Cr)	mg/L	-	-	0.0010	0.00037	< 0.00010	0.00049	0.00021	0.00016
	Dissolved Cobalt (Co)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Dissolved Copper (Cu)	mg/L	-	-	0.020/0.013[g]	0.0013	0.0057	0.0020	0.0019	0.0021
	Dissolved Iron (Fe)	mg/L	-	-	1.1	0.35	< 0.010	0.17	0.047	0.10
	Dissolved Lead (Pb)	mg/L	-	-	0.0040	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
	Dissolved Lithium (Li)	mg/L	-	-	-	< 0.0010	< 0.0010	0.0015	0.0014	0.0014
	Dissolved Magnesium (Mg)	mg/L	-	-	-	6.0	10	11	10	13
	Dissolved Manganese (Mn)	mg/L	-	-	-	0.029	0.015	0.012	0.015	0.0051
	Dissolved Mercury (Hg)	mg/L	-	-	-	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
	Dissolved Molybdenum (Mo)	mg/L	-	-	0.073	0.00080	0.0021	0.00044	0.0012	0.0015
	Dissolved Nickel (Ni)	mg/L	-	-	0.11	0.0012	< 0.00050	0.0019	0.0011	0.0010
	Dissolved Phosphorus (P)	mg/L	-	-	-	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
	Dissolved Potassium (K)	mg/L	-	-	-	0.47	1.8	0.65	0.85	1.4
	Dissolved Selenium (Se)	mg/L	-	-	0.0020	0.00030	0.00069	0.00013	0.000073	0.00023
	Dissolved Silicon (Si)	mg/L	-	-	-	6.8	2.2	5.8	6.3	5.1
	Dissolved Silver (Ag)	mg/L	-	-	0.00010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Dissolved Sodium (Na)	mg/L	-	-	-	4.1	11	7.3	7.7	9.7
	Dissolved Strontium (Sr)	mg/L	-	-	-	0.12	0.32	0.18	0.26	0.36
	Dissolved Thallium (Tl)	mg/L	-	-	-	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Dissolved Tin (Sn)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Dissolved Titanium (Ti)	mg/L	-	-	-	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
	Dissolved Uranium (U)	mg/L	-	-	-	0.00036	0.00065	0.00061	0.0025	0.00090
	Dissolved Vanadium (V)	mg/L	-	-	-	0.00050	< 0.00050	0.00092	0.00080	< 0.00050
	Dissolved Zinc (Zn)	mg/L	-	-	0.030	< 0.0010	0.0036	< 0.0010	< 0.0010	< 0.0010

Water use licence objectives exceeded.

Water quality guideline exceeded.

[1] CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. 1999 (plus updates), Canadian Council of Ministers of the Environment, Winnipeg. See Appendix Table B.6 for explanatory notes on selected water quality guidelines.

[a] Based on the median of background levels plus 5 mg/L for 30 day and 25 mg/L for max guidelines.

[b] Based on the median of background levels plus 2 NTU for 30 day and 8 NTU for max guidelines.

[c] Based on lowest guideline using highest temperature and pH.

[d] Based on lowest guideline using highest pH.

[e] Based on lowest guideline using lowest hardness.

[f] Based on the following formula using the lowest hardness: $e^{(0.736(\ln(\text{Hardness})-4.943)}$ (µg/L).

[g] Copper water quality objective depends on concentration of dissolved organic carbon (DOC). If DOC is > 10 mg/L/ DOC is ≤ 10 mg/L.

Mine) were above guideline at all areas including reference except for upper McGinty Creek (Table 3.1). Total copper was above guidelines but dissolved copper was below water quality objectives set out in the WUL (Appendix Table B.7).

Chlorophyll *α* data quality was assessed prior to data analysis and interpretation, and exceed the Data Quality Objective (DQO) for precision. This was considered when interpreting the data (Appendix A). Concentration of chlorophyll *α* in periphyton was higher at lower Minto Creek than at lower Wolverine Creek but not significantly (Figure 3.3). Mean chlorophyll *α* concentrations at both areas were below the British Columbia Water Quality Guideline (BCWQG) of 100 mg/m^2 for the protection of aquatic life (BCMOE 1985). Concentration at one station, LMC-3, was higher than guidelines but overall both areas were below guidelines and not significantly different from reference. Concentrations were higher in 2016 compared to previous years but there has been variability among stations and between areas (Appendix Figure B.1, B.2). In previous years, production of both creeks were classified as low (oligotrophic) based on the classification system of Dodds et al. (1998), which sets the oligotrophic-mesotrophic boundary for benthic chlorophyll *α* at 20 mg/m^2. Production in September 2016 was classified as eutrophic at lower Minto Creek (73 mg/m^2) and mesotrophic at lower Wolverine Creek (39 mg/m^2). Based on only total phosphorus, both creeks would be defined as oligotrophic as was observed in previous years (Dodds et al. 1998). While sampling it was noted that periphyton was more plentiful than in previous years. Since total phosphorus in water did not exceed guidelines and chlorophyll *α* was high at both areas, higher levels chlorophyll *α* could be related to natural variability (e.g., low flow) of periphyton production.

3.3 Summary

Supporting measures collected in September 2016 indicated good Minto Creek water quality. Influence of the Minto Mine was evident in higher specific conductance than in reference creeks, however, water quality parameters concentrations were lower than WUL water quality objectives. Concentrations of total copper at upper Minto Creek were higher than guidelines and the reference area but dissolved copper was not higher than the WUL water quality objectives. Moving downstream, total copper concentrations were elevated at lower Minto Creek but also at associated reference areas, indicating natural elevation and variability in the area. Mean concentrations of chlorophyll *α* were higher at both lower Minto and lower Wolverine creeks then in previous years but were not significantly different from each area or above guidelines. Production was increased compared to previous years at both the exposure and reference area as lower Minto Creek was defined as eutrophic and lower Wolverine was mesotrophic.

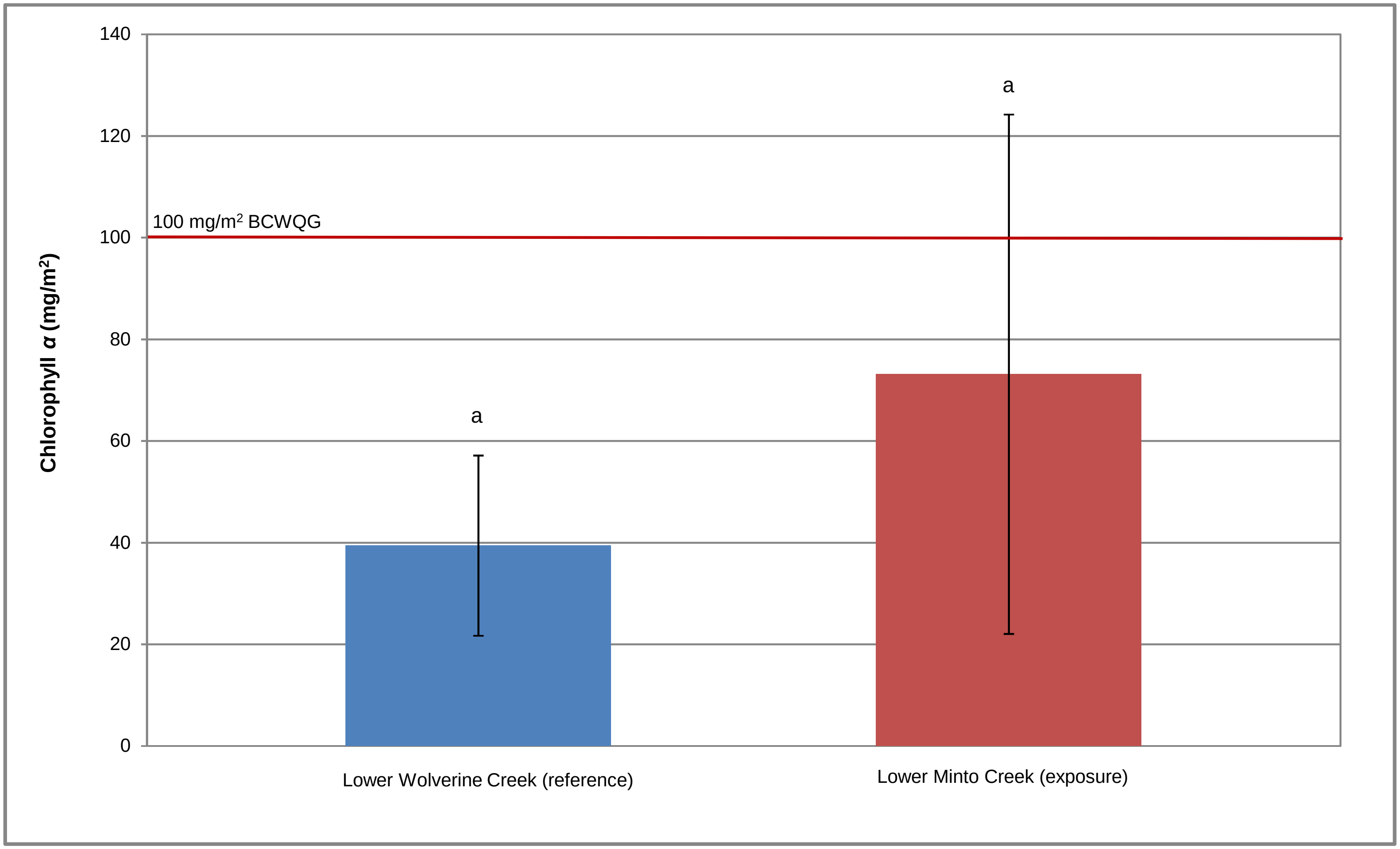

Figure 3.3: Concentrations of chlorophyll *α* in periphyton measured at five benthic stations in lower Wolverine and lower Minto Creeks, Minto Mine WUL, 2016. Data presented as mean ± standard deviation. Different letters represent significant differences between areas.

4.0 SEDIMENT QUALITY

4.1 Sediment Particle Size and Chemistry

Sediment data quality were assessed prior to data analysis and interpretation, and were judged to be of good quality (Appendix A). Sediments collected in 2016 were largely composed of fine particles in the silt and sand size categories (Figure 4.1; Table 4.1; Appendix Table C.1). Mean total organic carbon (TOC) content of sediment collected from upper Minto Creek (3.4%) and lower Minto Creek (6.2%) were lower than the comparable reference areas; upper McGinty Creek (5.3%) and lower Wolverine Creek (6.6%; Table 4.1). Arsenic and copper were the only analytes with mean concentrations greater than Interim Sediment Quality Guidelines for the protection of aquatic life (ISQG; CCME 1999) in an effluent-exposed area (upper and/or lower Minto Creek; Table 4.1; Appendix Table C.1). However, mean arsenic concentrations in upper Minto Creek was below ISQG and lower than the reference area, upper McGinty Creek (which was greater than ISQG). This suggests that arsenic concentrations were not mine-related. Mean copper concentrations in lower Minto Creek were greater than the ISQG and mean copper concentrations at upper Minto Creek were above the Probable Effect Level (PEL). Both areas had higher concentrations than the corresponding reference areas, which were lower than the ISQG (Figure 4.2; Table 4.1). With progression from upper to lower Minto Creek, sediment copper concentrations decreased from a mean of 216 to 72 mg/kg, respectively, indicating improvement with distance downstream.

Due to the predominantly erosional habitat in upper Minto Creek, there were relatively few areas where sediment was deposited and even this only occurs in small quantities that likely wash away each year during freshet. Therefore, elevated sediment copper in fine sediment in the upper reaches of Minto Creek may be of limited importance in terms of exposure and potential effects to biota. In lower Minto Creek, fine sediment deposits were somewhat more common and therefore more relevant to aquatic life.

4.2 Temporal Comparisons

Sediment particle size distribution in 2016 was similar to 2010-2015 but was notably different from data collected prior to 2010 which employed different sampling methodology (Figure 4.1). Mean concentration of copper in Minto Creek was compared to earlier data to detect any increasing or decreasing trends in sediment quality. Mean copper concentration at upper Minto Creek in 2016 was greater than the PEL, but was also greater than the ISQG in all previous years including the 1994 baseline (Figure 4.2). At lower Minto Creek, mean copper concentrations have been greater than guidelines during most of the sampling events, and the

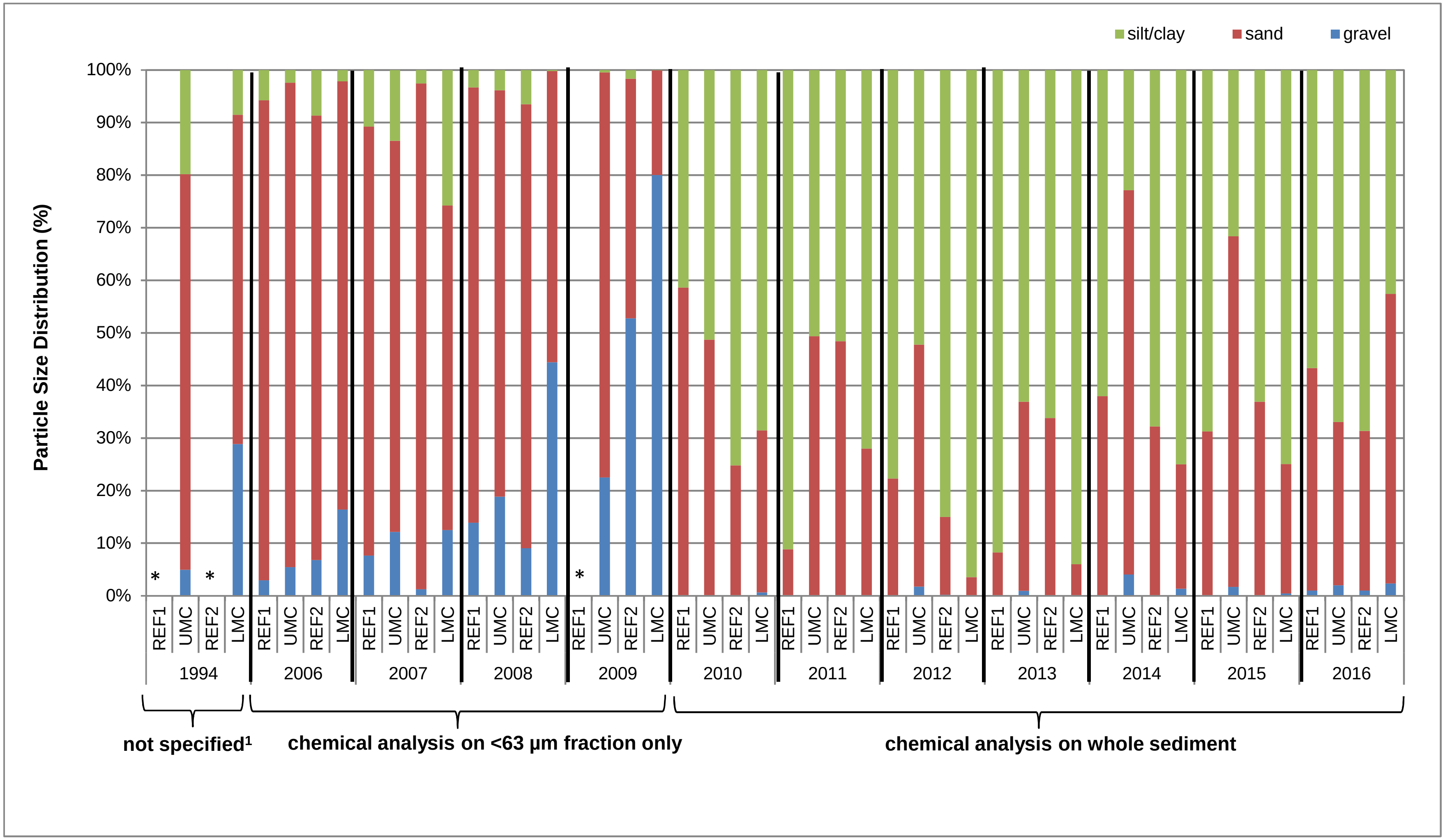

Figure 4.1: Particle size distribution of sediment collected in Minto Creek and reference locations, 1994-2016[a]

[1] Methods were not specified, fine sediment was collected in triplicate in the mainstem of Minto Creek (HKP 1994).

[a] REF1 = Station W6 (south-flowing tributary) in 2006 to 2008 and McGinty Creek in 2010 to 2016; UMC = Upper Minto Creek; REF2 = Station W7 (north-flowing tributary) in 2006 to 2009 and Wolverine Creek in 2010 to 2016; LMC = Lower Minto Creek.

[*] No data.

Table 4.1: Sediment chemistry data collected at exposed and reference areas, Minto Mine WUL, 2016[a].

	Analytes	Units	CSQG [1]		Upper McGinty Creek (Reference)				Upper Minto Creek (Exposure)				Lower Wolverine Creek (Reference)				Lower Minto Creek (Exposure)			
			ISQG	PEL	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
Particle size, TKN, carbon analytes and pH	Loss on Ignition	%	-	-	14	7.8	3.0	20	8.8	3.8	5.0	15	15	6.5	4.0	21	13	3.3	8.0	17
	pH (1:2 soil:water)	pH units	-	-	6.97	0.44	6.54	7.58	7.58	0.07	7.51	7.66	6.99	0.24	6.76	7.37	8.03	0.04	7.97	8.07
	% Gravel (>2mm)	%	-	-	-	-	-	-	-	-	-	-	2.0	2.2	< 1.0	6.0	< 1.0	-	< 1.0	< 1.0
	% Sand (2.0mm - 0.063mm)	%	-	-	-	-	-	-	-	-	-	-	31	22	8.6	58	31	6.7	22	38
	% Silt (0.063mm - 4um)	%	-	-	-	-	-	-	-	-	-	-	61	21	32	80	61	4.7	55	67
	% Clay (<4um)	%	-	-	-	-	-	-	-	-	-	-	6.7	3.1	3.7	12	8.7	2.5	4.8	11
	Total Kjeldahl Nitrogen	%	-	-	0.30	0.17	0.073	0.50	0.23	0.072	0.13	0.28	0.35	0.15	0.10	0.49	0.38	0.11	0.22	0.51
	Inorganic Carbon	%	-	-	0.16	0.080	0.072	0.29	0.17	0.029	0.15	0.22	0.16	0.051	0.077	0.20	0.26	0.068	0.17	**0.35**
	Inorganic Carbon (as CaCO3 Equivalent)	%	-	-	1.4	0.67	0.60	2.4	1.4	0.24	1.2	1.8	1.3	0.43	0.6	1.7	2.2	0.57	1.4	**2.9**
	Total Carbon by Combustion	%	-	-	5.5	3.1	1.4	10	3.5	1.3	2.2	4.9	6.8	3.0	1.8	9.2	6.5	1.8	3.7	8.8
	Total Organic Carbon	%	-	-	5.3	3.0	1.3	9.3	3.4	1.3	2.0	4.8	6.6	2.9	1.7	9.0	6.2	1.8	3.5	8.5
Total Metals	Aluminum (Al)	mg/kg	-	-	10,530	3,996	4,800	15,500	12,240	1,203	10,600	13,400	12,824	2,743	8,020	14,800	14,720	1,219	12,600	15,700
	Antimony (Sb)	mg/kg	-	-	0.39	0.14	0.19	0.56	0.51	0.058	0.45	0.59	0.43	0.084	0.28	0.49	0.59	0.065	0.48	0.65
	Arsenic (As)	mg/kg	5.9	17	7.2	1.9	4.6	10	5.9	0.33	5.5	6.3	6.3	1.4	4.8	8.2	8.8	1.0	7.1	9.7
	Barium (Ba)	mg/kg	-	-	207	77	100	309	225	38	181	266	194	55	97	235	289	40	221	321
	Beryllium (Be)	mg/kg	-	-	0.34	0.12	0.17	0.48	0.48	0.042	0.41	0.52	0.73	0.16	0.45	0.83	0.53	0.053	0.44	0.57
	Bismuth (Bi)	mg/kg	-	-	< 0.20	-	< 0.20	< 0.20	< 0.20	-	< 0.20	< 0.20	< 0.20	-	< 0.20	< 0.20	< 0.20	-	< 0.20	< 0.20
	Boron (B)	mg/kg			< 5.0	-	< 5.0	< 5.0	< 5.0	-	< 5.0	< 5.0	< 5.0	-	< 5.0	< 5.0	< 5.0	-	< 5.0	< 5.0
	Cadmium (Cd)	mg/kg	0.60	3.5	0.16	0.072	< 0.050	0.24	0.27	0.078	0.18	0.37	0.23	0.082	0.086	0.29	0.26	0.054	0.17	0.32
	Calcium (Ca)	mg/kg	-	-	7,906	2,407	3,840	10,200	8,944	1,145	7,460	10,400	10,078	2,645	5,490	12,300	13,120	1,445	10,600	14,200
	Chromium (Cr)	mg/kg	37	90	22	9.6	7.7	34	28	1.7	26	30	43	9.3	26	49	36	2.2	32	38
	Cobalt (Co)	mg/kg	-	-	9.1	2.8	4.5	12	11	0.87	9.8	12	12	2.0	9.1	14	12	1.1	10	13
	Copper (Cu)	mg/kg	36	197	21	9.5	7.2	33	**216**	93	**97**	**334**	27	7.9	13	32	**72**	8.4	**57**	**78**
	Iron (Fe)	mg/kg	-	-	23,840	7,534	12,700	31,300	25,380	1,386	23,800	26,800	27,080	4,070	20,500	30,600	29,700	1,899	26,400	30,900
	Lead (Pb)	mg/kg	35	91	4.6	1.6	2.2	6.5	6.3	0.58	5.8	7.0	6.0	1.2	3.8	6.9	6.8	0.42	6.1	7.1
	Lithium (Li)	mg/kg	-	-	6.9	2.2	3.6	9.5	8.7	0.92	7.5	9.5	9.6	1.9	6.4	11	12	0.86	10	12
	Magnesium (Mg)	mg/kg	-	-	3,846	1,197	1,920	5,130	6,636	518	5,980	7,140	8,220	1,345	5,860	9,090	7,246	544	6,300	7,640
	Manganese (Mn)	mg/kg	-	-	558	195	422	897	**2,336**	778	**1,370**	**3,280**	485	184	300	776	**1,485**	335	977	**1,830**
	Mercury (Hg)	mg/kg	0.17	0.49	0.055	0.027	0.015	0.087	0.043	0.010	0.029	0.050	0.086	0.046	0.024	0.15	0.077	0.023	0.054	0.11
	Molybdenum (Mo)	mg/kg	-	-	0.52	0.072	0.44	0.61	**2.1**	0.68	**1.2**	**2.7**	0.54	0.068	0.46	0.63	0.83	0.11	0.66	0.94
	Nickel (Ni)	mg/kg	-	-	16	5.7	7.3	23	28	2.3	25	31	35	6.2	24	38	31	3.0	25	32
	Phosphorus (P)	mg/kg	-	-	785	218	425	954	931	46	851	965	1,030	138	859	1,150	918	48	864	973
	Potassium (K)	mg/kg	-	-	690	223	370	930	1,648	243	1,300	1,920	984	161	720	1,130	1,450	114	1,250	1,520
	Selenium (Se)	mg/kg	-	-	0.48	0.17	0.22	0.66	0.67	0.27	0.39	**1.0**	0.39	0.11	< 0.20	0.47	0.82	0.20	0.53	**1.1**
	Silver (Ag)	mg/kg	-	-	0.10	0.0045	< 0.10	0.11	0.14	0.035	< 0.010	0.18	0.11	0.0084	< 0.10	0.12	0.13	0.018	< 0.10	0.14
	Sodium (Na)	mg/kg	-	-	203	63	111	265	353	13	335	370	421	30	386	447	340	20	306	358
	Strontium (Sr)	mg/kg	-	-	66	21	34	90	98	16	78	117	99	28	51	122	122	16	95	138
	Thallium (Tl)	mg/kg	-	-	0.069	0.020	< 0.050	0.096	0.096	0.012	0.081	0.11	0.086	0.0070	< 0.050	0.094	0.11	0.011	0.095	0.12
	Tin (Sn)	mg/kg	-	-	< 2.0	-	< 2.0	< 2.0	< 2.0	-	< 2.0	< 2.0	< 2.0	-	< 2.0	< 2.0	< 2.0	-	< 2.0	< 2.0
	Titanium (Ti)	mg/kg	-	-	582	181	315	780	735	29	699	769	800	84	680	916	715	24	689	749
	Uranium (U)	mg/kg	-	-	1.2	0.40	0.48	1.5	1.2	0.29	0.90	1.6	2.8	1.0	1.1	3.4	1.3	0.17	1.1	1.5
	Vanadium (V)	mg/kg	-	-	47	13	27	63	57	1.6	55	59	65	7.4	53	71	61	2.2	57	62
	Zinc (Zn)	mg/kg	123	315	41	14	20	56	68	10	54	78	53	8.5	39	59	63	5.4	54	67

Indicates sediment concentration exceeding CSQG ISQG.

Indicates sediment concentration exceeding CSQG PEL.

Bold Indicates sediment concentration exceeding higher reference mean by more than two times.

[a] If value was < method detection limit (MDL), summary statistics were calculated using 1x MDL (i.e. if result was < 0.048, summary statistics were calculated using the value 0.048).

[1] Canadian Sediment Quality Guidelines - ISQG = interim sediment quality guideline; PEL = probable effect level (CCME 1999).

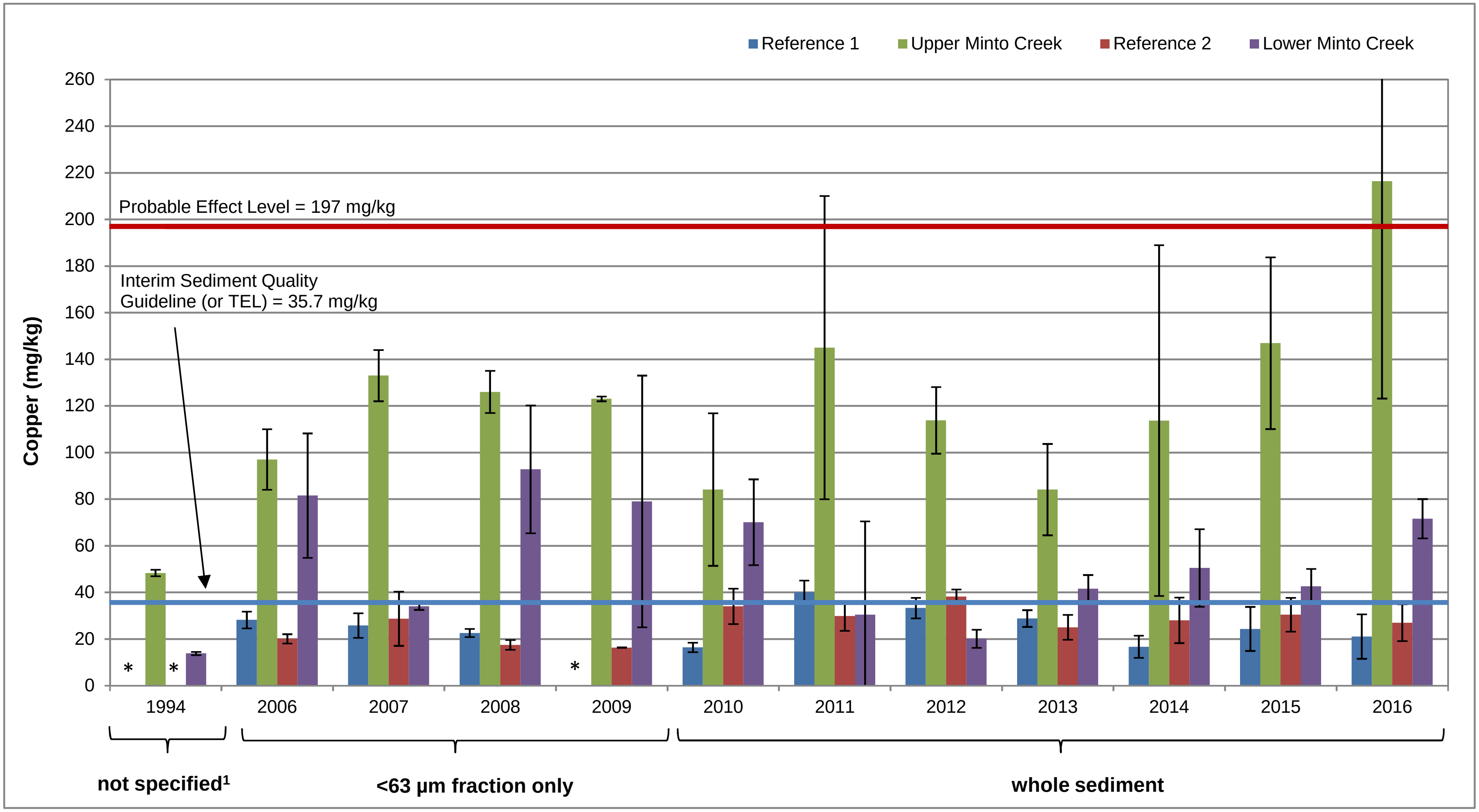

Figure 4.2: Copper (mean ± standard deviation) concentrations in sediment collected in Minto Creek and reference locations, 1994-2016[a].

[1] Methods were not specified, fine sediment was collected in triplicate in the mainstem of Minto Creek (HKP 1994).

[a] Reference 1 = Station W6 (south-flowing tributary) in 2006 to 2008 and McGinty Creek in 2010 to 2016; Reference 2 = Station W7 (north-flowing tributary) in 2006 to 2009 and Wolverine Creek in 2010 to 2016.

* = no data.

mean concentration observed in 2016 was similar to a number of previous years and greater than 1994 baseline (Figure 4.2; Table 4.1; Appendix Table C.1). This does not necessarily indicate a Minto Mine influence as concentrations were within the range of historical and the sampling methodology applied in 1994 was unspecified. The relationship between percent TOC and copper was evaluated and indicated a positive relationship (Appendix Figure C.1). Copper concentrations were normalized to percent TOC and lithium. Ratios of copper relative to TOC and lithium were consistent over the 2010-2016 period, further indicating that elevated copper showed no changes in mine influence over this period (Appendix Figure C.2, C.3).

4.3 Sediment Toxicity

Sediment toxicity tests and associated water quality parameters were all within the range outlined in the test protocols and testing was judged to be acceptable (Appendix A). Survival and growth the midge *Chironomus dilutus* was evaluated in 10-day tests, and survival and growth of the amphipod *Hyalella azteca* was evaluated in 14-day tests. Lower Minto Creek sediment did not result in any effects to survival or growth of either test organism relative to the laboratory control or the field reference sediment (lower Wolverine Creek; Table 4.2). In fact, growth of *C. dilutus* was greater in lower Minto Creek sediment than in the laboratory control sediment (sand) and reference sediment (Table 4.2). These results were similar to those of 2011 and 2015 (Minnow 2012, 2016b) and continue to indicate no adverse effects associated with lower Minto Creek sediment.

4.4 Summary

Overall, concentrations of metals in Minto Creek sediments were similar to reference and lower than sediment quality guidelines with the exception of copper. Concentrations of copper in Minto Creek (both upper and lower) were greater than the sediment quality guideline and reference. Copper concentrations in sediment was similar to results seen after the methodology change and lower than concentrations in 2008. Minto Creek sediment quality has not shown any trend over time based on temporal comparisons of absolute and normalized (to TOC and to lithium) concentrations. Sediment toxicity testing of *C. dilutus* and *H. azteca* indicated no adverse effects to survival or growth in lower Minto Creek sediment when compared to the laboratory control and the field reference (lower Wolverine Creek).

Table 4.2: Minto mine effluent sediment toxicity test results collected for lower Wolverine Creek and lower Minto Creek, September 2016.

Site	*Hyalella azteca*		*Chironomus dilutus*	
	Survival (%)	**Dry Weight (mg)**	**Survival (%)**	**Dry Weight (mg)**
Control Sediment	100 ± 0	0.24 ± 0.060	94 ± 8.9	2.35 ± 0.20
Lower Wolverine Creek	100 ± 0	0.30 ± 0.020	90 ± 7.1	2.65 ± 0.30
Lower Minto Cree	100 ± 0	0.31 ± 0.070	82 ± 16	3.39 ± 0.47

Significantly different than control sediment.

Significantly different than reference sediment.

5.0 PERIPHYTON COMMUNITY

5.1 Primary Metrics and Community Composition

Periphyton community data quality were assessed prior to data analysis and interpretation, and were judged to be of good quality (Appendix A). Analysis of the periphyton community based on cells/cm^2 indicated that four of the five periphyton community metrics (taxon richness, Simpson's Diversity, Simpson's Evenness and Bray-Curtis index) were significantly higher at lower Minto Creek than at lower Wolverine Creek (Table 5.1). Only density did not differ significantly between areas. This indicates that lower Minto Creek had higher diversity and different community structure than the reference areas.

Analysis of the periphyton community based on biomass (µg/cm^2) indicated that two out of five metrics (taxon richness and Bray-Curtis index) were significantly higher at lower Minto Creek compared to lower Wolverine Creek (Table 5.2). Both areas were diverse with similar taxon richness and dominated by Bacillariophycae (diatoms) but the community composition differed between each area (Table 5.2; Appendix Table D.2, D.4).

Dominant phyla in lower Minto and Wolverine creeks were Bacillariophycae and Cyanophyta (blue-green algae). Bacillariophycae were dominant at lower Minto Creek (68% of community) and lower Wolverine Creek (84% of the community; Figure 5.1). Little information is available regarding specific periphyton taxon group sensitivities and tolerances to mining activities to assist in interpretation (Deniseger et al. 1986; De Jonge et al. 2008).

5.2 Temporal Comparisons

Temporal variability in periphyton community composition was evident among samples taken in 1994 and 2011-2016 (Figure 5.1). For example, at lower Minto Creek, Bacillariophycae (diatom) were dominant in 1994, 2013, 2014, 2016; Rhodophyta (red algae) in 2012 and Cyanophyta (blue-green algae) in 2011, 2015 (Figure 5.1). This lack of temporal consistency was also observed at lower Wolverine Creek, with Cyanophyta dominant in 2011, 2013 and Bacillariophycae in 2012, 2014-2016 (Minnow 2013a; 2014, 2015b, 2016b).

5.3 Summary

Evaluation of periphyton community composition on the basis of density (cells/cm^2) and biomass (µg/cm^2) indicated significant differences in a number of metrics in lower Minto Creek relative to the lower Wolverine Creek reference. In general, lower Minto Creek was more diverse with more taxa than lower Wolverine Creek but the two areas had different community structures. However, differences in periphyton community summary metrics and community

Table 5.1: Statistical contrasts of periphyton density (cells/cm^2) community metrics between lower Wolverine Creek (reference) and lower Minto Creek (exposure) areas, Minto Mine WUL, 2016.

Metric	Significant Difference Between Areas? (p < 0.10)	Test Type	p-value	Mean Lower Wolverine Creek	Mean Lower Minto Creek	Mean Difference (LWC-LMC)	Power[1]	Magnitude of Difference (# of SDs)[2]	Minimum Detectable Effect Size[1] (# of SDs)[2]
Density (Log Transformation)	No	ANOVA	0.394	57,918	46,598	11,321	0.213	-	2.8
Number of Taxa	Yes	Mann-Whitney	0.073	13	15	-2.8	-	-	-
Simpson's Diversity	Yes	Mann-Whitney	0.016	0.48	0.76	-0.28	-	-	-
Simpson's Evenness	Yes	ANOVA	0.036	0.17	0.29	-0.12	0.740	2.4	-
Bray-Curtis Index	Yes	Mann-Whitney	0.009	0.24	0.92	-0.68	-	-	-

[shaded] Indicates p-value of < 0.10.

[1] Power and minimum detectable effect size were calculated using p = 0.10.

[2] Relative to reference standard deviations.

Table 5.2: Statistical contrasts of periphtyon biomass (µg/cm^2) community metrics between lower Wolverine Creek (reference) and lower Minto Creek (exposure) areas, Minto Mine WUL, 2016.

Metric	Significant Difference Between Areas? (p < 0.1)	Test Type	p-value	Mean Lower Wolverine Creek	Mean Lower Minto Creek	Mean Difference (LWC-LMC)	Power[1]	Magnitude of Difference (# of SDs)[2]	Minimum Detectable Effect Size[1] (# of SDs)[2]
Density (Square Root Transformation)	No	ANOVA	0.810	32	30	2.4	0.109	-	3.2
Number of Taxa	Yes	Mann-Whitney	0.073	13	15	-2.8	-	-	-
Simpson's Diversity	No	ANOVA	0.584	0.70	0.74	-0.039	0.146	-	2.8
Simpson's Evenness	No	ANOVA	0.754	0.28	0.30	-0.022	0.115	-	3.8
Bray-Curtis Index	Yes	ANOVA	0.004	0.41	0.78	-0.37	0.980	2.0	-

Indicates p-value of < 0.10.

[1] Power and minimum detectable effect size were calculated using p = 0.10.

[2] Relative to reference standard deviations.

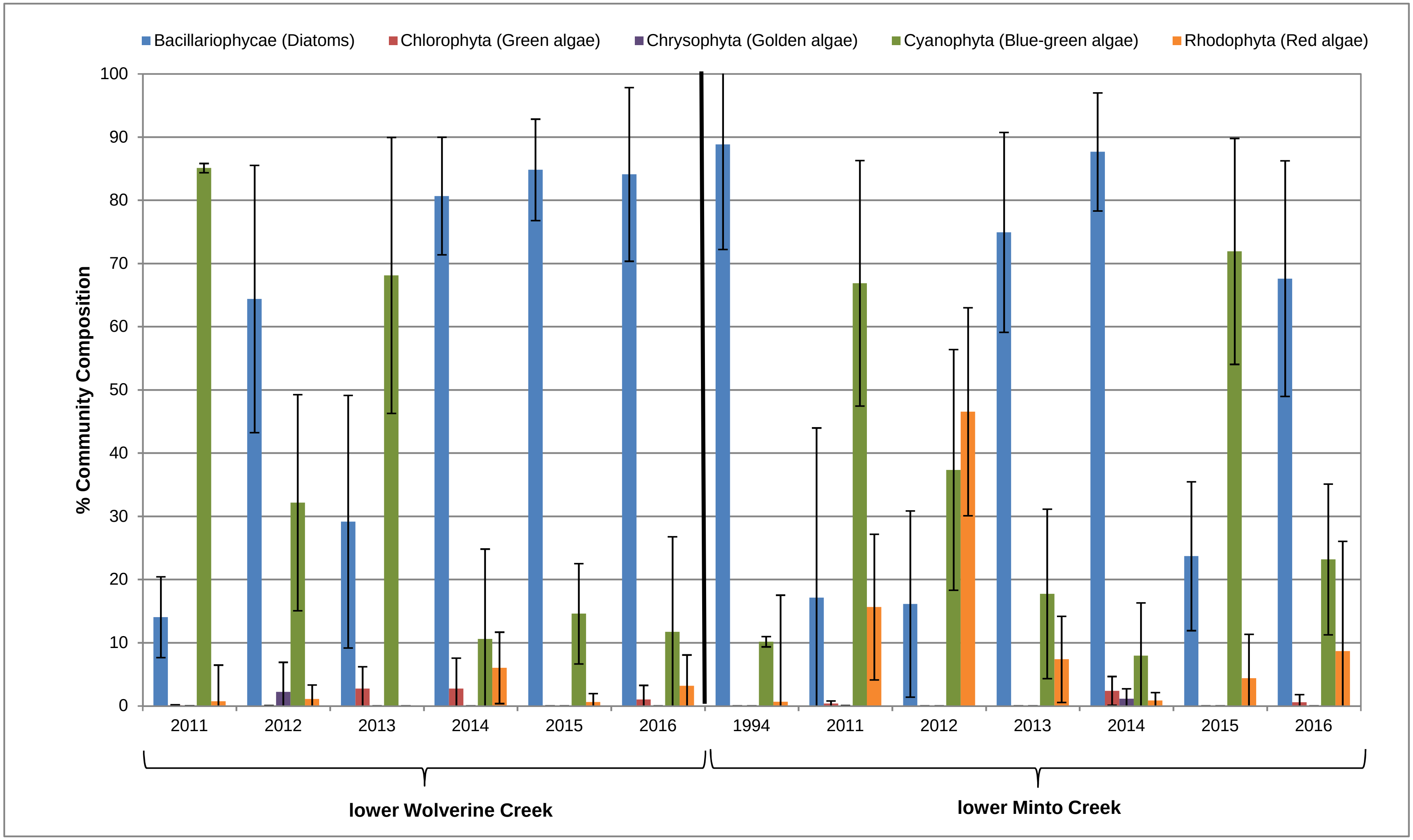

Figure 5.1: Periphyton community (cells/cm^2) composition in lower Minto Creek (1994, 2011-2016) and lower Wolverine Creek (2011-2016). Data presented as mean ± standard deviation.

composition were apparent among years at both lower Minto Creek and lower Wolverine Creek, indicating substantial temporal variability. The differences observed in the periphyton communities of lower Minto Creek and lower Wolverine Creek in 2016 were within natural temporal variability and do not provide any resolution of potential mine influence.

6.0 BENTHIC INVERTEBRATE COMMUNITY

6.1 Primary Metrics and Community Composition

Benthic invertebrate community data quality were assessed prior to data analysis and interpretation, and were judged to be of good quality (Appendix A). The benthic invertebrate community of lower Minto Creek differed significantly from both lower Wolverine Creek and lower Big Creek on the basis of two metrics: Simpson's Diversity and Bray-Curtis index (Table 6.1). Density and taxon richness were only significantly lower at lower Minto Creek (307; 19) compared to lower Big Creek (735; 33) and did not differ significantly from lower Wolverine Creek (226; 24; Table 6.1; Figure 6.1). Simpson's Diversity of lower Minto Creek was significantly different than both reference areas but the responses were in opposite directions (Table 6.1). Bray-Curtis index (compared to combined reference areas) was significantly greater at lower Minto Creek (0.86) when compared to lower Wolverine Creek (0.38) and lower Big Creek (0.65; Table 6.1; Figure 6.1). This, as well as significant differences between reference areas suggest a limited mine influence (Table 6.1, Table E.3).

Dominant taxonomic groups in lower Minto, lower Wolverine and lower Big creeks included EPT taxa, chironomids (non-biting midges) and oligochaetes (worms; only dominant at reference areas). Consistent with Bray-Curtis index results, communities differed among areas. Percent EPT did not differ significantly among areas but differences were seen with abundances of chironomids and oligochaetes (Figure 6.2; Table 6.1; Appendix Table E.1, E.2). The relative abundance of chironomids was significantly greater at lower Minto Creek (61%) compared to lower Wolverine (12%) and lower Big (38%) creeks (Figure 6.2; Table 6.1; Appendix Table E.1, E.2). Oligochaetes were a small proportion of the community at lower Minto Creek (3.9%) compared to higher proportions at lower Wolverine (44%) and lower Big (24%) creeks. The higher proportion of chironomids suggest a mine influence, but in combination with the lower presence of oligochaetes together with EPT taxa not being significantly different between areas suggest limited influence of the mine on the benthic invertebrate community (Chapman et al. 1982a,b; Rosenberg and Resh 1993; Taylor and Bailey 1997).

Correspondence Analysis (CA) explained 57.8 percent of the total community variance in the first two CA axes (Appendix Table E.6). The first CA axis explained 33.6 percent of the total inertia (variation) in the original benthic abundance data, and clearly and significantly separated lower Minto Creek from lower Wolverine and lower Big creeks (Figure 6.3; Table 6.1). Lower Minto Creek had strong positive CA Axis-1 scores, indicating high relative abundance of the Plecoptera Nemouridae and chironomids *Orthocladius*, *Micropsectra* and

Table 6.1: Summary of benthic invertebrate community metrics and statistical comparisons, Minto Mine WUL, 2016.

Metric	Comparison		Area Means		Statistical Contrasts		
	Exposure Site	Reference Site			Significant Difference between areas?	Direction	p-value
Density (organisms/m^2)	lower Minto Creek	lower Wolverine Creek	307	226	NO	-	1.000
		lower Big Creek		735	YES	Minto < Big	0.025
Number of Taxa	lower Minto Creek	lower Wolverine Creek	19	24	NO	-	0.217
		lower Big Creek		33	YES	Minto < Big	0.001
Simpson's Diversity[1]	lower Minto Creek	lower Wolverine Creek	0.79	0.73	YES	Minto > Wolverine	0.056
		lower Big Creek		0.87	YES	Minto < Big	0.016
Simpson's Evenness[1]	lower Minto Creek	lower Wolverine Creek	0.26	0.21	NO	-	1.000
		lower Big Creek		0.26	NO	-	1.000
BC Index to Combined Reference Median	lower Minto Creek	lower Wolverine Creek	0.86	0.38	YES	Minto > Wolverine	0.009
		lower Big Creek		0.65	YES	Minto > Big	0.016
EPT (%)[2]	lower Minto Creek	lower Wolverine Creek	27	33	NO	-	1.000
		lower Big Creek		25	NO	-	1.000
Chironomids (%)	lower Minto Creek	lower Wolverine Creek	61	12	YES	Minto > Wolverine	< 0.001
		lower Big Creek		38	YES	Minto > Big	0.042
Oligochaetes (%)	lower Minto Creek	lower Wolverine Creek	3.9	44	YES	Minto < Wolverine	0.001
		lower Big Creek		24	YES	Minto < Big	0.020
CA Axis-1 (33.6%)	lower Minto Creek	lower Wolverine Creek	235	-105	YES	Minto > Wolverine	< 0.001
		lower Big Creek		-68	YES	Minto > Big	< 0.001
CA Axis-2 (24.2%)	lower Minto Creek	lower Wolverine Creek	18	170	YES	Minto < Wolverine	< 0.001
		lower Big Creek		-40	NO	-	0.323

Indicates a statistically significant difference between exposed and reference areas, p = 0.10.

[1] Calculated as recommended by Environment Canada 2012.

[2] Percent Ephemeroptera (mayfly), Plecoptera (stonefly), Trichoptera (caddisfly).

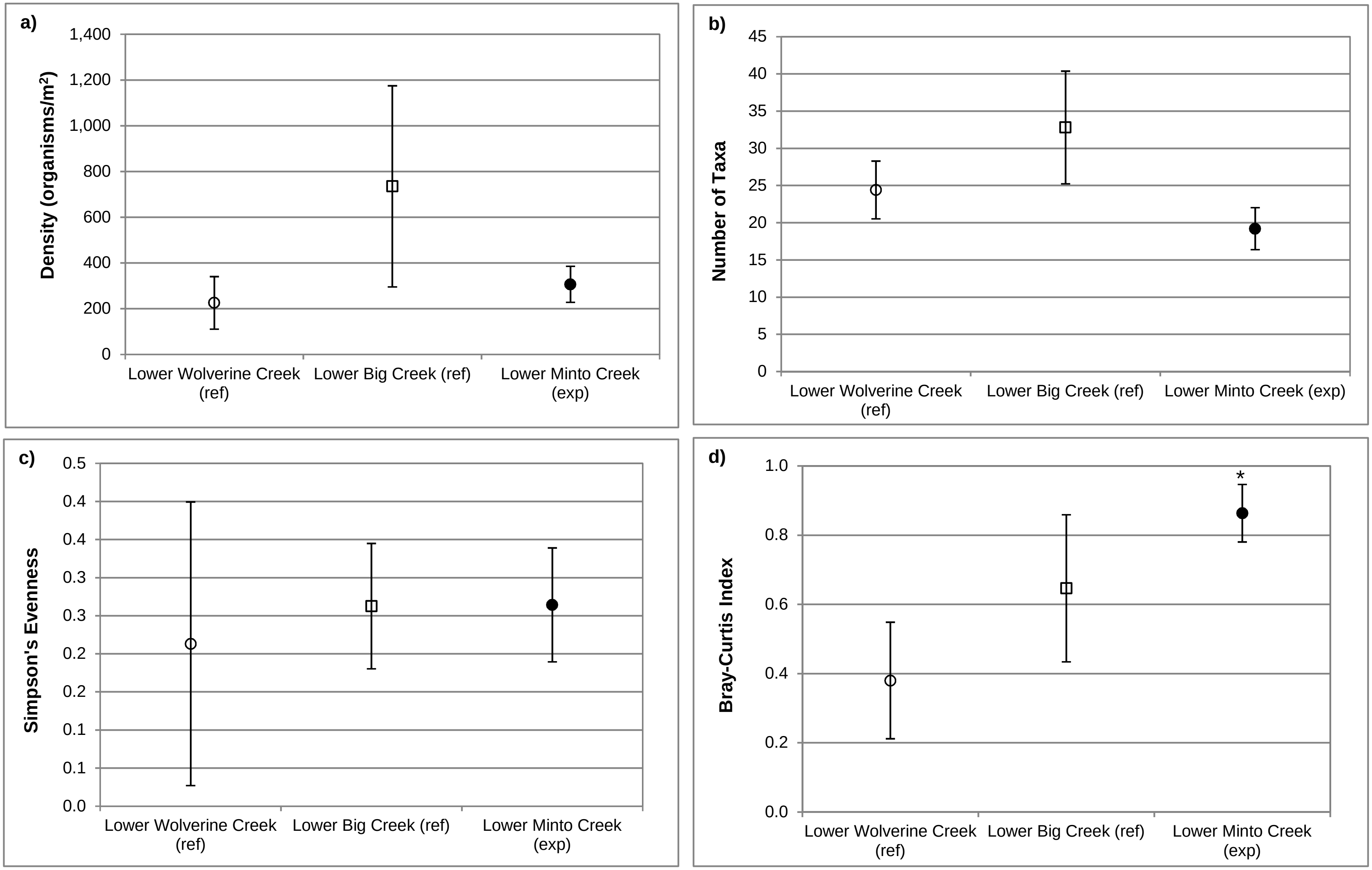

Figure 6.1: Comparison (mean ± 95% confidence intervals; n = 5 in all areas) of benthic invertebrate a) density, b) number of taxa, c) Simpson's Evenness and d) Bray-Curtis index, Minto Mine WUL, 2016. An asterisk (*) above lower Minto Creek indicates exposure area was significantly different ($p < 0.10$) from both reference areas.

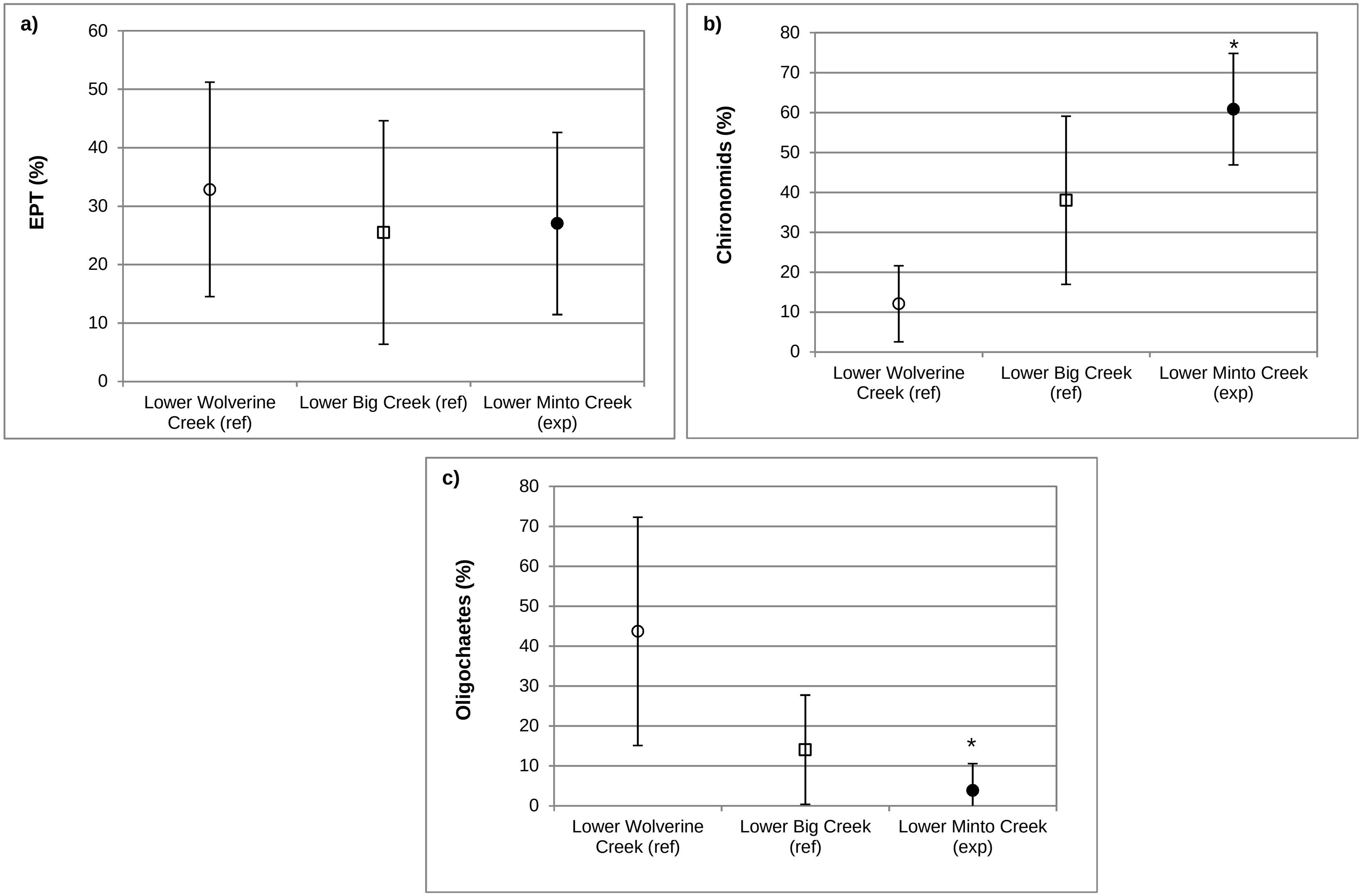

Figure 6.2: The relative abundance as percent of total organisms in an area for a) EPT, b) Chironomids and c) Oligochaetes, Minto Mine WUL, 2016. Data represents area means and 95% confidence intervals (n = 5 in all areas). An asterisk (*) above lower Minto Creek indicates exposure area was significantly different ($p < 0.1$) from both reference areas.

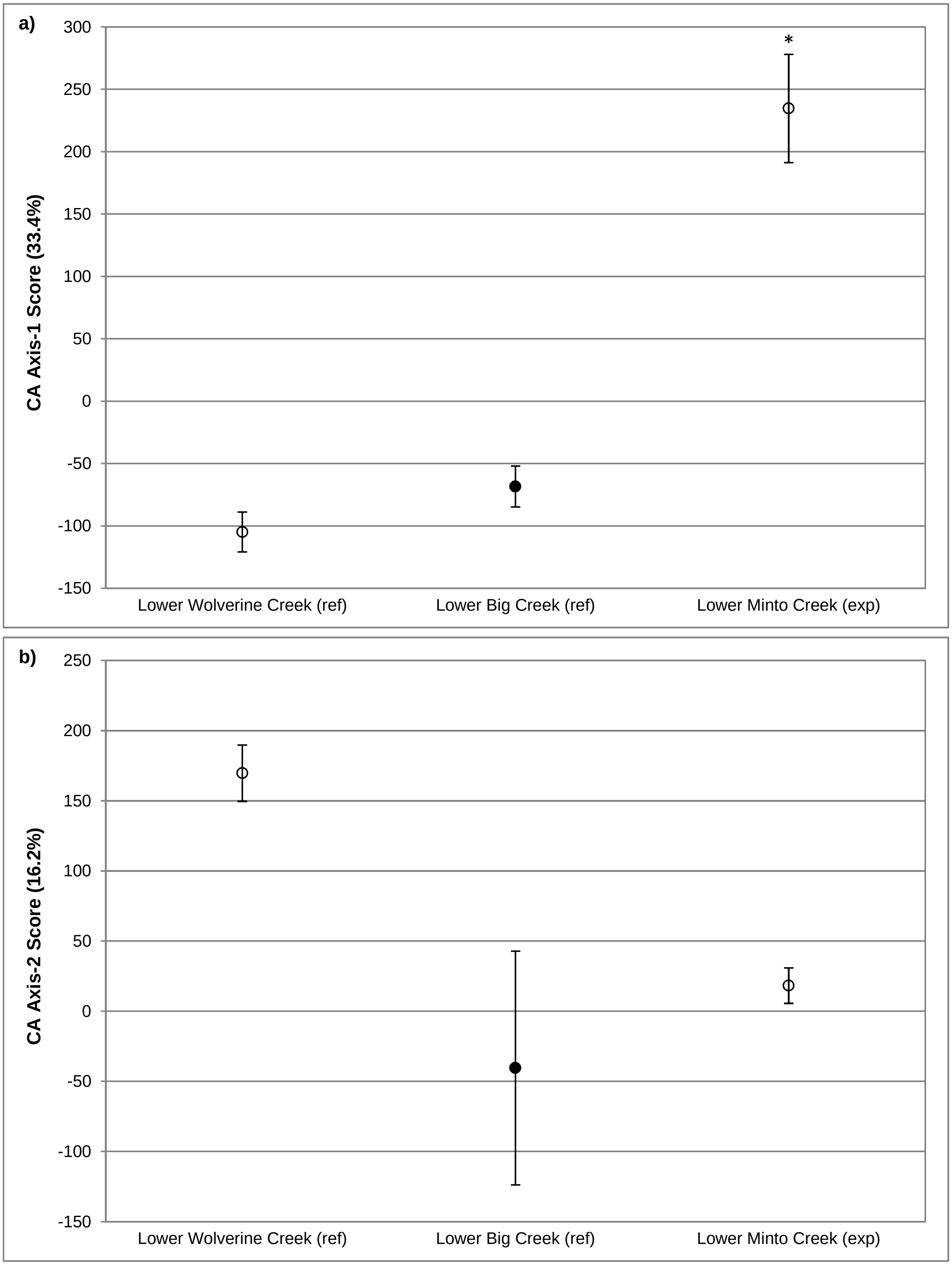

Figure 6.3: Comparison (mean ± 95 % confidence interval) of a) CA Axis-1 and b) CA Axis-2, Minto Mine, 2016. An asterisk (*) above lower Minto Creek indicates exposure area was significantly different ($p < 0.1$) from both reference areas.

Eukiefferiella (Appendix Table E.5, E.6). Lower Wolverine Creek had strong negative CA Axis-1 scores and was dominated by the oligochaete Lumbriculidae, the Plecoptera Chloroperlidae and the Trichoptera *Rhyacophila* (Appendix Table E.5, E.6). Lower Big Creek had negative CA Axis-1 scores but the scores were not significant (Appendix Table E.5, E.6). The subsequent axes of the correspondence analysis summarized within-area variability and did not show further dimensions of significant difference among creeks (Table 6.1; Figure 6.3).

6.2 Correlation Analysis

Correlation analysis between 10 benthic indices and four supporting measurements resulted in 11 significant correlations at a p-level of 0.050, of which five were significant at the Bonferroni-corrected p-level of 0.0013 (Table 6.2). It is important to consider that illustration of a significant or suggestive degree of correlation between two variables does not necessarily imply a cause-and-effect relationship, although it is cause to investigate further and to consider known biological responses to environmental change.

Of the five correlations significant at the Bonferroni-corrected p-level, four were correlated with specific conductance (Table 6.2; Figure 6.4). Bray-Curtis index, percent chironomids and CA Axis-1 were positively correlated with specific conductance, while percent oligochaetes was negatively correlated with specific conductance (Table 6.2; Figure 6.4). CA Axis-2 scores were positively correlated with temperature (Table 6.2; Figure 6.4). High specific conductance suggests an influence of the Minto Mine on lower Minto Creek but the CA Axis-1 score indicates a high proportion of chironomids of the following genus: *Orthocladius*, *Micropsectra* and *Eukiefferiella*. Abundance of chironomid taxa are associated with tolerance but these genus can be associated with very good to fair water quality in terms of organic pollution (Mandeville 2002). Abundances of these organisms at lower Minto Creek may not suggest poorer water quality.

6.3 Temporal Comparisons

Temporal comparisons of the benthic invertebrate community condition of lower Minto Creek were made in order to augment data interpretation, but their power was tempered by temporal changes in sampling location, sampling methodology, level of replication and analytical processing techniques. For example, 1994 baseline data were collected near the mouth of Minto Creek as three single grab samples, 2006 data were collected at Station W2 in the same manner, 2008 and 2010 data were collected at Station W2 as three-grab composites whereas 2011-2016 data were collected as five replicate three-grab samples from a large area upstream of Station W2. Only in the later years (2011-2016) do data represent an area (i.e., lower Minto Creek) rather than a station. In addition, data collected in 2013-2016 were sieved

Table 6.2: Correlations between benthic metrics and supporting environmental measurements at Minto Mine WUL, 2016.

		Depth (m)	Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (%)
Density (organisms/m^2)	Pearson Correlation	0.212	0.53	-0.16	0.49
	Sig. (2-tailed)	0.448	0.041	0.576	0.064
	N	15	15	15	15
Number of Taxa	Pearson Correlation	0.39	0.26	-0.57	0.37
	Sig. (2-tailed)	0.151	0.342	0.028	0.171
	N	15	15	15	15
Simpson's Diversity	Pearson Correlation	0.29	0.354	0.11	0.371
	Sig. (2-tailed)	0.293	0.195	0.692	0.173
	N	15	15	15	15
BC Index to Combined Reference Median	Pearson Correlation	-0.44	0.59	0.76	0.08
	Sig. (2-tailed)	0.101	0.021	0.001	0.769
	N	15	15	15	15
Chironomids (%)	Pearson Correlation	-0.443	0.49	0.77	0.27
	Sig. (2-tailed)	0.098	0.061	0.001	0.336
	N	15	15	15	15
Oligochaetes (%)	Pearson Correlation	0.47	-0.44	-0.839	0.10
	Sig. (2-tailed)	0.078	0.102	0.000	0.720
	N	15	15	15	15
Ephemeroptera (%)	Pearson Correlation	0.44	-0.15	-0.69	0.19
	Sig. (2-tailed)	0.100	0.595	0.005	0.504
	N	15	15	15	15
Trichoptera (%)	Pearson Correlation	0.07	-0.48	-0.39	-0.40
	Sig. (2-tailed)	0.793	0.072	0.146	0.141
	N	15	15	15	15
CA Axis-1 (33.6%)	Pearson Correlation	-0.677	0.34	0.97	-0.14
	Sig. (2-tailed)	0.006	0.211	0.000	0.630
	N	15	15	15	15
CA Axis-2 (24.2%)	Pearson Correlation	-0.04	-0.76	-0.39	-0.60
	Sig. (2-tailed)	0.886	0.001	0.156	0.018
	N	15	15	15	15

(blue) Correlation scatterplot inspected: $p < 0.050$.

(orange) Significant after Bonferroni correction; $p < 0.0013$ ($p = 0.050$ adjusted for 40 comparisons).

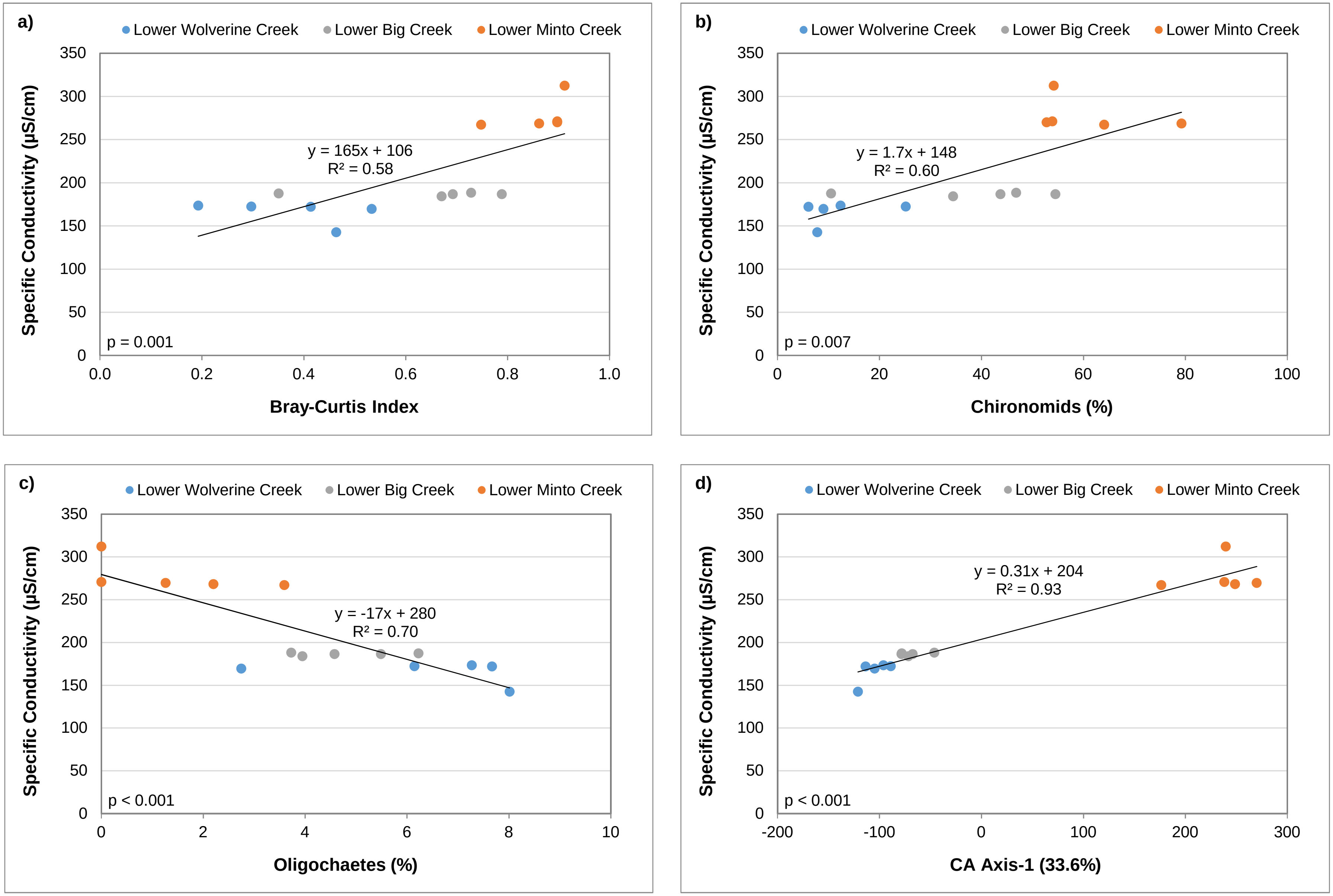

Figure 6.4: Scatterplots of significant relationships (Bonferroni corrected; $p < 0.0013$), between specific conductivity and a) Bray-Curtis Index, b) chironomids, c) oligochaetes and d) CA Axis-1, Minto Mine WUL, 2016.

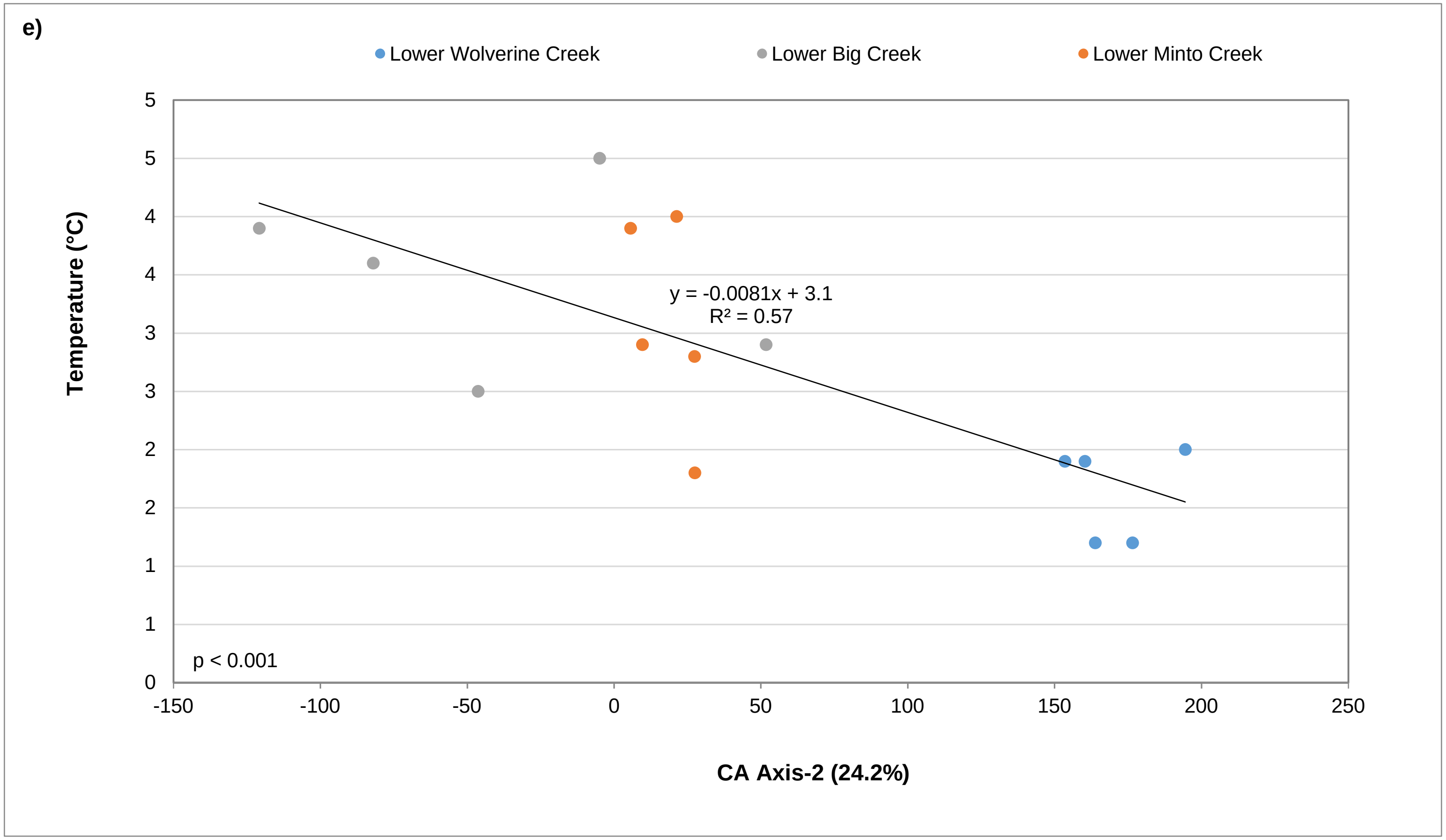

Figure 6.4: Scatterplots of significant relationships (Bonferroni corrected; $p < 0.0013$), between temperature and e) CA Axis-2, Minto Mine WUL, 2016.

using 500 µm mesh, whereas all years prior to 2011 used smaller mesh (both 250 µm and 500 µm were used in 2012 to assist in transition). This was expected to result in lower densities in 2013 and later.

Benthic invertebrate density at lower Minto Creek in 2016 was lower than in 2014 and 2015 but higher than in 2013 (Figure 6.5). Number of taxa at lower Minto Creek in 2016 was within the historical range from 2006 onwards, but moderately lower than in 1994 (Figure 6.5). Lastly, Simpson's Evenness was within the historical range documented after methodological change in 2011 (Figure 6.5). Over the 2012-2016 period benthic invertebrate community metrics parameters were stable, any differences between this time period and earlier sampling was more likely due to a change in mesh size of the Hess sampler, with 2012 used as a bridge.

6.4 Summary

The erosional benthic invertebrate community of lower Minto Creek did not differ from reference, or was intermediate between references, on the basis of all metrics except Bray-Curtis index, which was greater at lower Minto Creek than both reference areas. A potential decrease in number of taxa from 2012-2014 identified was not supported by the higher number of taxa in 2015 and 2016 and appears to represent natural variability (Minnow 2015b, 2016b). This lack of a clear pattern and only one significant difference shown between references areas suggest limited mine.

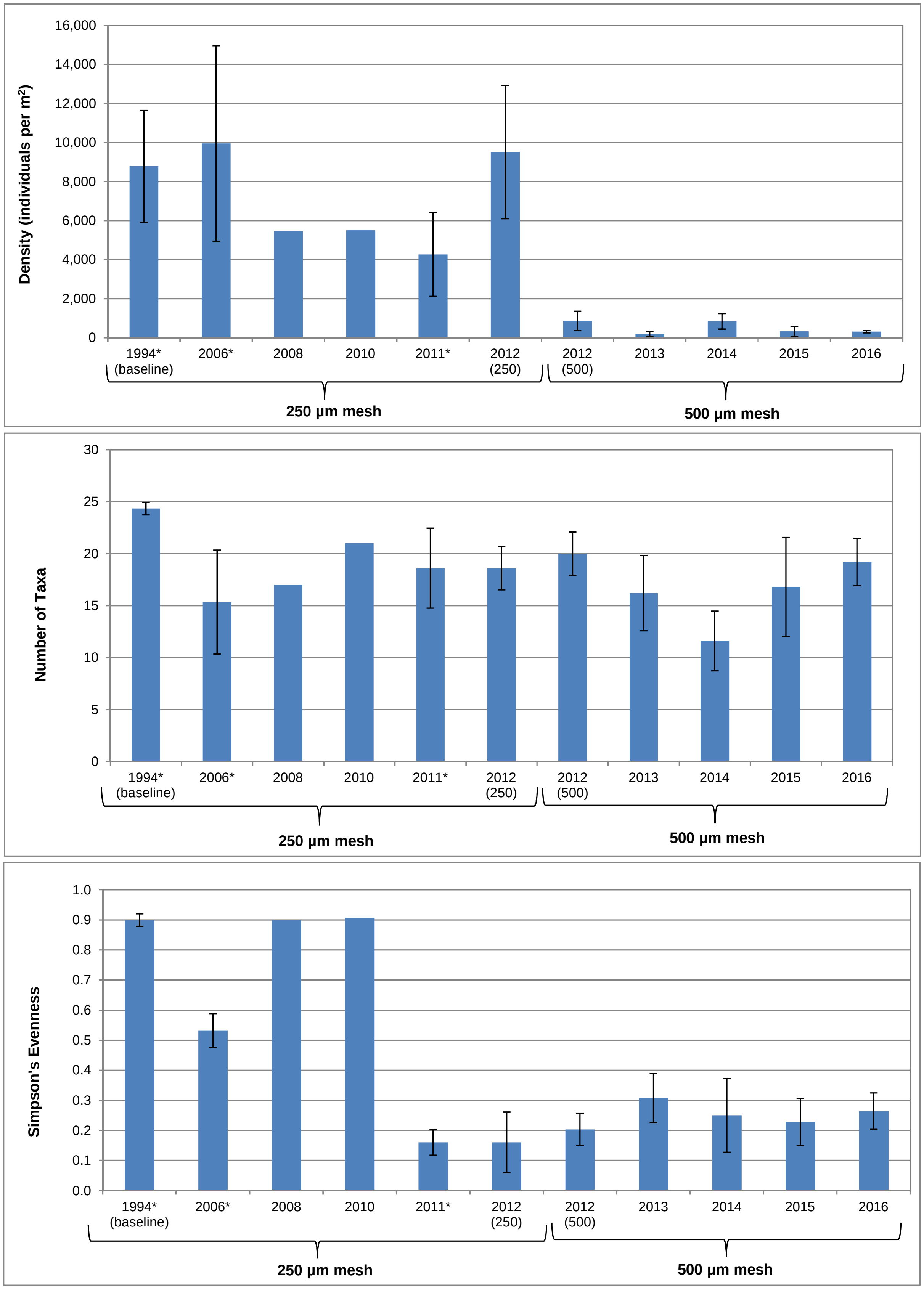

Figure 6.5: Primary benthic invertebrate community metrics at lower Minto Creek, 1994-2016. Data presented as mean ± standard deviation where replicated. Asterisk (*) indicates a year the mine was not discharging.

7.0 TISSUE CHEMISTRY

As indicated in Section 2.5, tissue chemistry data are provided here simply to report the ancillary data that were collected along with the selenium data reported under separate cover. Data interpretation were therefore limited to basic comparisons of metal concentrations in tissue collected at the exposure area (lower Minto Creek) to those collected at reference creeks (lower Wolverine and lower Big creeks).

7.1 Periphyton Tissue

Periphyton tissue data quality were assessed prior to data analysis and interpretation and were judged to be of good quality (Appendix A). Mean concentrations of barium, boron and selenium were the only analytes at lower Minto Creek that were significantly greater than both reference areas (Table 7.1; Appendix Table C.2). There were no significant differences between areas for selenium in 2013 (Minnow 2014), whereas in 2014-2016, periphyton selenium concentrations were significantly greater at lower Minto Creek than at the reference areas (Minnow 2015b). Significantly higher concentrations of selenium at lower Minto Creek compared to reference areas over the last three years could indicate an influence of the mine on Minto Creek.

7.2 Benthic Invertebrate Tissue

Benthic invertebrate tissue data quality were assessed prior to data analysis and interpretation and were judged to be of good quality, with the exception that data precision was hard to judge as there were issues with homogenization of some samples (Appendix A). There were five analytes (antimony, bismuth, boron, selenium and thallium) at lower Minto Creek that were significantly different from both reference areas (Table 7.1; Appendix Table C.3), but only selenium has been identified as strongly mine-related (Sections 3.0 and 4.0). Selenium at lower Minto Creek was significantly lower than at lower Wolverine Creek but significantly higher than lower Big Creek (Table 7.1; Appendix Table C.3). Concentration of copper at lower Minto Creek was significantly higher than at lower Wolverine Creek but was not significantly different than lower Big Creek. Variability in concentrations of copper in benthic invertebrate tissue has been high among years. In 2013, copper was significantly higher in benthic invertebrates from lower Minto Creek compared to lower Wolverine Creek, but in 2014 and 2015 copper did not differ significantly among areas. This lack of consistency suggests that the observed differences likely represent natural variability.

Table 7.1: Periphyton and benthic invertebrate tissue chemistry results, Minto Mine WUL, September 2016[a].

Analyte	Units	Periphyton						Benthic Invertebrates					
		Lower Wolverine Creek (Reference)		Lower Big Creek (Reference)		Lower Minto Creek (Exposed)		Lower Wolverine Creek (Reference)		Lower Big Creek (Reference)		Lower Minto Creek (Exposed)	
		n = 5		n = 5		n = 5		n = 5		n = 5		n = 5	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Aluminum (Al)	mg/kg dwt	15,088	2,705	10,967	2,278	13,226	4,348	1,762	784	2,516	462	1,924	507
Antimony (Sb)[1,2]	mg/kg dwt	0.037	0.0085	0.16	0.050	0.061	0.051	0.063	0.043	0.28	0.032	0.10	0.010
Arsenic (As)	mg/kg dwt	5.1	0.65	23	5.7	10	3.1	1.5	0.73	9.6	2.07	2.1	0.27
Barium (Ba)	mg/kg dwt	212	31	186	36	530	213	51	11	67	8.2	74	19
Beryllium (Be)[3]	mg/kg dwt	0.65	0.068	0.48	0.089	0.47	0.13	0.13	0.058	0.16	0.030	0.078	0.017
Bismuth (Bi)[1,2]	mg/kg dwt	0.084	0.012	0.93	0.31	0.11	0.032	0.010	0.0015	0.35	0.066	0.029	0.014
Boron (B)[2]	mg/kg dwt	3.5	1.3	3.4	0.85	6.5	1.7	0.69	0.061	1.9	0.45	2.7	0.59
Cadmium (Cd)	mg/kg dwt	0.17	0.019	0.19	0.044	0.34	0.15	0.26	0.092	0.66	0.45	0.24	0.012
Calcium (Ca)	mg/kg dwt	9,073	1,127	6,828	1,138	12,047	3,665	2,817	744	2,897	499	2,783	448
Cesium (Cs)	mg/kg dwt	1.4	0.38	2.3	0.49	0.95	0.42	0.17	0.054	0.73	0.16	0.22	0.044
Chromium (Cr)[4]	mg/kg dwt	42	8.3	25	4.8	31	9.3	9.4	2.4	12.1	1.5	10	5.7
Cobalt (Co)	mg/kg dwt	13	1.4	8.4	1.3	16	5.1	2.5	0.92	3.3	0.92	2.0	0.46
Copper (Cu)[1,2]	mg/kg dwt	22	3.4	35	6.4	45	16	15	1.6	28	7.2	23	2.7
Iron (Fe)[1]	mg/kg dwt	26,360	3,728	20,693	3,099	26,625	8,297	4,562	1,652	5,803	1,125	4,745	1,205
Lead (Pb)[1]	mg/kg dwt	5.4	0.68	7.8	1.3	5.6	1.6	0.77	0.21	2.7	0.67	1.1	0.25
Lithium (Li)	mg/kg dwt	11	1.3	8.5	1.5	11	2.4	1.8	1.11	2.0	0.48	1.5	0.41
Magnesium (Mg)	mg/kg dwt	9,740	1,134	6,053	957	7,157	1,925	2,116	513	2,132	220	1,758	329
Manganese (Mn)	mg/kg dwt	860	170	626	136	6,780	5,703	385	147	314	77	430	92
Mercury (Hg)[1,5]	mg/kg dwt	0.038	0.013	0.072	0.081	0.033	0.015	0.017	0.0065	0.024	0.0058	0.018	0.0050
Molybdenum (Mo)	mg/kg dwt	0.38	0.044	1.2	0.30	0.97	0.34	1.0	0.10	1.1	0.24	0.91	0.12
Nickel (Ni)	mg/kg dwt	38	4.0	21	3.5	31	6.1	7.8	2.3	8.4	0.74	6.6	2.3
Phosphorus (P)[1]	mg/kg dwt	1,198	142	971	115	1,254	227	6,982	664	5,837	489	6,799	352
Potassium (K)[3]	mg/kg dwt	1,156	291	1,590	376	1,781	922	6,240	551	6,146	657	6,806	649
Rubidium (Rb)[4]	mg/kg dwt	13	3.1	13	2.7	12	5.0	2.4	0.37	5.0	1.2	3.6	0.44
Selenium (Se)	mg/kg dwt	0.47	0.13	0.31	0.090	1.2	0.44	4.5	0.13	1.1	0.28	1.9	0.27
Sodium (Na)	mg/kg dwt	391	62	331	51	302	71	2,129	110	2,474	429	2,624	146
Strontium (Sr)	mg/kg dwt	82	8.4	66	14	120	40	27	3.1	28	3.0	25	4.0
Tellurium (Te)	mg/kg dwt	0.022	0.0070	0.065	0.019	0.031	0.015	< 0.013	-	0.027	0.0043	< 0.016	-
Thallium (Tl)[2]	mg/kg dwt	0.082	0.019	0.11	0.026	0.094	0.038	0.010	0.0021	0.035	0.0052	0.017	0.0029
Tin (Sn)[1,2]	mg/kg dwt	0.58	0.17	0.49	0.10	0.49	0.24	1.7	0.39	2.9	0.96	3.8	1.6
Uranium (U)[1]	mg/kg dwt	1.1	0.11	1.2	0.26	0.83	0.38	0.65	0.30	1.0	0.38	0.27	0.052
Vanadium (V)[1]	mg/kg dwt	57	10	47	7.6	53	15	11	3.9	12	1.8	8.9	2.4
Zinc (Zn)[1]	mg/kg dwt	60	9.5	56	8.4	62	18	83	13	79	19	106	17
Zirconium (Zr)	mg/kg dwt	13	1.8	7.5	1.2	9.9	2.2	2.4	0.60	3.0	0.32	2.0	0.44

Indicates a mean concentration in lower Minto Creek that is significantly different than the mean concentration in lower Wolverine Creek (ANOVA; p = 0.050).

Indicates a mean concentration in lower Minto Creek that is significantly different than the mean concentration in lower Big Creek (ANOVA; p = 0.050).

[1] Periphyton tissue data were normalized by log transformation (ANOVA, p = 0.050).

[2] Benthic invertebrate tissue data were normalized by log transformation (ANOVA, p = 0.050).

[3] Periphyton tissue data were normalized by inverse transformation (ANOVA, p = 0.050).

[4] Benthic invertebrate tissue data were normalized by inverse transformation (ANOVA, p = 0.050).

[5] Benthic invertebrate tissue data could not be normalized, therefore a non-parametric Mann-Whitney U-test was conducted, p = 0.050.

[a] If value was < method detection limit (MDL), summary statistics were calculated using 1x MDL (i.e. if result was < 0.048, summary statistics were calculated using the value 0.048).

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The Minto Mine sediment, periphyton and benthic assessment undertaken from September 22nd to 28th, 2016 served to quantitatively compare water quality (field measures and chemistry), sediment quality, periphyton community, benthic invertebrate community, periphyton tissue quality and benthic invertebrate tissue quality of Minto Creek to reference creeks and previous data for interpretation. Periphyton tissue quality data were also provided.

Supporting measures collected in September 2016 indicated good Minto Creek water quality. An influence of the Minto Mine was evident in higher specific conductance than in reference creeks; however, there were no water quality parameters with concentrations greater than WUL water quality objectives. Concentration of total copper at upper Minto Creek was above guidelines but the associated reference areas were not but dissolved copper was not above the WUL water quality objectives. Moving downstream, copper concentration at lower Minto Creek and associated reference areas were all above guidelines. Mean concentrations of chlorophyll *α* at lower Minto and lower Wolverine creeks were not significantly different from each other and did not exceed guidelines. Compared to previous years, concentrations of chlorophyll *α* were higher at both stations. Production was greater in 2016 from previous years since lower Minto Creek was classified as eutrophic and lower Wolverine creek was classified as mesotrophic (Dodds et al. 1998).

Concentrations of metals in Minto Creek sediments were similar to reference and lower than sediment quality guidelines with the exception of copper. Concentrations of copper in Minto Creek (both upper and lower) were greater than the sediment quality guideline and reference, but were similar to concentrations observed in previous years. Minto Creek sediment quality has not shown any trend over time based on temporal comparisons of absolute and normalized (to TOC and to lithium) concentrations. Sediment toxicity testing of *Chironomus dilutus* and *Hyalella azteca* indicated no adverse effects to survival or growth in lower Minto Creek sediment when compared to the laboratory control and the field reference (lower Wolverine Creek) sediment.

Evaluation of periphyton community composition on the basis of density (cells/cm^2) and biomass (μg/cm^2) indicated significant differences in a number of metrics in lower Minto Creek relative to the lower Wolverine Creek reference. In general, lower Minto Creek was more diverse with more taxa compared to lower Wolverine Creek but the areas had different community structures. However, differences in periphyton community summary metrics and community composition were apparent among years at both lower Minto Creek and lower

Wolverine Creek, indicating substantial temporal variability. The differences observed in the periphyton communities of lower Minto Creek and lower Wolverine Creek in 2016 were within natural temporal variability and do not provide any resolution of potential mine influence.

The erosional benthic invertebrate community of lower Minto Creek did not differ from reference, or was intermediate between references, on the basis of all metrics except Bray-Curtis index, which was greater at lower Minto Creek than both reference areas. A potential decrease in number of taxa from 2012-2014 was not supported by the 2015 and 2016 data and appears to represent natural variability (Minnow 2015b, 2016b). High temporal variability has been observed at the exposure and reference areas (Minnow 2009b; 2011, 2012, 2013b, 2014, 2015b, 2016b), presumably due to inter-annual variability in environmental conditions (e.g., flow, ice scour).

The chemical quality of biological tissues (periphyton and benthic invertebrates) collected at mine-exposed lower Minto Creek and reference areas indicated that selenium concentrations were significantly different between areas. Significantly higher concentrations of selenium at lower Minto Creek compared to reference areas over the last three years could indicate an influence of the mine on Minto Creek. Selenium concentration in benthic invertebrate tissue was significantly lower at lower Minto Creek than at lower Wolverine Creek but was significantly higher compared to lower Big Creek

8.2 Recommendations

Based on the results and conclusions of the 2016 Minto Mine sediment, periphyton and benthic assessment, it is recommended that the program is repeated in 2017. It is recommended that both lower Wolverine Creek and lower Big Creek continue to be sampled as reference areas for the benthic invertebrate community assessment to provide better perspective on whether any of the observed differences are actually due to mine influence or simply due to natural differences among creeks. It is recommended that sediment toxicity testing is not completed in 2017, but that it is completed at a three-year frequency (next monitoring in 2019) or in response to any increase in concentrations of copper (or other mine-related analyte). It is also recommended that periphyton community monitoring is removed from the WUL monitoring program as results are highly variable and are not effective in determining potential mine effects.

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APPENDIX A

DATA QUALITY ASSESSMENT

APPENDIX A: DATA QUALITY ASSESSMENT

LIST OF TABLES

After Page…

A1.0 INTRODUCTION

Data Quality Assessment (DQA) was conducted on data collected as part of the 2016 Minto Creek Sediment, Periphyton and Benthic Invertebrate Community Assessment Report. The objective of DQA is to define the overall quality of the data presented in the report, and, by extension, the confidence with which the data can be used to derive conclusions.

A1.1 Background

A variety of factors can influence the chemical and biological measurements made in an environmental study and thus affect the accuracy and/or precision of the data. Inconsistencies in sampling or laboratory methods, use of instruments that are inadequately calibrated or which cannot measure to the desired level of accuracy or precision, and contamination of samples in the field or laboratory are just some of the potential factors that can lead to the reporting of data that do not accurately reflect actual environmental conditions. Depending on the magnitude of the problem, inaccuracy or imprecision have the potential to affect the reliability of any conclusions made from the data. Therefore, it is important to ensure that monitoring programs incorporate appropriate steps to control the non-natural sources of data variability (i.e., minimize the variability that does not reflect natural spatial and temporal variability in the environment) and thus assure the quality of the data.

Data quality as a concept is meaningful only when it relates to the intended use of the data. That is, one must know the context in which the data will be interpreted in order to establish a relevant basis for judging whether or not the data set is adequate. DQA involves comparison of actual field and laboratory measurement performance to data quality objectives (DQOs) established for a particular study, such as evaluation of method detection limits, blank sample data, data precision (based on field and laboratory duplicate samples), and data accuracy (based on matrix spike recoveries and/or analysis of standards or certified reference materials). A trusted analytical laboratory certified by Canadian Association for Laboratory Accreditation (CALA) with a rigorous internal quality assurance program was selected to ensure the highest possible quality.

DQOs were established either at the outset of the field program or by the laboratory (ALS Environmental) and reflect reasonable and achievable performance expectations. The method detection limit (MDL) was set at the outset of the field program for water, sediment and tissue quality. Only samples that were below the laboratory detection limits were evaluated against target detection limits. Target detection limits should be at least as low as applicable guidelines, ideally ≤ 1/10th guideline values. Tissue samples are compared to the detection limit the laboratory quoted they could achieve. Programs involving a large amount of samples and analytes usually result in some analytes that exceed the DQOs. This is particularly so for multi-element scans (e.g., ICP scans for metals) since the analytical conditions are not necessarily optimal for every element included in the scan. Generally, scan results may be considered acceptable if no more than 20% of the parameters fail to meet the DQOs. Overall, the intent of comparing data to DQOs was not to reject any measurement that did not meet the DQO, but to ensure that any questionable data received more scrutiny to determine what effect, if any, this had on interpretation of results within the context of this project.

A1.2 Types of Quality Control Samples

Several types of quality control (QC) samples were assessed based on samples collected (or prepared) in the field and laboratory. These samples, and a description of each, include the following:

- **Blanks** are samples of de-ionized water and/or appropriate reagent(s) that are handled and analyzed the same way as regular samples. These samples will reflect any contamination that occurred in the field (in the case of field or travel blanks) or the laboratory (in the case of laboratory or method blanks). Analyte concentrations should be non-detectable although a DQO of twice the method detection limit allows for slight "noise" around the detection limit.

- **Field Duplicates** are sub-sample pairs collected from a randomly selected field station using identical collection and handling methods that are then analyzed separately in the laboratory. The duplicate samples are handled and analyzed in an identical manner in the laboratory. The data from field duplicate samples reflect natural variability, as well as the variability associated with sample collection methods, and therefore provide a measure of field precision.

- **Laboratory Duplicates** are sub-sample pairs created in the laboratory from randomly selected field samples which are sub-sampled and then analyzed independently using identical analytical methods. The laboratory duplicate sample results reflect any variability introduced during laboratory sample handling and analysis and thus provide a measure of laboratory precision.

- **Spike Recovery Samples** are created in the laboratory by adding a known amount/concentration of a given analyte (or mixture of analytes) to a randomly selected test sample previously divided to create two sub-samples. The spiked and regular sub-samples are then analyzed in an identical manner. The spike recovery represents the difference between the measured spike amount (total amount in spiked sample minus amount in original sample) relative to the known spike amount (as a percentage). Two types of spike recovery samples are commonly analyzed. Spiked blanks (or blank spikes) are created using laboratory control materials whereas matrix spikes are created using field-collected samples. The analysis of spiked samples provides an indication of the accuracy of analytical results.
- **Certified Reference Materials** are samples containing known chemical concentrations that are processed and analyzed along with batches of environmental samples. The sample results are then compared to target results to provide a measure of analytical accuracy. The results are reported as the percent of the known amount that was recovered in the analysis.

The following QC was applied to benthic invertebrate community samples as follows:

- **Organism Recovery Checks** for benthic invertebrate community samples involve the re-processing of previously sorted material from a randomly selected sample to determine the number of invertebrates that were not recovered during the original sample processing. The reprocessing is conducted by an analyst not involved during the original processing to reduce any bias. This check allows the determination of accuracy through assessment of recovery efficiency.

A2.0 WATER SAMPLES

A2.1 Method Detection Limits

Three analytes were higher than targeted detection limits: total suspended solids, bromide and total mercury. Even though these analytes were higher than detection limits they were lower than guideline levels (Table A.1). Therefore, data for this project can be reliably interpreted relative to guidelines.

A2.2 Laboratory Blank Sample Analysis

All blank samples contained non-detectable analyte concentrations indicating no inadvertent contamination of samples within the laboratory during analysis (Appendix B).

A2.3 Data Precision

The relative percent difference (RPD) between field duplicate samples were greater than 25% for three analytes: total suspended solids, total selenium and dissolved zinc (Table A.2). The field duplicates were associated with good field precision. Fewer than 20% of the field duplicate samples failed the DQO so therefore the samples were associated with good field precision.

Agreement was achieved between all laboratory duplicate samples (Appendix B). This indicates that reported sample results were associated with good analytical precision.

A2.4 Data Accuracy

Analyte recoveries for spiked blanks all met the data quality objectives indicating excellent analytical accuracy for the water sample analyses (Appendix B).

The analyte recoveries for matrix spiked samples met the data quality objectives for all analytes except for dissolved organic carbon, total inorganic carbon and total organic carbon. These analytes could not be accurately calculated due to high analyte background in the samples. The matrix spiked samples indicate good analytical accuracy for the water sample analyses (Appendix B).

All the data quality objectives were met for analyte recoveries of certified reference materials indicating excellent analytical accuracy (Appendix B).

Table A.1: Laboratory method detection limits (MDLs) relative to targets and water quality guidelines, Minto Mine, 2016[a].

Analyte		Units	Method Detection Limit		Water Use Licence Objectives	CCME Water Quality Guidelines[1]	
			Target	Achieved		30 Day	Max
Physical Tests	Total Suspended Solids	mg/L	0.80	3.0	-	8.0[b]	28[b]
Anions and Nutrients	Total Ammonia (as N)	mg/L	0.025	0.0050	0.25	0.41[c]	-
	Bromide (Br)	mg/L	0.030	0.050	-	-	-
	Chloride (Cl)	mg/L	12	0.50	-	120	640
	Nitrate (as N)	mg/L	0.30	0.0050	9.1	3.0	124
	Nitrite (as N)	mg/L	0.0060	0.0010	0.060	0.060	-
Cyanides	Total Cyanide	mg/L	-	0.0050	-	-	
Total Metals	Total Antimony (Sb)	mg/L	-	0.00010	-	-	-
	Total Beryllium (Be)	mg/L	-	0.00010	-	-	-
	Total Bismuth (Bi)	mg/L	-	0.000050	-	-	-
	Total Boron (B)	mg/L	0.15	0.010	-	1.5	29
	Total Cadmium (Cd)	mg/L	0.000013	0.0000050	-	0.00013[d]	0.0016[d]
	Total Cobalt (Co)	mg/L	-	0.00010	-	-	-
	Total Lead (Pb)	mg/L	0.00022	0.000050	-	0.0022[d]	-
	Total Lithium (Li)	mg/L	-	0.0010	-	-	-
	Total Mercury (Hg)	mg/L	0.0000026	0.0000050	-	0.000026	-
	Total Phosphorus (P)	mg/L	-	0.30	-	-	-
	Total Silver (Ag)	mg/L	0.000025	0.000010	-	0.00025	
	Total Thallium (Tl)	mg/L	0.000080	0.000010	-	0.00080	-
	Total Tin (Sn)	mg/L	-	0.00010	-	-	-
	Total Titanium (Ti)	mg/L	-	0.010	-	-	-
	Total Vanadium (V)	mg/L	-	0.00050	-	-	-
	Total Zinc (Zn)	mg/L	0.0030	0.0030	-	0.030	-
Dissolved Metals	Dissolved Antimony (Sb)	mg/L	-	0.00010	-	-	-
	Dissolved Beryllium (Be)	mg/L	-	0.00010	-	-	-
	Dissolved Bismuth (Bi)	mg/L	-	0.000050	-	-	-
	Dissolved Boron (B)	mg/L	-	0.010	-	-	-
	Dissolved Cadmium (Cd)	mg/L	0.000018	0.0000050	0.00018[e]	-	-
	Dissolved Chromium (Cr)	mg/L	0.00010	0.00010	0.0010	-	-
	Dissolved Cobalt (Co)	mg/L	-	0.00010	-	-	-
	Dissolved Iron (Fe)	mg/L	0.11	0.010	1.1	-	-
	Dissolved Lead (Pb)	mg/L	0.00040	0.000050	0.0040	-	-
	Dissolved Lithium (Li)	mg/L	-	0.0010	-	-	-
	Dissolved Mercury (Hg)	mg/L	-	0.0000050	-	-	-
	Dissolved Nickel (Ni)	mg/L	0.011	0.00050	0.11	-	-
	Dissolved Phosphorus (P)	mg/L	-	0.30	-	-	-
	Dissolved Silver (Ag)	mg/L	0.000010	0.000010	0.00010	-	-
	Dissolved Thallium (Tl)	mg/L	-	0.000010	-	-	-
	Dissolved Tin (Sn)	mg/L	-	0.00010	-	-	-
	Dissolved Titanium (Ti)	mg/L	-	0.010	-	-	-
	Dissolved Vanadium (V)	mg/L	-	0.00050	-	-	-
	Dissolved Zinc (Zn)	mg/L	0.0030	0.0010	0.030	-	-

Value greater than DQO.

[1] CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. 1999 (plus updates), Canadian Council of Ministers of the Environment, Winnipeg. See Appendix Table B.6 for explanatory notes on selected water quality guidelines.

[a] Only analytes with reported values less than MDL were presented.

[b] Based on the median of background levels plus 5 mg/L for 30 day and 25 mg/L for max guidelines.

[c] Based on lowest guideline using highest temperature and pH.

[d] Based on lowest guideline using lowest hardness.

[e] Based on the following formula using the lowest hardness: $e^{(0.736(\ln(\text{Hardness})-4.943))}$ (µg/L).

Table A.2: Field duplicate results for analysis of water quality, Minto Mine, 2016. Higlighted values did not meet the data quality objective of 25% relative percent difference (RPD).

Analytes		Units	Lab Report L1837418		RPD (%)
			LBC	LBCX	
			28-Sep-2016	28-Sep-2016	
Physical Tests	Conductivity	µS/cm	207	208	0.48
	Hardness (as $CaCO_3$)	mg/L	104	104	0
	pH	pH Units	8.24	8.23	0.12
	Total Suspended Solids	mg/L	< 3.0	4.3	36
	Total Dissolved Solids	mg/L	148	158	6.5
	Turbidity	NTU	1.11	1.14	2.7
Anions and Nutrients	Total Alkalinity	mg/L	99	100	1.3
	Total Ammonia (as N)	mg/L	< 0.0050	< 0.0050	0
	Bromide (Br)	mg/L	< 0.050	< 0.050	0
	Chloride (Cl)	mg/L	0.56	0.57	1.8
	Fluoride (F)	mg/L	0.13	0.13	0
	Nitrate (as N)	mg/L	0.0301	0.0298	1.0
	Nitrite (as N)	mg/L	< 0.0010	< 0.0010	0
	Total dissolved Phosphorus (P)	mg/L	0.0035	0.0029	19
	Total Phosphorus (P)	mg/L	0.0053	0.0047	12
	Sulfate (SO_4)	mg/L	14.3	14.2	0.70
Other	Total Cyanide	mg/L	< 0.0050	< 0.0050	0
	Dissolved Organic Carbon	mg/L	8.5	8.2	3.5
	Total Inorganic Carbon	mg/L	24	23	7.7
	Total Organic Carbon	mg/L	8.23	8.22	0.12
Total Metals	Total Aluminum (Al)	mg/L	0.059	0.055	6.0
	Total Antimony (Sb)	mg/L	0.00018	0.00021	15
	Total Arsenic (As)	mg/L	0.00095	0.00092	3.2
	Total Barium (Ba)	mg/L	0.0662	0.0663	0.15
	Total Beryllium (Be)	mg/L	< 0.00010	< 0.00010	0
	Total Bismuth (Bi)	mg/L	< 0.000050	< 0.000050	0
	Total Boron (B)	mg/L	< 0.010	< 0.010	0
	Total Cadmium (Cd)	mg/L	0.0000066	0.0000072	8.7
	Total Calcium (Ca)	mg/L	25	25	2.0
	Total Chromium (Cr)	mg/L	0.00031	0.00031	0
	Total Cobalt (Co)	mg/L	< 0.00010	< 0.00010	0
	Total Copper (Cu)	mg/L	0.0023	0.0022	1.3
	Total Iron (Fe)	mg/L	0.12	0.11	2.6
	Total Lead (Pb)	mg/L	0.000071	0.000083	16
	Total Lithium (Li)	mg/L	0.0014	0.0015	6.9
	Total Magnesium (Mg)	mg/L	10	11	1.9
	Total Manganese (Mn)	mg/L	0.0171	0.0169	1.2
	Total Mercury (Hg)	mg/L	< 0.0000050	< 0.0000050	0
	Total Molybdenum (Mo)	mg/L	0.0014	0.0014	0
	Total Nickel (Ni)	mg/L	0.0013	0.0014	6.1
	Total Phosphorus (P)	mg/L	< 0.30	< 0.30	0
	Total Potassium (K)	mg/L	0.86	0.87	0.35
	Total Selenium (Se)	mg/L	0.000055	0.000072	27
	Total Silicon (Si)	mg/L	6.46	6.54	1.2
	Total Silver (Ag)	mg/L	< 0.000010	< 0.000010	0
	Total Sodium (Na)	mg/L	7.9	7.8	0.76
	Total Strontium (Sr)	mg/L	0.267	0.269	0.75
	Total Thallium (Tl)	mg/L	< 0.000010	< 0.000010	0
	Total Tin (Sn)	mg/L	< 0.00010	< 0.00010	0
	Total Titanium (Ti)	mg/L	< 0.010	< 0.010	0
	Total Uranium (U)	mg/L	0.00271	0.00274	1.1
	Total Vanadium (V)	mg/L	0.00109	0.00105	3.7
	Total Zinc (Zn)	mg/L	< 0.0030	< 0.0030	0
Dissolved Metals	Dissolved Aluminum (Al)	mg/L	0.017	0.018	8.5
	Dissolved Antimony (Sb)	mg/L	0.00014	0.00015	6.9
	Dissolved Arsenic (As)	mg/L	0.00075	0.00075	0
	Dissolved Barium (Ba)	mg/L	0.0664	0.0663	0.15
	Dissolved Beryllium (Be)	mg/L	< 0.00010	< 0.00010	0
	Dissolved Bismuth (Bi)	mg/L	< 0.000050	< 0.000050	0
	Dissolved Boron (B)	mg/L	< 0.010	< 0.010	0
	Dissolved Cadmium (Cd)	mg/L	< 0.0000050	0.0000050	0
	Dissolved Calcium (Ca)	mg/L	25	25	0.80
	Dissolved Chromium (Cr)	mg/L	0.00021	0.00022	4.7
	Dissolved Cobalt (Co)	mg/L	< 0.00010	< 0.00010	0
	Dissolved Copper (Cu)	mg/L	0.0019	0.0022	16
	Dissolved Iron (Fe)	mg/L	0.047	0.050	6.2
	Dissolved Lead (Pb)	mg/L	< 0.000050	< 0.000050	0
	Dissolved Lithium (Li)	mg/L	0.0014	0.0014	0
	Dissolved Magnesium (Mg)	mg/L	10	10	0
	Dissolved Manganese (Mn)	mg/L	0.0150	0.0152	1.3
	Dissolved Mercury (Hg)	mg/L	< 0.0000050	< 0.0000050	0
	Dissolved Molybdenum (Mo)	mg/L	0.00121	0.00124	2.4
	Dissolved Nickel (Ni)	mg/L	0.0011	0.0013	14
	Dissolved Phosphorus (P)	mg/L	< 0.30	< 0.30	0
	Dissolved Potassium (K)	mg/L	0.85	0.86	1.4
	Dissolved Selenium (Se)	mg/L	0.000073	0.000066	10
	Dissolved Silicon (Si)	mg/L	6.3	6.3	0
	Dissolved Silver (Ag)	mg/L	< 0.000010	< 0.000010	0
	Dissolved Sodium (Na)	mg/L	7.7	7.8	0.91
	Dissolved Strontium (Sr)	mg/L	0.259	0.262	1.2
	Dissolved Thallium (Tl)	mg/L	< 0.000010	< 0.000010	0
	Dissolved Tin (Sn)	mg/L	< 0.00010	< 0.00010	0
	Dissolved Titanium (Ti)	mg/L	< 0.010	< 0.010	0
	Dissolved Uranium (U)	mg/L	0.00248	0.00252	1.6
	Dissolved Vanadium (V)	mg/L	0.00080	0.00082	2.5
	Dissolved Zinc (Zn)	mg/L	< 0.0010	0.0023	79

> 25% RPD.

A3.0 SEDIMENT SAMPLES

A3.1 Method Detection Limits

All analytes had reported MDLs that were lower than the target MDLs indicating that the data can be reliably interpreted (Table A.3).

A3.2 Laboratory Blank Sample Analysis

All blank samples contained non-detectable analyte concentrations indicating no inadvertent contamination of samples within the laboratory during analysis (Appendix C).

A3.3 Data Precision

The relative percent differences (RPDs) between field duplicate samples were all found to be in agreement (Table A.4). This indicates that the results were associated with excellent field precision.

Agreement was achieved between all laboratory duplicate samples (Appendix C). This indicates that reported sample results were associated with excellent analytical precision.

A3.4 Data Accuracy

Analyte recoveries for spiked blanks all met the data quality objectives indicating excellent analytical accuracy for the sediment sample analyses (Appendix C).

Recoveries of all analytes in certified reference materials met the data quality objective (Appendix C). These data indicated excellent analytical accuracy associated with the analysis of sediment samples.

Table A.3: Laboratory method detection limits (MDLs) relative to targets and sediment guidelines, Minto Mine, 2016[a].

Analyte		Units	Method Detection Limit		CSQG[1]	
			Target	Achieved	ISQG	PEL
Particle Size	Gravel (> 2 mm)	%	-	1.0	-	-
Total Metals	Bismuth (Bi)	mg/kg	-	0.20	-	-
	Boron (B)	mg/kg	-	5.0	-	-
	Cadmium (Cd)	mg/kg	0.060	0.050	0.60	3.5
	Selenium (Se)	mg/kg	-	0.20	-	-
	Silver (Ag)	mg/kg	-	0.10	-	-
	Thallium (Tl)	mg/kg	-	0.050	-	-
	Tin (Sn)	mg/kg	-	2.0	-	-

Value greater than DQO.

[1] Canadian Sediment Quality Guidelines - ISQG = interim sediment quality guideline; PEL = probable effect level (CCME 1999).

[a] Only analytes with reported values less than MDL were presented.

Table A.4: Field duplicate results for analysis of sediment quality, Minto Mine, 2016. Higlighted values did not meet the data quality objective of 40% relative percent difference (RPD).

Analytes		Units	Lab Report L1837161		
			LWC-5	LWC-5X	RPD (%)
			26-Sep-2016	26-Sep-2016	
Physical Tests	Loss on Ignition	%	17	21	21
	pH (1:2 soil:water)	pH	6.8	6.7	0.59
Particle Size	Gravel (> 2 mm)	%	< 1.0	< 1.0	0
	Sand (2.0 mm - 0.063 mm)	%	17	16	5.5
	Silt (0.063 mm - 4 µm)	%	77	78	1.7
	Clay (< 4 µm)	%	6.6	6.2	6.2
Other	Total Kjeldahl Nitrogen	%	0.49	0.43	13
	Inorganic Carbon	%	0.20	0.16	24
	Inorganic Carbon (as CaCO3 Equivalent)	%	1.7	1.3	25
	Total Carbon by Combustion	%	9.2	8.5	8.5
	Total Organic Carbon	%	9.0	8.3	8.2
Total Metals	Total Aluminum (Al)	mg/kg	13,600	14,500	6.4
	Total Antimony (Sb)	mg/kg	0.45	0.48	6.5
	Total Arsenic (As)	mg/kg	8.2	8.0	2.2
	Total Barium (Ba)	mg/kg	235	235	0
	Total Beryllium (Be)	mg/kg	0.78	0.82	5.0
	Total Bismuth (Bi)	mg/kg	< 0.20	< 0.20	0
	Total Boron (B)	mg/kg	< 5.0	< 5.0	0
	Total Cadmium (Cd)	mg/kg	0.28	0.27	2.9
	Total Calcium (Ca)	mg/kg	10,900	11,000	0.91
	Total Chromium (Cr)	mg/kg	47	49	2.9
	Total Cobalt (Co)	mg/kg	13.7	13.8	0.73
	Total Copper (Cu)	mg/kg	31	30	2.6
	Total Iron (Fe)	mg/kg	30,600	30,800	0.65
	Total Lead (Pb)	mg/kg	6.6	6.7	0.75
	Total Lithium (Li)	mg/kg	10	11	5.7
	Total Magnesium (Mg)	mg/kg	8,620	8,790	2.0
	Total Manganese (Mn)	mg/kg	511	478	6.7
	Total Mercury (Hg)	mg/kg	0.15	0.12	23
	Total Molybdenum (Mo)	mg/kg	0.51	0.54	5.7
	Total Nickel (Ni)	mg/kg	38	38	0
	Total Phosphorus (P)	mg/kg	1,130	1,170	3.5
	Total Potassium (K)	mg/kg	950	1,060	11
	Total Selenium (Se)	mg/kg	0.47	0.46	2.2
	Total Silver (Ag)	mg/kg	0.12	0.11	8.7
	Total Sodium (Na)	mg/kg	390	435	11
	Total Strontium (Sr)	mg/kg	107	109	1.9
	Total Thallium (Tl)	mg/kg	0.085	0.092	7.9
	Total Tin (Sn)	mg/kg	< 2.0	< 2.0	0
	Total Titanium (Ti)	mg/kg	680	787	15
	Total Uranium (U)	mg/kg	3.4	3.3	1.8
	Total Vanadium (V)	mg/kg	66	68	3.1
	Total Zinc (Zn)	mg/kg	56	57	1.9

> 40% RPD.

A4.0 SEDIMENT TOXICITY TESTING

Results for the reference toxicant test for both the 10 day *Chironomus dilutus* and the 14 day *Hyalella azteca* tests were within the acceptability range for organism performance of mean and two standard deviations (Appendix C – Nautilus Environmental Report). Water quality parameters throughout testing remained within the acceptability criteria as well. The sensitivity of the organisms was deemed to be appropriate when compared to historical results obtained by the laboratory (Appendix C – Nautilus Environmental Report).

A5.0 PERIPHYTON COMMUNITY

One sample was re-counted and the RPD was calculated. Close agreement was achieved between laboratory duplicate samples for both density (cells/cm^2; Table A.5) and biomass (µg/cm^2; Table A.6). Cyanobacteria had the highest RPD between duplicate samples for periphyton density (7%; Table A.5) and biomass (28%; just within the DQO of 30%; Table A.6). This indicates that the data can be reliably interpreted.

Table A.5: Laboratory duplicate results for analysis of periphyton group densities (cells/cm^2). Highlighted values did not meet the data quality objective of ≤ 30% relative percent difference (RPD).

Algal Density (cells/cm^2)	LMC-4	LMC-4R	RPD
Cyanobacteria	3,176	2,961	7.0%
Diatom	13,943	14,212	1.9%
Total	17,119	17,173	0.31%

> 30% RPD.

Table A.6: Laboratory duplicate results for analysis of periphyton group biomass (µg/cm^2). Highlighted values did not meet the data quality objective of ≤ 30% relative percent difference (RPD).

Algal Biomass (µg/cm^2)	LMC-4	LMC-4R	RPD
Cyanobacteria	1.9	2.5	28%
Diatom	15	14	2.8%
Total	16	17	1.3%

> 30% RPD.

A6.0 BENTHIC MACROINVERTEBRATE COMMUNITY

The objective for percent organism recovery was met for two re-sorted samples, with a percent recovery of 98% each (Table A.7). Precision and accuracy of the sub-sampled benthic invertebrate community samples also met the DQO of 20% (Table A.8). This indicates that the data can be reliably interpreted.

Table A.7: Percent sorting efficiency of benthic invertebrates, Minto Mine, 2016.

Station	Initial Sort	Re-sort	Percent sorting efficiency[1]
LWC-3	322	6	98%
LBC-4	124	2	98%

[1] Percent sorting efficiency = (1-(# in QA/AC re-sort / (# sorted originally + # in QA/QC re-sort)))* 100.

Value less than 90%.

Table A.8: Calculation of subsampling error for benthic invertebrate samples, Minto Mine, 2016. Shading indicates that the data quality objective of < 20% was not met.

Sample	Number of organisms in fraction 1 (50%)	Number of organisms in fraction 2 (50%)	Actual density	Precision (range of RPD)[a]		Accuracy (range expressed as %)[b]	
LBC-3	421	483	904	13	13	6.9	6.9

[a] relative percent difference among subsamples.

[b] range of deviation of abundance estimates derived from sub-samples compared to analysis of entire sample (expressed as % of total organisms present).

A7.0 TISSUE SAMPLES

A7.1 Method Detection Limits

For periphyton tissue samples, only one analyte (tellurium) was below laboratory detection limits and greater than the targeted detection (Table A.9). Target concentrations are not guidelines but based on detection limits the laboratory quoted were achievable.

All of the benthic invertebrate tissue analytes that were below the laboratory detection limits (boron and tellurium), were less than or equal to the target MDL that the laboratory quoted they could achieve (Table A.10). Data for this project can be reliably interpreted.

All chlorophyll *α* periphyton samples were detectable so therefore were considered interpretable.

A7.2 Laboratory Blank Sample Analysis

Periphyton and benthic invertebrate tissue blank samples contained non-detectable analyte concentrations indicating no inadvertent contamination of samples within the laboratory during analysis (Appendix C).

A7.3 Data Precision

Periphyton field duplicate samples showed close agreement between most analytes except for bismuth, indicating samples were associated with good field precision (Table A.11).

The laboratory duplicate periphyton tissue samples showed good agreement between all duplicate analyte concentrations (Appendix C). Periphyton samples were associated with good analytical precision.

Benthic invertebrate field duplicate samples did not show close agreement with 16 analytes. The following analytes had RPD greater than 30%; aluminum, antimony, barium, beryllium, bismuth, boron, calcium, cesium, cobalt, iron, lead, manganese, rubidium, strontium, thallium and vanadium (Table A.12). Key analytes of concern, copper and selenium had RPD that did show close agreement.

Laboratory benthic invertebrate duplicate samples did not show close agreement

Table A.9: Laboratory method detection limits (MDL) for periphyton tissue samples relative to targets, Minto Mine, 2016[a].

Analyte	Units	Method Detection Limits	
		Target	Achieved
Total Tellurium (Te)	mg/kg wwt	0.0040	0.0040 - 0.016

Target concentrations were exceeded.

[a] Only analytes with reported values less than MDL were presented.

Table A.10: Laboratory method detection limits (MDL) for benthic tissue samples relative to targets, Minto Mine, 2016[a].

Analyte	Units	Method Detection Limits	
		Target	Achieved
Total Boron (B)	mg/kg wwt	0.20	0.20
Total Tellurium (Te)	mg/kg wwt	0.0040	0.0040

Target concentrations were exceeded.

[a] Only analytes with reported values less than MDL were presented.

Table A.11: Field duplicate results for analysis of periphyton tissue quality, Minto Mine, 2016. Higlighted values did not meet the data quality objective of 30% relative percent difference (RPD).

Analyte		Units	Lab Report L1837190		
			LBC-3	LBC-3X	RPD (%)
			24-Sep-2016	24-Sep-2016	
Physical Tests	% Moisture	%	74	69	7.0
Metals	Total Aluminum (Al)	mg/kg wwt	3,600	4,390	20
	Total Antimony (Sb)	mg/kg wwt	0.051	0.053	3.7
	Total Arsenic (As)	mg/kg wwt	7.5	9.3	23
	Total Barium (Ba)	mg/kg wwt	61	74	20
	Total Beryllium (Be)	mg/kg wwt	0.16	0.19	21
	Total Bismuth (Bi)	mg/kg wwt	0.32	0.55	52
	Total Boron (B)	mg/kg wwt	1.1	1.3	17
	Total Cadmium (Cd)	mg/kg wwt	0.065	0.083	25
	Total Calcium (Ca)	mg/kg wwt	2,160	2,690	22
	Total Cesium (Cs)	mg/kg wwt	0.77	0.93	20
	Total Chromium (Cr)	mg/kg wwt	8.0	9.7	20
	Total Cobalt (Co)	mg/kg wwt	2.6	3.2	21
	Total Copper (Cu)	mg/kg wwt	11	14	22
	Total Iron (Fe)	mg/kg wwt	6,240	7,630	20
	Total Lead (Pb)	mg/kg wwt	2.5	3.0	17
	Total Lithium (Li)	mg/kg wwt	2.7	3.4	23
	Total Magnesium (Mg)	mg/kg wwt	1,870	2,280	20
	Total Manganese (Mn)	mg/kg wwt	193	254	27
	Total Mercury (Hg)	mg/kg wwt	0.012	0.015	22
	Total Molybdenum (Mo)	mg/kg wwt	0.40	0.50	23
	Total Nickel (Ni)	mg/kg wwt	6.5	8.0	21
	Total Phosphorus (P)	mg/kg wwt	245	314	25
	Total Potassium (K)	mg/kg wwt	418	526	23
	Total Rubidium (Rb)	mg/kg wwt	4.2	5.1	20
	Total Selenium (Se)	mg/kg wwt	0.10	0.12	19
	Total Sodium (Na)	mg/kg wwt	102	125	20
	Total Strontium (Sr)	mg/kg wwt	22	27	21
	Total Tellurium (Te)	mg/kg wwt	0.022	0.026	15
	Total Thallium (Tl)	mg/kg wwt	0.039	0.047	19
	Total Tin (Sn)	mg/kg wwt	0.17	0.19	9.0
	Total Uranium (U)	mg/kg wwt	0.41	0.51	23
	Total Vanadium (V)	mg/kg wwt	14	17	21
	Total Zinc (Zn)	mg/kg wwt	17	21	21
	Total Zirconium (Zr)	mg/kg wwt	2.4	2.9	20

> 30% RPD.

Table A.12: Field duplicate results for analysis of benthic invertebrate tissue quality, Minto Mine, 2016. Higlighted values did not meet the data quality objective of 30% relative percent difference (RPD).

Analyte		Units	Lab Report L1837212		
			LWC-4	LWC-4X	RPD (%)
			25-Sep-2016	25-Sep-2016	
Physical Tests	% Moisture	%	69	63	8.2
Metals	Total Aluminum (Al)	mg/kg wwt	668	945	34
	Total Antimony (Sb)	mg/kg wwt	0.043	0.021	70
	Total Arsenic (As)	mg/kg wwt	0.84	0.90	6.6
	Total Barium (Ba)	mg/kg wwt	12	23	59
	Total Beryllium (Be)	mg/kg wwt	0.055	0.091	50
	Total Bismuth (Bi)	mg/kg wwt	0.0033	0.0060	58
	Total Boron (B)	mg/kg wwt	< 0.20	0.34	52
	Total Cadmium (Cd)	mg/kg wwt	0.055	0.069	22
	Total Calcium (Ca)	mg/kg wwt	1,080	1,730	46
	Total Cesium (Cs)	mg/kg wwt	0.058	0.24	122
	Total Chromium (Cr)	mg/kg wwt	3.7	2.8	27
	Total Cobalt (Co)	mg/kg wwt	1.0	1.4	33
	Total Copper (Cu)	mg/kg wwt	5.3	6.0	11
	Total Iron (Fe)	mg/kg wwt	1,850	2,670	36
	Total Lead (Pb)	mg/kg wwt	0.31	0.53	51
	Total Lithium (Li)	mg/kg wwt	0.68	0.86	23
	Total Magnesium (Mg)	mg/kg wwt	749	979	27
	Total Manganese (Mn)	mg/kg wwt	81	142	55
	Total Mercury (Hg)	mg/kg wwt	0.0045	0.0056	22
	Total Molybdenum (Mo)	mg/kg wwt	0.34	0.38	11
	Total Nickel (Ni)	mg/kg wwt	3.2	3.6	14
	Total Phosphorus (P)	mg/kg wwt	2,120	2,570	19
	Total Potassium (K)	mg/kg wwt	1,840	2,200	18
	Total Rubidium (Rb)	mg/kg wwt	0.73	1.6	75
	Total Selenium (Se)	mg/kg wwt	1.35	1.40	3.6
	Total Sodium (Na)	mg/kg wwt	691	682	1.3
	Total Strontium (Sr)	mg/kg wwt	9.3	23	85
	Total Tellurium (Te)	mg/kg wwt	< 0.0040	< 0.0040	0
	Total Thallium (Tl)	mg/kg wwt	0.0034	0.0067	65
	Total Tin (Sn)	mg/kg wwt	0.55	0.50	9.7
	Total Uranium (U)	mg/kg wwt	0.28	0.29	1.4
	Total Vanadium (V)	mg/kg wwt	4.0	6.7	51
	Total Zinc (Zn)	mg/kg wwt	23	27	15
	Total Zirconium (Zr)	mg/kg wwt	0.84	1.1	25

> 30% RPD.

between nine duplicate analytes: aluminum, antimony, beryllium, cesium, cobalt, magnesium, rubidium, vanadium and zirconium (Appendix C). The RPD between duplicates for these analytes did not show close agreement due to heterogeneity within the samples. Some tissue can be hard to homogenize and can cause higher variation between duplicate samples. All other samples were deemed to be acceptable.

The RPD between the field duplicate periphyton chlorophyll *α* samples was 30.4%, indicating that the DQO was not met (Table A.13). Tissue samples can be highly variable and will be considered when analyzing the data.

A7.4 Data Accuracy

Analyte recoveries for spiked blanks all met the data quality objectives indicating excellent analytical accuracy for periphyton and benthic invertebrate tissue (Appendix C).

Certified reference material met the data quality objective for periphyton tissue except for one sample of sodium. The benthic invertebrate data quality objectives were met for analyte recoveries of certified reference materials indicating good analytical accuracy (Appendix C).

Table A.13: Field duplicate results for analysis of chlorophyll α quality, Minto Mine, 2016. Higlighted values did not meet the data quality objective of 30% relative percent difference (RPD).

Analytes	Units	Lab Report L1837240		
		LMC-1	LMC-1X	RPD (%)
		24-Sep-2016	24-Sep-2016	
Chlorophyll α	mg/m^2	37.4	50.8	30.4

(shaded) > 30% RPD.

A8.0 DATA QUALITY STATEMENT

Water, sediment, benthic community and periphyton tissue data were all of good quality compared to DQO indicating that they can be reliably interpreted. There was close agreement between all periphyton community laboratory duplicate samples; cyanobacteria was high at 28% but did fall within the DQO. The laboratory had difficulties with benthic invertebrate tissue homogenization, which resulted in high RPD and this should be considered when interpreting the data. Chlorophyll *α* field duplicate samples just exceeded the 30% data quality objective at 30.4% and will be considered when interpreting the data. The overall quality of data for this project was good to serve the project objectives.

APPENDIX B

SUPPORTING INFORMATION AND DATA

Table B.1: Habitat characteristics for benthic invertebrate areas, Minto Mine, September 2016.

Characteristics		Lower Wolverine Creek (Reference)	Lower Big Creek (Reference)	Lower Minto Creek (Exposure)
UTM		08V 382467 6954825	08V 396622 6942458	08V 392217 6948011
Approximate Length of Reach Assessed (m)		200	100	25
Gradient (%)		1.5 - 2.0	0.50	1.0
Velocity (m/s)	Mean (min-max)	0.31 - 0.35	0.30 - 0.36	0.30 - 0.36
Depth (m)	Mean	0.25	0.28	0.080
	Maximum	0.48	0.45	0.11
Width (m)	Wetted	11.0	41.0	1.3
	Bankfull	24.0	57.0	3.5
General Morphology	% pool	25	5	5
	% riffle	75	95	90
	% run	0	0	5
Bank Condition		Moderate (some undercut banks)	Moderate (some undercut banks on one side)	Moderate (some undercut banks on one side)
Substrate Coverage	% bedrock	0	0	0
	% boulder	0	10	0
	% cobble	90	80	90
	% gravel	5	5	8
	% sand and finer	5	5	3
Instream Cover (% total Surface)	undercut banks	10	30	10
	boulder	0	5	0
	woody debris	10	5	20
	deep pool	25	10	5
	macrophytes	0	0	0
	other	0	0	0
Overhead Canopy (% Surface)	Dense	0	0	90
	Partially Open	5	5	10
	Open	95	95	0
Aquatic Vegetation (% areal coverage)	Emergent	0	0	0
	Submergent	0	0	0
	Floating	0	0	0
	Attached Algae	5 (attached brown algae)	20 (filamentous algae)	5 (attached brown algae)
Riparian vegetation		willow, alder, balsam, poplar, mature spruce	willow, spruce, alder, grasses	rough alder, willow, grasses, rose, white spruce
Surrounding Land Use		forested	forest, access road to mine	mining upstream
Evidence of Anthropogenic Disturbance		none	bridge, access road to mine	mine upstream

Table B.2: Supporting information for erosional benthic invertebrate grab sample collections, Minto Mine, September 2016.

Characteristics		Lower Wolverine Creek (Reference)				
		LWC-1	LWC-2	LWC-3	LWC-4	LWC-5
Date/Time		25-Sep-16 16:42	25-Sep-16 15:45	25-Sep-16 14:01	25-Sep-16 11:33	25-Sep-16 9:49
UTM		08V 382414 6954630	08V 382426 6954744	08V 382467 6954825	08V 382547 6955028	08V 382563 6955142
Sampling Device		Hess Sampler	Hess Sampler	Hess Sampler	Hess Sampler	Hess Sampler
Sampler Size (m^2)		0.10	0.10	0.10	0.10	0.10
Mesh Size (µm)		500	500	500	500	500
Grabs in Composite		3	3	3	3	3
Water Velocity (m/s)		0.35	0.30	0.35	0.31	0.32
Depth (m)		0.14	0.16	0.11	0.15	0.11
Number of Jars		1	1	1	1	1
Average Depth (cm) (Sampler pushed into substrate)		1	1	1	2	2
Average Depth (cm) (Substrate is sampled/cleaned)		2	2	2	3	3
Average Sampling Time per Grab (min)		6	6	5	7	6
Macrophytes (in sample)		none	none	none	none	none
Algae (in sample)		none	none	none	none	none
Sample Texture	% cobble	90	90	85	90	90
	% gravel	5	8	10	5	5
	% sand and finer	5	3	5	5	5
	% organic	0	0	0	0	0

Table B.2: Supporting information for erosional benthic invertebrate grab sample collections, Minto Mine, September 2016.

Characteristics		Lower Big Creek (Reference)				
		LBC-1	LBC-2	LBC-3	LBC-4	LBC-5
Date/Time		27-Sep-16 16:45	27-Sep-16 14:46	24-Sep-16 16:44	27-Sep-16 11:55	27-Sep-16 9:48
UTM		08V 396400 6942225	08V 396504 6942224	08V 396622 6942458	08V 396620 6942549	08V 396480 6942710
Sampling Device		Hess Sampler	Hess Sampler	Hess Sampler	Hess Sampler	Hess Sampler
Sampler Size (m^2)		0.10	0.10	0.10	0.10	0.10
Mesh Size (µm)		500	500	500	500	500
Grabs in Composite		3	3	3	3	3
Water Velocity (m/s)		0.32	0.33	0.31	0.34	0.33
Depth (m)		0.19	0.11	0.13	0.14	0.13
Number of Jars		1	1	1	1	1
Average Depth (cm) (Sampler pushed into substrate)		1	2	1	2	2
Average Depth (cm) (Substrate is sampled/cleaned)		2	3	2	3	3
Average Sampling Time per Grab (min)		5	6	6	6	6
Macrophytes (in sample)		none	none	none	none	none
Algae (in sample)		common (attached brown algae)	common (green/brown attached algae)	abundant (filamentous algae)	common (attached brown algae)	common (attached brown algae)
Sample Texture	% cobble	85	90	75	90	90
	% gravel	10	5	15	5	5
	% sand and finer	5	5	10	5	5
	% organic	0	0	0	0	0

Table B.2: Supporting information for erosional benthic invertebrate grab sample collections, Minto Mine, September 2016.

Characteristics		Lower Minto Creek (Exposure)				
		LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Date/Time		24-Sep-16 13:33	24-Sep-16 11:47	23-Sep-16 17:40	23-Sep-16 15:26	23-Sep-16 9:49
UTM		08V 392102 6948053	08V 392127 6948038	08V 392217 6948011	08V 392234 6948024	08V 392271 6948076
Sampling Device		Hess sampler	Hess Sampler	Hess Sampler	Hess Sampler	Hess Sampler
Sampler Size (m^2)		0.10	0.10	0.10	0.10	0.10
Mesh Size (µm)		500	500	500	500	500
Grabs in Composite		3	3	3	3	3
Water Velocity (m/s)		0.32	0.32	0.35	0.32	0.34
Depth (m)		0.093	0.11	0.093	0.097	0.093
Number of Jars		1	1	1	1	1
Average Depth (cm) (Sampler pushed into substrate)		1	1	2	2	2
Average Depth (cm) (Substrate is sampled/cleaned)		3	3	3	3	3
Average Sampling Time per Grab (min)		7	7	6	8	10
Macrophytes (in sample)		none	none	sparse (willow roots)	sparse (willow roots)	sparse (willow roots)
Algae (in sample)		none	none	none	none	none
Sample Texture	% cobble	90	85	90	90	85
	% gravel	5	5	5	7.5	10
	% sand and finer	5	10	5	2.5	5
	% organic	0	0	0	0	0

Table B.3: *In situ* water quality measures at sediment sampling stations, Minto Mine WUL, September 2016.

Area	Variable	Temperature	Specific Conductance	Dissolved Oxygen	Dissolved Oxygen	pH
	Unit	°C	µS/cm	mg/L	%	pH units
	CCME Water Quality Guidelines	-	-	6.5 - 9.5	54	6.5 - 9.0[a]
Upper McGinty Creek (Reference)	URC-1	0.50	115	13.12	91.1	7.62
	URC-2	0.50	115	13.28	92.1	7.64
	URC-3	0.50	118	12.95	89.6	7.58
	URC-4	0.40	120	13.34	92.7	7.68
	URC-5	0.60	130	13.44	94.0	7.91
	Mean	0.50	120	13.23	91.9	7.69
	Standard Deviation	0.07	6	0.19	1.7	0.13
Upper Minto Creek (Exposure)	UMC-1	7.40	235	10.64	88.6	7.81
	UMC-2	7.30	235	10.56	87.6	7.82
	UMC-3	7.10	234	10.73	88.6	7.79
	UMC-4	6.90	233	10.59	87.2	7.76
	UMC-5	6.70	234	10.73	88.4	7.54
	Mean	7.08	234	10.65	88.1	7.74
	Standard Deviation	0.29	1	0.08	0.6	0.12
Lower Wolverine Creek (Reference)	LWC-1	4.70	165	3.35	26.1	7.03
	LWC-2	5.50	166	2.82	22.3	6.93
	LWC-3	5.30	166	2.62	20.8	6.93
	LWC-4	5.20	164	3.76	29.3	6.95
	LWC-5	5.10	166	3.76	29.3	6.54
	Mean	5.16	165	3.26	25.6	6.88
	Standard Deviation	0.30	1	0.53	3.9	0.19
Lower Minto Creek (Exposure)	LMC-1	6.80	310	11.52	94.9	7.87
	LMC-2	3.30	274	12.24	92.0	8.22
	LMC-3	3.20	274	12.66	94.5	8.20
	LMC-4	6.90	312	11.65	94.6	7.81
	LMC-5	6.30	313	11.93	97.5	7.56
	Mean	5.30	297	12.00	94.7	7.93
	Standard Deviation	1.89	21	0.46	2.0	0.28

Value does not meet the water quality objective.

[a] Range for the Water Use Licence is 6.0 - 9.0.

Table B.4: *In situ* water quality measures at benthic invertebrate sampling stations, Minto Mine WUL, September 2016.

Area	Variable	Temperature	Specific Conductance	Dissolved Oxygen	Dissolved Oxygen	pH	Mean Depth	Mean Velocity
	Unit	**°C**	**µS/cm**	**mg/L**	**%**	**pH units**	**m**	**m/s**
	CCME Water Quality Guidelines	**-**	**-**	**6.5 - 9.5**	**54**	**6.5 - 9.0[a]**	**-**	**-**
Lower Wolverine Creek (Reference)	LWC-1	1.90	174	13.94	101.6	8.06	0.14	0.35
	LWC-2	1.90	172	13.53	97.6	8.21	0.16	0.30
	LWC-3	2.00	143	13.62	98.7	8.22	0.11	0.35
	LWC-4	1.20	170	13.29	93.9	8.17	0.15	0.31
	LWC-5	1.20	172	12.66	89.4	7.86	0.11	0.32
	Mean	1.64	166	13.41	96.2	8.10	0.13	0.33
	Standard Deviation	0.40	13	0.48	4.7	0.15	0.02	0.02
Lower Big Creek (Reference)	LBC-1	3.90	187	13.77	104.9	8.47	0.19	0.32
	LBC-2	3.60	187	14.00	105.7	8.53	0.11	0.33
	LBC-3	4.50	184	13.63	105.3	8.65	0.13	0.31
	LBC-4	2.90	188	13.72	101.8	8.25	0.14	0.34
	LBC-5	2.50	188	13.44	98.5	7.93	0.13	0.33
	Mean	3.48	187	13.71	103.2	8.37	0.14	0.33
	Standard Deviation	0.79	2	0.20	3.1	0.28	0.03	0.01
Lower Minto Creek (Exposure)	LMC-1	2.80	269	13.45	99.4	-	0.09	0.32
	LMC-2	1.80	267	13.83	99.5	8.25	0.11	0.32
	LMC-3	4.00	270	12.91	98.7	8.40	0.09	0.35
	LMC-4	3.90	271	12.77	97.2	8.37	0.10	0.32
	LMC-5	2.90	312	12.85	95.1	-	0.09	0.34
	Mean	3.08	278	13.16	98.0	8.34	0.10	0.33
	Standard Deviation	0.90	19	0.46	1.9	0.08	0.01	0.01

Value does not meet the water quality objective.

[a] Range for the Water Use Licence is 6.0 - 9.0.

Table B.5: Water quality results at reference and exposure areas, Minto Mine WUL, September 2016.

Analyte		Units	URC (reference)	UMC (exposure)	LWC (reference)	LBC (reference)	LMC (exposure)
Sampling Dates:			26-Sep-16	28-Sep-16	26-Sep-16	28-Sep-16	28-Sep-16
Physical Tests	Conductivity	µS/cm	142	252	191	207	294
	Hardness (as $CaCO_3$)	mg/L	75	120	98	104	159
	pH	pH Units	7.88	8.10	8.11	8.24	8.22
	Total Suspended Solids	mg/L	< 3.0	< 3.0	< 3.0	< 3.0	3.9
	Total Dissolved Solids	mg/L	101	179	141	148	212
	Turbidity	NTU	1.6	0.82	1.0	1.1	1.4
Anions and Nutrients	Total Alkalinity	mg/L	68	96	95	99	141
	Total Ammonia (as N)	mg/L	0.0058	0.0077	0.0051	< 0.0050	< 0.0050
	Bromide (Br)	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
	Chloride (Cl)	mg/L	< 0.50	2.9	< 0.50	0.56	2.1
	Fluoride (F)	mg/L	0.25	0.16	0.13	0.13	0.29
	Nitrate (as N)	mg/L	0.050	2.3	< 0.0050	0.030	0.84
	Nitrite (as N)	mg/L	< 0.0010	0.0039	< 0.0010	< 0.0010	< 0.0010
	Phosphorus (P)-Total dissolved	mg/L	0.014	0.0066	0.0068	0.0035	0.0097
	Phosphorus (P)-Total	mg/L	0.018	0.013	0.0069	0.0053	0.012
	Sulfate (SO_4)	mg/L	8.8	31	14	14	21
Cyanides	Total Cyanide	mg/L	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
Organic/inorganic carbon	Dissolved Organic Carbon	mg/L	15	5.4	17	8.5	9.4
	Total Inorganic Carbon	mg/L	13.4	24	21	24	32
	Total Organic Carbon	mg/L	14	5.2	16.9	8.2	9.5
Total Metals	Total Aluminum (Al)	mg/L	0.095	0.023	0.060	0.059	0.041
	Total Antimony (Sb)	mg/L	< 0.00010	< 0.00010	< 0.00010	0.00018	0.00010
	Total Arsenic (As)	mg/L	0.00065	0.00021	0.00052	0.0010	0.00051
	Total Barium (Ba)	mg/L	0.034	0.039	0.035	0.066	0.058
	Total Beryllium (Be)	mg/L	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Total Bismuth (Bi)	mg/L	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
	Total Boron (B)	mg/L	< 0.010	0.028	< 0.010	< 0.010	0.012
	Total Cadmium (Cd)	mg/L	0.0000051	0.000015	< 0.0000050	0.0000066	< 0.0000050
	Total Calcium (Ca)	mg/L	21	32	21	25	43
	Total Chromium (Cr)	mg/L	0.00058	0.00010	0.00063	0.00031	0.00025
	Total Cobalt (Co)	mg/L	0.00019	< 0.00010	0.00011	< 0.00010	< 0.00010
	Total Copper (Cu)	mg/L	0.0017	0.0066	0.0022	0.0023	0.0023
	Total Iron (Fe)	mg/L	0.69	0.046	0.22	0.12	0.20
	Total Lead (Pb)	mg/L	< 0.000050	< 0.000050	< 0.000050	0.000071	< 0.000050
	Total Lithium (Li)	mg/L	< 0.0010	0.0010	0.0016	0.0014	0.0014
	Total Magnesium (Mg)	mg/L	6.1	10	11	10	14
	Total Manganese (Mn)	mg/L	0.050	0.039	0.015	0.017	0.013
	Total Mercury (Hg)	mg/L	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
	Total Molybdenum (Mo)	mg/L	0.0010	0.0024	0.00057	0.0014	0.0016
	Total Nickel (Ni)	mg/L	0.0014	0.00053	0.0021	0.0013	0.0011
	Total Phosphorus (P)	mg/L	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
	Total Potassium (K)	mg/L	0.47	1.8	0.63	0.86	1.4
	Total Selenium (Se)	mg/L	0.00027	0.00059	0.00011	0.000055	0.00022
	Total Silicon (Si)	mg/L	7.1	2.3	6.0	6.5	5.4
	Total Silver (Ag)	mg/L	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Total Sodium (Na)	mg/L	4.2	12	7.3	7.9	9.9
	Total Strontium (Sr)	mg/L	0.13	0.33	0.19	0.27	0.36
	Total Thallium (Tl)	mg/L	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Total Tin (Sn)	mg/L	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Total Titanium (Ti)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
	Total Uranium (U)	mg/L	0.00043	0.00074	0.00068	0.0027	0.0010
	Total Vanadium (V)	mg/L	0.0011	< 0.00050	0.0012	0.0011	0.00075
	Total Zinc (Zn)	mg/L	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Dissolved Metals	Dissolved Aluminum (Al)	mg/L	0.029	0.0017	0.027	0.017	0.0052
	Dissolved Antimony (Sb)	mg/L	< 0.00010	< 0.00010	< 0.00010	0.00014	< 0.00010
	Dissolved Arsenic (As)	mg/L	0.00053	0.00018	0.00046	0.00075	0.00047
	Dissolved Barium (Ba)	mg/L	0.032	0.038	0.036	0.066	0.058
	Dissolved Beryllium (Be)	mg/L	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Dissolved Bismuth (Bi)	mg/L	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
	Dissolved Boron (B)	mg/L	< 0.010	0.027	< 0.010	< 0.010	0.012
	Dissolved Cadmium (Cd)	mg/L	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
	Dissolved Calcium (Ca)	mg/L	20	32	21	25	42
	Dissolved Chromium (Cr)	mg/L	0.00037	< 0.00010	0.00049	0.00021	0.00016
	Dissolved Cobalt (Co)	mg/L	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Dissolved Copper (Cu)	mg/L	0.0013	0.0057	0.0020	0.0019	0.0021
	Dissolved Iron (Fe)	mg/L	0.35	< 0.010	0.17	0.047	0.10
	Dissolved Lead (Pb)	mg/L	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
	Dissolved Lithium (Li)	mg/L	< 0.0010	< 0.0010	0.0015	0.0014	0.0014
	Dissolved Magnesium (Mg)	mg/L	6.0	10	11	10	13
	Dissolved Manganese (Mn)	mg/L	0.029	0.015	0.012	0.015	0.0051
	Dissolved Mercury (Hg)	mg/L	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
	Dissolved Molybdenum (Mo)	mg/L	0.00080	0.0021	0.00044	0.0012	0.0015
	Dissolved Nickel (Ni)	mg/L	0.0012	< 0.00050	0.0019	0.0011	0.0010
	Dissolved Phosphorus (P)	mg/L	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
	Dissolved Potassium (K)	mg/L	0.47	1.8	0.65	0.85	1.4
	Dissolved Selenium (Se)	mg/L	0.00030	0.00069	0.00013	0.000073	0.00023
	Dissolved Silicon (Si)	mg/L	6.8	2.2	5.8	6.3	5.1
	Dissolved Silver (Ag)	mg/L	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Dissolved Sodium (Na)	mg/L	4.1	11	7.3	7.7	9.7
	Dissolved Strontium (Sr)	mg/L	0.12	0.32	0.18	0.26	0.36
	Dissolved Thallium (Tl)	mg/L	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Dissolved Tin (Sn)	mg/L	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Dissolved Titanium (Ti)	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
	Dissolved Uranium (U)	mg/L	0.00036	0.00065	0.00061	0.0025	0.00090
	Dissolved Vanadium (V)	mg/L	0.00050	< 0.00050	0.00092	0.00080	< 0.00050
	Dissolved Zinc (Zn)	mg/L	< 0.0010	0.0036	< 0.0010	< 0.0010	< 0.0010

Table B.6: Explanatory notes for selected water quality guidelines, Minto Mine WUL, 2016.

Analyte		Water Quality Guidelines	Unit	CCME[1]
Physical, anion and nutrient analytes	Ammonia (Total)	**0.41**	mg/L	Ammonia guideline is based on highest field pH of 8.41 and highest temperature of 7.4°C
	Fluoride	**0.12**	mg/L	Guideline is an interim level
	Total Suspended Solids	**8.0 / 28[a]**	mg/L	Guideline is based on the median of background of 3.0 mg/L plus 5.0 mg/L for 30 day and plus 25 mg/L for max
	Turbidity	**3.1 / 9.1[a]**	NTU	Guideline is based on the median of background of 1.1 NTU plus 2.0 NTU for 30 day and plus 8 NTU for max
Total Metals	Aluminum	**0.10**	mg/L	Guideline is based on pH of > 6.5
	Cadmium	**0.00013 / 0.0016[a]**	mg/L	Guideline is based on lowest hardness of 75 mg/L
	Chromium	**0.0010**	mg/L	Guideline is based hexavalent chromium (Cr VI)
	Copper	**0.0020**	mg/L	Guideline is based on lowest hardness of 75 mg/L
	Lead	**0.0022**	mg/L	Guideline is based on lowest hardness of 75 mg/L
	Nickel	**0.077**	mg/L	Guideline is based on lowest hardness of 75 mg/L

[1] CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. 1999 (plus updates), Canadian Council of Ministers of the Environment, Winnipeg. See Appendix Table B.6 for explanatory notes on selected water quality guidelines.

[a] 30 day guideline / Max guideline.

Table B.7: Comparison of water quality results at reference and exposure areas in 2015 and 2016, Minto Mine WUL.

Analyte		Units	CCME Water Quality Guidelines[1]		WUL Objectives at W2	2015					2016				
			30 Day	Max		Upper McGinty Creek (reference)	Upper Minto Creek (exposure)	Lower Wolverine Creek (reference)	Little Big Creek (reference)	Lower Minto Creek (exposure)	Upper McGinty Creek (reference)	Upper Minto Creek (exposure)	Lower Wolverine Creek (reference)	Little Big Creek (reference)	Lower Minto Creek (exposure)
Physical Tests	Total Suspended Solids	mg/L	8.0[a]	28[a]	-	5.3	21	6.0	13	8.7	< 3.0	< 3.0	< 3.0	< 3.0	3.9
Total Metals	Total Aluminum (Al)	mg/L	0.10[b]	-	-	0.074	0.085	0.28	0.31	0.077	0.095	0.023	0.060	0.059	0.041
	Total Antimony (Sb)	mg/L	-	-	-	0.00010	< 0.00010	< 0.00010	0.00020	< 0.00010	< 0.00010	< 0.00010	< 0.00010	0.00018	0.00010
	Total Arsenic (As)	mg/L	0.0050	-	-	0.00065	0.00038	0.00062	0.0017	0.00066	0.00065	0.00021	0.00052	0.0010	0.00051
	Total Barium (Ba)	mg/L	-	-	-	0.034	0.079	0.035	0.058	0.065	0.034	0.039	0.035	0.066	0.058
	Total Beryllium (Be)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Total Bismuth (Bi)	mg/L	-	-	-	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
	Total Boron (B)	mg/L	1.5	2.9	-	< 0.010	0.026	< 0.010	< 0.010	< 0.010	< 0.010	0.028	< 0.010	< 0.010	0.012
	Total Cadmium (Cd)	mg/L	0.00013[c]	0.0016[c]	-	< 0.0000050	< 0.0000050	0.0000080	0.000016	< 0.0000050	0.0000051	0.000015	< 0.0000050	0.0000066	< 0.0000050
	Total Calcium (Ca)	mg/L	-	-	-	16	56	15	20	45	21	32	21	25	43
	Total Chromium (Cr)	mg/L	0.0010 Cr(VI)	-	-	0.00069	0.00026	0.0012	0.00076	0.00044	0.00058	0.00010	0.00063	0.00031	0.00025
	Total Cobalt (Co)	mg/L	-	-	-	0.00015	0.00010	0.00025	0.00023	0.00011	0.00019	< 0.00010	0.00011	< 0.00010	< 0.00010
	Total Copper (Cu)	mg/L	0.0020[c]	-	-	0.0022	0.0043	0.0032	0.0040	0.0022	0.0017	0.0066	0.0022	0.0023	0.0023
	Total Iron (Fe)	mg/L	0.30	-	-	0.50	0.15	0.50	0.44	0.24	0.69	0.046	0.22	0.12	0.20
	Total Lead (Pb)	mg/L	0.0022[c]	-	-	< 0.000050	0.000088	0.00011	0.00029	< 0.000050	< 0.000050	< 0.000050	< 0.000050	0.000071	< 0.000050
	Total Lithium (Li)	mg/L	-	-	-	0.0013	0.0043	0.0023	0.0024	0.0024	< 0.0010	0.0010	0.0016	0.0014	0.0014
	Total Magnesium (Mg)	mg/L	-	-	-	4.5	27	7.8	7.8	15	6.1	10	11	10	14
	Total Manganese (Mn)	mg/L	-	-	-	0.027	0.051	0.019	0.021	0.010	0.050	0.039	0.015	0.017	0.013
	Total Mercury (Hg)	mg/L	0.000026	-	-	0.0000084	< 0.0000050	0.000011	0.0000080	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
	Total Molybdenum (Mo)	mg/L	0.073	-	-	0.00060	0.0051	0.00040	0.0012	0.0015	0.0010	0.0024	0.00057	0.0014	0.0016
	Total Nickel (Ni)	mg/L	0.077[c]	-	-	0.0014	0.0010	0.0024	0.0015	0.0013	0.0014	0.00053	0.0021	0.0013	0.0011
	Total Phosphorus (P)	mg/L	-	-	-	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
	Total Potassium (K)	mg/L	-	-	-	0.39	2.3	0.52	0.75	1.4	0.47	1.8	0.63	0.86	1.4
	Total Selenium (Se)	mg/L	0.0010	-	-	0.00026	0.00034	0.00011	0.000069	0.00012	0.00027	0.00059	0.00011	0.000055	0.00022
	Total Silicon (Si)	mg/L	-	-	-	6.7	6.4	5.9	7.3	6.9	7.1	2.3	6.0	6.5	5.4
	Total Silver (Ag)	mg/L	0.00025		-	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Total Sodium (Na)	mg/L	-	-	-	3.5	18	5.1	5.7	9.4	4.2	12	7.3	7.9	9.9
	Total Strontium (Sr)	mg/L	-	-	-	0.10	0.72	0.14	0.21	0.43	0.13	0.33	0.19	0.27	0.36
	Total Thallium (Tl)	mg/L	0.00080	-	-	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Total Tin (Sn)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Total Titanium (Ti)	mg/L	-	-	-	< 0.010	< 0.010	0.012	0.012	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
	Total Uranium (U)	mg/L	0.015	0.033	-	0.00020	0.0026	0.00040	0.0016	0.0014	0.00043	0.00074	0.00068	0.0027	0.0010
	Total Vanadium (V)	mg/L	-	-	-	0.0012	0.0010	0.0022	0.0020	0.0013	0.0011	< 0.00050	0.0012	0.0011	0.00075
	Total Zinc (Zn)	mg/L	0.030	-	-	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030

Water use licence objectives not met.

Water quality guideline not met.

[1] CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. 1999 (plus updates), Canadian Council of Ministers of the Environment, Winnipeg. See Appendix Table B.6 for explanatory notes on selected water quality guidelines.

[a] Based on the median of background levels plus 5 mg/L for 30 day and 25 mg/L for max guidelines.

[b] Based on lowest guideline using highest pH.

[c] Based on lowest guideline using lowest hardness.

[d] Dissolved copper water quality objective depends on concentration of dissolved organic carbon (DOC). If DOC is > 10 mg/L/ DOC is ≤ 10 mg/L.

Table B.7: Comparison of water quality results at reference and exposure areas in 2015 and 2016, Minto Mine WUL.

Analyte		Units	CCME Water Quality Guidelines[1]		WUL Objectives at W2	2015					2016				
			30 Day	Max		Upper McGinty Creek (reference)	Upper Minto Creek (exposure)	Lower Wolverine Creek (reference)	Little Big Creek (reference)	Lower Minto Creek (exposure)	Upper McGinty Creek (reference)	Upper Minto Creek (exposure)	Lower Wolverine Creek (reference)	Little Big Creek (reference)	Lower Minto Creek (exposure)
Dissolved Metals	Dissolved Aluminum (Al)	mg/L	-	-	0.10	0.054	0.0028	0.047	0.035	0.010	0.029	0.0017	0.027	0.017	0.0052
	Dissolved Antimony (Sb)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	0.00015	< 0.00010	< 0.00010	< 0.00010	< 0.00010	0.00014	< 0.00010
	Dissolved Arsenic (As)	mg/L	-	-	0.0050	0.00053	0.00028	0.00045	0.00081	0.00055	0.00053	0.00018	0.00046	0.00075	0.00047
	Dissolved Barium (Ba)	mg/L	-	-	-	0.034	0.077	0.032	0.053	0.061	0.032	0.038	0.036	0.066	0.058
	Dissolved Beryllium (Be)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Dissolved Bismuth (Bi)	mg/L	-	-	-	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
	Dissolved Boron (B)	mg/L	-	-	-	< 0.010	0.022	< 0.010	< 0.010	< 0.010	< 0.010	0.027	< 0.010	< 0.010	0.012
	Dissolved Cadmium (Cd)	mg/L	-	-	0.15	< 0.0000050	< 0.0000050	< 0.0000050	0.0000069	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
	Dissolved Calcium (Ca)	mg/L	-	-	-	16	58	16	20	44	20	32	21	25	42
	Dissolved Chromium (Cr)	mg/L	-	-	0.0010	0.00056	0.00013	0.00063	0.00032	0.00025	0.00037	< 0.00010	0.00049	0.00021	0.00016
	Dissolved Cobalt (Co)	mg/L	-	-	-	0.00012	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Dissolved Copper (Cu)	mg/L	-	-	0.020/0.013[d]	0.0021	0.0026	0.0026	0.0024	0.0019	0.0013	0.0057	0.0020	0.0019	0.0021
	Dissolved Iron (Fe)	mg/L	-	-	1.1	0.39	0.020	0.17	0.071	0.12	0.35	< 0.010	0.17	0.047	0.10
	Dissolved Lead (Pb)	mg/L	-	-	0.0040	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050
	Dissolved Lithium (Li)	mg/L	-	-	-	< 0.0010	0.0038	0.0016	0.0017	0.0020	< 0.0010	< 0.0010	0.0015	0.0014	0.0014
	Dissolved Magnesium (Mg)	mg/L	-	-	-	4.5	29	8.0	7.8	15	6.0	10	11	10	13
	Dissolved Manganese (Mn)	mg/L	-	-	-	0.024	0.042	0.0071	0.0091	0.0027	0.029	0.015	0.012	0.015	0.0051
	Dissolved Mercury (Hg)	mg/L	-	-	-	< 0.0000050	< 0.0000050	0.000010	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050	< 0.0000050
	Dissolved Molybdenum (Mo)	mg/L	-	-	0.073	0.00054	0.0050	0.00041	0.0011	0.0015	0.00080	0.0021	0.00044	0.0012	0.0015
	Dissolved Nickel (Ni)	mg/L	-	-	0.11	0.0013	0.00088	0.0019	0.0011	0.0011	0.0012	< 0.00050	0.0019	0.0011	0.0010
	Dissolved Phosphorus (P)	mg/L	-	-	-	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
	Dissolved Potassium (K)	mg/L	-	-	-	0.37	2.3	0.53	0.69	1.4	0.47	1.8	0.65	0.85	1.4
	Dissolved Selenium (Se)	mg/L	-	-	0.0020	0.00022	0.00033	0.00012	0.000058	0.00012	0.00030	0.00069	0.00013	0.000073	0.00023
	Dissolved Silicon (Si)	mg/L	-	-	-	6.6	6.4	5.5	6.8	6.5	6.8	2.2	5.8	6.3	5.1
	Dissolved Silver (Ag)	mg/L	-	-	0.00010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Dissolved Sodium (Na)	mg/L	-	-	-	3.3	18	5.3	5.6	9.1	4.1	11	7.3	7.7	9.7
	Dissolved Strontium (Sr)	mg/L	-	-	-	0.099	0.72	0.14	0.21	0.42	0.12	0.32	0.18	0.26	0.36
	Dissolved Thallium (Tl)	mg/L	-	-	-	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
	Dissolved Tin (Sn)	mg/L	-	-	-	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	Dissolved Titanium (Ti)	mg/L	-	-	-	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
	Dissolved Uranium (U)	mg/L	-	-	-	0.00020	0.0025	0.00036	0.0016	0.0013	0.00036	0.00065	0.00061	0.0025	0.00090
	Dissolved Vanadium (V)	mg/L	-	-	-	0.00069	< 0.00050	0.0012	0.00093	0.00073	0.00050	< 0.00050	0.00092	0.00080	< 0.00050
	Dissolved Zinc (Zn)	mg/L	-	-	0.030	0.0017	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0036	< 0.0010	< 0.0010	< 0.0010

Water use licence objectives not met.

Water quality guideline not met.

[1] CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. 1999 (plus updates), Canadian Council of Ministers of the Environment, Winnipeg. See Appendix Table B.6 for explanatory notes on selected water quality guidelines.

[a] Based on the median of background levels plus 5 mg/L for 30 day and 25 mg/L for max guidelines.

[b] Based on lowest guideline using highest pH.

[c] Based on lowest guideline using lowest hardness.

[d] Dissolved copper water quality objective depends on concentration of dissolved organic carbon (DOC). If DOC is > 10 mg/L/ DOC is ≤ 10 mg/L.

Table B.8: Concentration of chlorophyll α measured at five benthic stations in lower Wolverine and lower Minto Creeks, Minto Mine WUL, 2016.

Lower Wolverine Creek (reference)		**Lower Minto Creek (exposure)**	
Station	mg/m^2	Station	mg/m^2
LWC-1	68	LMC-1	37
LWC-2	38	LMC-2	78
LWC-3	26	LMC-3	160
LWC-4	24	LMC-4	46
LWC-5	41	LMC-5	44
Mean	39	Mean	73
Standard Deviation	18	Standard Deviation	51

[shaded] BCWQG for chlorophyll α not met (100 mg/m^2).

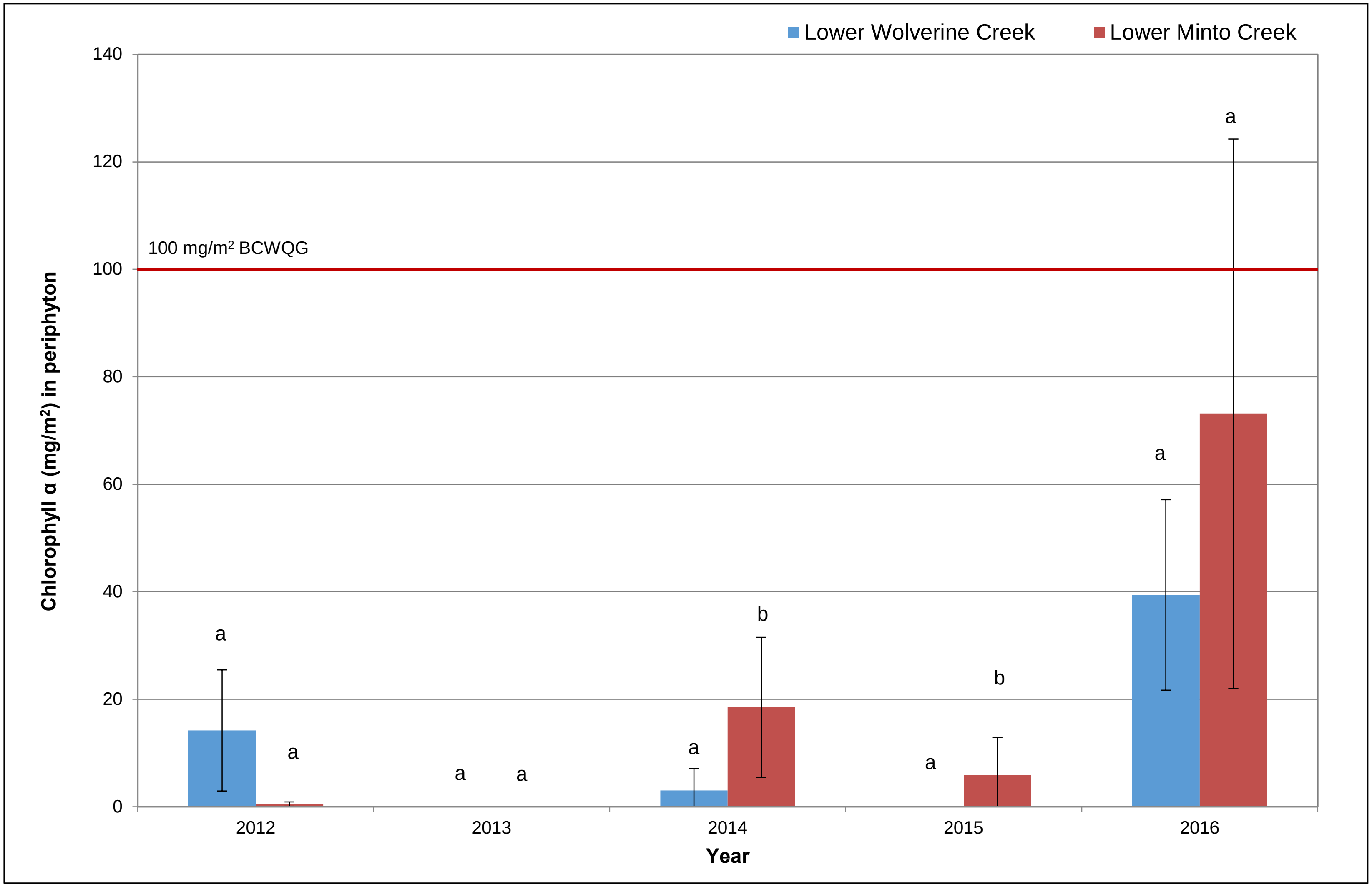

Figure B.1: Concentrations of chlorophyll *α* in periphyton measured in lower Wolverine and lower Minto Creeks, Minto Mine WUL, 2012 - 2016. Data presented as mean ± standard deviation. Different letters represent significant differences between sites within years.

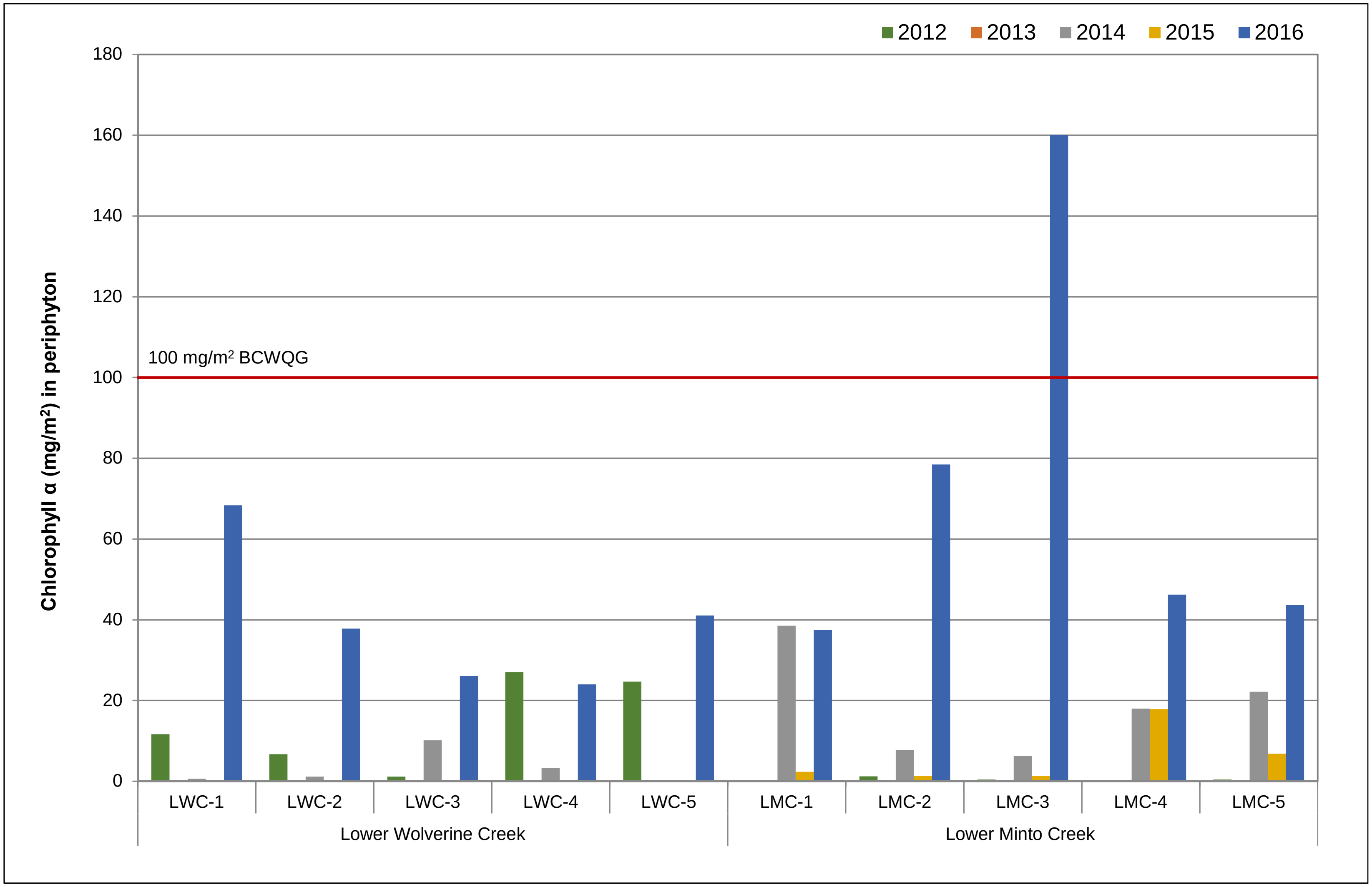

Figure B.2: Concentrations of chlorophyll *α* in periphyton measured at lower Wolverine and lower Minto creeks, Minto Mine WUL, 2012 - 2016.

MINNOW ENVIRONMENTAL INC.
ATTN: Lisa Bowron
101 - 1025 Hillside Ave.
Victoria BC V8T 2A2

Date Received: 01-OCT-16
Report Date: 05-OCT-16 18:32 (MT)
Version: FINAL

Client Phone: 250-595-1627

Certificate of Analysis

Lab Work Order #: L1837418

Project P.O. #: NOT SUBMITTED
Job Reference: MINNOW PROJECT 16-80
C of C Numbers:
Legal Site Desc:

Selam Worku
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1837418-1	L1837418-2	L1837418-3	L1837418-4	L1837418-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	28-SEP-16	28-SEP-16	28-SEP-16	28-SEP-16	26-SEP-16
	Sampled Time					
	Client ID	LBCX	LMC	LBC	UMC	URC
WATER						
Physical Tests	Conductivity (uS/cm)	208	294	207	252	142
	Hardness (as CaCO3) (mg/L)	104	159	104	120	75.2
	pH (pH)	8.23	8.22	8.24	8.10	7.88
	Total Suspended Solids (mg/L)	4.3	3.9	<3.0	<3.0	<3.0
	Total Dissolved Solids (mg/L)	158	212	148	179	101
	Turbidity (NTU)	1.14	1.42	1.11	0.82	1.62
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	100	141	98.7	95.8	67.9
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050	0.0077	0.0058
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	0.57	2.13	0.56	2.86	<0.50
	Fluoride (F) (mg/L)	0.133	0.292	0.133	0.163	0.249
	Nitrate (as N) (mg/L)	0.0298	0.844	0.0301	2.34	0.0502
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	0.0039	<0.0010
	Phosphorus (P)-Total Dissolved (mg/L)	0.0029	0.0097	0.0035	0.0066	0.0142
	Phosphorus (P)-Total (mg/L)	0.0047	0.0118	0.0053	0.0126	0.0177
	Sulfate (SO4) (mg/L)	14.2	21.2	14.3	31.0	8.80
Cyanides	Cyanide, Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	8.21	9.42	8.50	5.37	14.5
	Total Inorganic Carbon (mg/L)	22.5	32.2	24.3	23.8	13.4
	Total Organic Carbon (mg/L)	8.22	9.49	8.23	5.16	14.2
Total Metals	Aluminum (Al)-Total (mg/L)	0.0554	0.0410	0.0588	0.0230	0.0952
	Antimony (Sb)-Total (mg/L)	0.00021	0.00010	0.00018	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00092	0.00051	0.00095	0.00021	0.00065
	Barium (Ba)-Total (mg/L)	0.0663	0.0582	0.0662	0.0390	0.0340
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	0.012	<0.010	0.028	<0.010
	Cadmium (Cd)-Total (mg/L)	0.0000072	<0.0000050	0.0000066	0.0000149	0.0000051
	Calcium (Ca)-Total (mg/L)	25.4	42.5	24.9	31.7	20.5
	Chromium (Cr)-Total (mg/L)	0.00031	0.00025	0.00031	0.00010	0.00058
	Cobalt (Co)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	0.00019
	Copper (Cu)-Total (mg/L)	0.00222	0.00232	0.00225	0.00662	0.00172
	Iron (Fe)-Total (mg/L)	0.113	0.202	0.116	0.046	0.689
	Lead (Pb)-Total (mg/L)	0.000083	<0.000050	0.000071	<0.000050	<0.000050
	Lithium (Li)-Total (mg/L)	0.0015	0.0014	0.0014	0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	10.5	13.7	10.3	10.1	6.07

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837418-6				
	Description	WATER				
	Sampled Date	26-SEP-16				
	Sampled Time					
	Client ID	LWC-3				
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	191				
	Hardness (as CaCO3) (mg/L)	97.7				
	pH (pH)	8.11				
	Total Suspended Solids (mg/L)	<3.0				
	Total Dissolved Solids (mg/L)	141				
	Turbidity (NTU)	1.0				
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	94.5				
	Ammonia, Total (as N) (mg/L)	0.0051				
	Bromide (Br) (mg/L)	<0.050				
	Chloride (Cl) (mg/L)	<0.50				
	Fluoride (F) (mg/L)	0.127				
	Nitrate (as N) (mg/L)	<0.0050				
	Nitrite (as N) (mg/L)	<0.0010				
	Phosphorus (P)-Total Dissolved (mg/L)	0.0068				
	Phosphorus (P)-Total (mg/L)	0.0069				
	Sulfate (SO4) (mg/L)	13.8				
Cyanides	Cyanide, Total (mg/L)	<0.0050				
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	16.7				
	Total Inorganic Carbon (mg/L)	20.8				
	Total Organic Carbon (mg/L)	16.9				
Total Metals	Aluminum (Al)-Total (mg/L)	0.0601				
	Antimony (Sb)-Total (mg/L)	<0.00010				
	Arsenic (As)-Total (mg/L)	0.00052				
	Barium (Ba)-Total (mg/L)	0.0354				
	Beryllium (Be)-Total (mg/L)	<0.00010				
	Bismuth (Bi)-Total (mg/L)	<0.000050				
	Boron (B)-Total (mg/L)	<0.010				
	Cadmium (Cd)-Total (mg/L)	<0.0000050				
	Calcium (Ca)-Total (mg/L)	21.0				
	Chromium (Cr)-Total (mg/L)	0.00063				
	Cobalt (Co)-Total (mg/L)	0.00011				
	Copper (Cu)-Total (mg/L)	0.00221				
	Iron (Fe)-Total (mg/L)	0.215				
	Lead (Pb)-Total (mg/L)	<0.000050				
	Lithium (Li)-Total (mg/L)	0.0016				
	Magnesium (Mg)-Total (mg/L)	11.4				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1837418-1	L1837418-2	L1837418-3	L1837418-4	L1837418-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	28-SEP-16	28-SEP-16	28-SEP-16	28-SEP-16	26-SEP-16
	Sampled Time					
	Client ID	LBCX	LMC	LBC	UMC	URC
WATER						
Total Metals	Manganese (Mn)-Total (mg/L)	0.0169	0.0126	0.0171	0.0389	0.0504
	Mercury (Hg)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Total (mg/L)	0.00142	0.00163	0.00142	0.00239	0.00100
	Nickel (Ni)-Total (mg/L)	0.00136	0.00106	0.00128	0.00053	0.00137
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	0.866	1.39	0.863	1.76	0.473
	Selenium (Se)-Total (mg/L)	0.000072	0.000224	0.000055	0.000585	0.000272
	Silicon (Si)-Total (mg/L)	6.54	5.38	6.46	2.33	7.08
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	7.83	9.89	7.89	11.5	4.17
	Strontium (Sr)-Total (mg/L)	0.269	0.363	0.267	0.329	0.129
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Total (mg/L)	0.00274	0.00104	0.00271	0.000738	0.000434
	Vanadium (V)-Total (mg/L)	0.00105	0.00075	0.00109	<0.00050	0.00108
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0184	0.0052	0.0169	0.0017	0.0287
	Antimony (Sb)-Dissolved (mg/L)	0.00015	<0.00010	0.00014	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00075	0.00047	0.00075	0.00018	0.00053
	Barium (Ba)-Dissolved (mg/L)	0.0663	0.0582	0.0664	0.0377	0.0315
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	<0.010	0.012	<0.010	0.027	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	25.1	42.2	24.9	31.9	20.3
	Chromium (Cr)-Dissolved (mg/L)	0.00022	0.00016	0.00021	<0.00010	0.00037
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	0.00219	0.00210	0.00186	0.00568	0.00134
	Iron (Fe)-Dissolved (mg/L)	0.050	0.101	0.047	<0.010	0.350
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0014	0.0014	0.0014	<0.0010	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	10.1	13.0	10.1	9.85	5.99
	Manganese (Mn)-Dissolved (mg/L)	0.0152	0.00513	0.0150	0.0145	0.0293
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837418-6				
	Description	WATER				
	Sampled Date	26-SEP-16				
	Sampled Time					
	Client ID	LWC-3				
Grouping	**Analyte**					
WATER						
Total Metals	Manganese (Mn)-Total (mg/L)	0.0148				
	Mercury (Hg)-Total (mg/L)	<0.0000050				
	Molybdenum (Mo)-Total (mg/L)	0.000570				
	Nickel (Ni)-Total (mg/L)	0.00205				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	0.634				
	Selenium (Se)-Total (mg/L)	0.000109				
	Silicon (Si)-Total (mg/L)	6.02				
	Silver (Ag)-Total (mg/L)	<0.000010				
	Sodium (Na)-Total (mg/L)	7.31				
	Strontium (Sr)-Total (mg/L)	0.188				
	Thallium (Tl)-Total (mg/L)	<0.000010				
	Tin (Sn)-Total (mg/L)	<0.00010				
	Titanium (Ti)-Total (mg/L)	<0.010				
	Uranium (U)-Total (mg/L)	0.000677				
	Vanadium (V)-Total (mg/L)	0.00120				
	Zinc (Zn)-Total (mg/L)	<0.0030				
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD				
	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	0.0271				
	Antimony (Sb)-Dissolved (mg/L)	<0.00010				
	Arsenic (As)-Dissolved (mg/L)	0.00046				
	Barium (Ba)-Dissolved (mg/L)	0.0356				
	Beryllium (Be)-Dissolved (mg/L)	<0.00010				
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050				
	Boron (B)-Dissolved (mg/L)	<0.010				
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050				
	Calcium (Ca)-Dissolved (mg/L)	20.9				
	Chromium (Cr)-Dissolved (mg/L)	0.00049				
	Cobalt (Co)-Dissolved (mg/L)	<0.00010				
	Copper (Cu)-Dissolved (mg/L)	0.00203				
	Iron (Fe)-Dissolved (mg/L)	0.172				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	0.0015				
	Magnesium (Mg)-Dissolved (mg/L)	11.1				
	Manganese (Mn)-Dissolved (mg/L)	0.0117				
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837418-1	L1837418-2	L1837418-3	L1837418-4	L1837418-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	28-SEP-16	28-SEP-16	28-SEP-16	28-SEP-16	26-SEP-16
	Sampled Time					
	Client ID	LBCX	LMC	LBC	UMC	URC
Grouping	**Analyte**					
WATER						
Dissolved Metals	Molybdenum (Mo)-Dissolved (mg/L)	0.00124	0.00145	0.00121	0.00210	0.000798
	Nickel (Ni)-Dissolved (mg/L)	0.00128	0.00101	0.00111	<0.00050	0.00118
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	0.857	1.40	0.845	1.76	0.469
	Selenium (Se)-Dissolved (mg/L)	0.000066	0.000231	0.000073	0.000692	0.000296
	Silicon (Si)-Dissolved (mg/L)	6.31	5.10	6.31	2.23	6.80
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	7.76	9.68	7.69	11.4	4.07
	Strontium (Sr)-Dissolved (mg/L)	0.262	0.360	0.259	0.317	0.123
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.00252	0.000899	0.00248	0.000648	0.000364
	Vanadium (V)-Dissolved (mg/L)	0.00082	<0.00050	0.00080	<0.00050	0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0023	<0.0010	<0.0010	0.0036	<0.0010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837418-6				
	Description	WATER				
	Sampled Date	26-SEP-16				
	Sampled Time					
	Client ID	LWC-3				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Molybdenum (Mo)-Dissolved (mg/L)	0.000438				
	Nickel (Ni)-Dissolved (mg/L)	0.00193				
	Phosphorus (P)-Dissolved (mg/L)	<0.30				
	Potassium (K)-Dissolved (mg/L)	0.647				
	Selenium (Se)-Dissolved (mg/L)	0.000125				
	Silicon (Si)-Dissolved (mg/L)	5.81				
	Silver (Ag)-Dissolved (mg/L)	<0.000010				
	Sodium (Na)-Dissolved (mg/L)	7.29				
	Strontium (Sr)-Dissolved (mg/L)	0.180				
	Thallium (Tl)-Dissolved (mg/L)	<0.000010				
	Tin (Sn)-Dissolved (mg/L)	<0.00010				
	Titanium (Ti)-Dissolved (mg/L)	<0.010				
	Uranium (U)-Dissolved (mg/L)	0.000607				
	Vanadium (V)-Dissolved (mg/L)	0.00092				
	Zinc (Zn)-Dissolved (mg/L)	<0.0010				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Dissolved Organic Carbon	MS-B	L1837418-1, -2, -3, -4, -5
Matrix Spike	Dissolved Organic Carbon	MS-B	L1837418-6
Matrix Spike	Total Inorganic Carbon	MS-B	L1837418-1, -2, -3, -4, -5, -6
Matrix Spike	Total Organic Carbon	MS-B	L1837418-1, -2, -3, -4, -5
Matrix Spike	Fluoride (F)	MS-B	L1837418-1, -2, -3, -4, -5, -6
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1837418-1, -2, -3, -4, -5, -6
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1837418-1, -2, -3, -4, -5, -6
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1837418-1, -2, -3, -4, -5, -6
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1837418-1, -2, -3, -4, -5, -6
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1837418-1, -2, -3, -4, -5, -6
Matrix Spike	Silicon (Si)-Total	MS-B	L1837418-1, -2, -3, -4, -5, -6
Matrix Spike	Sulfate (SO4)	MS-B	L1837418-1, -2, -3, -4, -5, -6

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TIC-VA	Water	Total inorganic carbon by CO2 purge	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CN-T-CFA-VA	Water	Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

HG-T-CVAA-VA	Water	Total Mercury in Water by CVAAS or CVAFS	EPA 1631E (mod)

Reference Information

Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-ICP-VA Water Dissolved Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA Water Total Metals in Water by CRC ICPMS EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-TOT-ICP-VA Water Total Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA Water Total P in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

P-TD-COL-VA Water Total Dissolved P in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-VA Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

Reference Information

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody / Analytical Request Form
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www.alsglobal.com

ALS Environmental

COC # ____________

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Water

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Minnow Environmental Inc.	☑ Standard ☐ Other		○ Regular (Standard Turnaround Times - Business Days)
Contact:	Lisa Bowron	☑ PDF ☑ Excel ☐ Digital ☐ Fax		● Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	101 - 1025 Hillside Ave.	Email 1:	lbowron@minnow.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Victoria, BC	Email 2:	pstecko@minnow.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(250)595-1627 x21 Fax: (250) 595-1625	Email 3:		
Invoice To	Same as Report ? ☐ Yes ☑ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Minnow Project 1680	
Company:	Minto Explorations Ltd	PO / AFE:		
Contact:	Cindy Keehn	LSD:		
Address:	Suite 2100 - 510 West Georgia St., Vancouver, BC			
Phone:	604-684-8894 Fax: 604-688-2180	Quote #:	Q51327	
[redacted] Lab Work Order # [redacted] (lab use only)		ALS Contact: Selam Worku	Sampler: Lisa Bowron	

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Metals by CCMS & ICPOES	Mercury by CVAFS (Low)	Alkalinity by Auto Titration	Phosphorus in water by colour	Organic/Inorganic Carbon	Cyanide	Conductivity, Hardness and pH	TDS & TSS by Gravimetric	Turbidity by Meter	Anions by Ion Chromatography	Ammonia by Fluorescence	**See Complete Quote #Q51327	Number of Containers
[redacted]	LBCX	28-Sep-16	—	Water	X	X	X	X	X	X	X	X	X	X	X	X	8
[redacted]	LMC	28-Sep-16	—		X	X	X	X	X	X	X	X	X	X	X	X	8
[redacted]	LBC	28-Sep-16	—		X	X	X	X	X	X	X	X	X	X	X	X	8
[redacted]	UMC	28-Sep-16	—		X	X	X	X	X	X	X	X	X	X	X	X	8
[redacted]	UKC	26-Sep-16	—		X	X	X	X	X	X	X	X	X	X	X	X	8
[redacted]	LWC-3	20-Sep-16	—		X	X	X	X	X	X	X	X	X	X	X	X	8

L1837418-COFC

RUSH

Priority processing

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Small samples. The critical analyte of interest is selenium; please ensure best possible MDLs.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.
Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Lisa Bowron	29-Sep-16	13:22	Jeremy Anany	Sept 29-16	3:40pm	2.6 °C				

Hmc 1:10PM Oct 1/16 4.2, 4, 5, 6, 6, 7 °C

MINNOW ENVIRONMENTAL INC.
ATTN: Lisa Bowron
101 - 1025 Hillside Ave.
Victoria BC V8T 2A2

Date Received: 30-SEP-16
Report Date: 24-OCT-16 16:48 (MT)
Version: FINAL

Client Phone: 250-595-1627

Certificate of Analysis

Lab Work Order #: L1837240

Project P.O. #: NOT SUBMITTED
Job Reference: MINNOW PROJECT 16-80
C of C Numbers:
Legal Site Desc:

Selam Worku
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837240-1	L1837240-2	L1837240-3	L1837240-4	L1837240-5
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	24-SEP-16	24-SEP-16	24-SEP-16	23-SEP-16	23-SEP-16
	Sampled Time					
	Client ID	LMC-1	LMC-1X	LMC-2	LMC-3	LMC-4
Grouping	**Analyte**					
BIOTA						
Field Tests	Area Sampled (cm2)	4	4	4	4	4
Plant Pigments	Chlorophyll a (mg/m2)	37.4	50.8	78.4	160.	46.2

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837240-6	L1837240-7	L1837240-8	L1837240-9	L1837240-10
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	23-SEP-16	26-SEP-16	25-SEP-16	25-SEP-16	25-SEP-16
	Sampled Time					
	Client ID	LMC-5	LWC-1	LWC-2	LWC-3	LWC-4
Grouping	**Analyte**					
BIOTA						
Field Tests	Area Sampled (cm2)	4	4	4	4	4
Plant Pigments	Chlorophyll a (mg/m2)	43.7	68.3	37.8	26.0	24.0

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837240-11
	Description	Tissue
	Sampled Date	25-SEP-16
	Sampled Time	
	Client ID	LWC-5
Grouping	**Analyte**	
BIOTA		
Field Tests	Area Sampled (cm2)	4
Plant Pigments	Chlorophyll a (mg/m2)	41.0

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
AREA SAMPLED-VA	Biota	Area Sampled (cm2)	Not Applicable
CHLOROA-F-VA	Biota	Chlorophyll a in Biota by Fluorometer	EPA 445.0

This analysis is done using procedures adapted from EPA Method 445.0. Chlorophyll-a is determined by a routine acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b. Note: Biota samples are typically submitted as scrapings on a filter.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L1837240-COFC

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

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Chloro a

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Minnow Environmental Inc.	☑ Standard ☐ Other		● Regular (Standard Turnaround Times - Business Days)
Contact:	Lisa Bowron	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	101 - 1025 Hillside Ave.	Email 1:	lbowron@minnow.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Victoria, BC	Email 2:	pstecko@minnow.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(250)595-1627 x21 Fax: (250) 595-1625	Email 3:		Analysis Request
Invoice To	Same as Report ? ☐ Yes ☑ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Minnow Project 16-80	
Company:	Minto Explorations Ltd	PO / AFE:		
Contact:	Cindy Keehn	LSD:		
Address:	Suite 2100 - 510 West George St., Vancouver, BC			
Phone:	604-684-8894 Fax: 604-688-2180	Quote #:	Q51327	
Lab Work Order # (lab use only)	[redacted]	ALS Contact:	Selam Worku	Sampler: Lisa Bowron

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Chlorophyll a					**See Complete Quote #Q51327						Number of Containers
[redacted]	LMC-1	24-Sep-16	—	Tissue	X					X						1
[redacted]	LMC-1X	24-Sep-16	—		X					X						1
[redacted]	LMC-2	24-Sep-16	—		X					X						1
[redacted]	LMC-3	23-Sep-16	—		X					X						1
[redacted]	LMC-4	23-Sep-16	—		X					X						1
[redacted]	LMC-5	23-Sep-16	—		X					X						1
[redacted]	LWC-1	26-Sep-16	—		X					X						1
[redacted]	LWC-2	25-Sep-16	—		X					X						1
[redacted]	LWC-3	25-Sep-16	—		X					X						1
[redacted]	LWC-4	25-Sep-16	—		X					X						1
[redacted]	LWC-5	25-Sep-16	-		X					X						1
[redacted]																

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Small samples. The critical analyte of interest is selenium; please ensure best possible MDLs. Periphyton samples.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Lisa Bowron	Date (dd-mmm-yy) 29-Sep-16	Time (hh-mm) 13:22	Received by: [illegible]	Date: Sept 29/16	Time: 1:20pm	Temperature: 2.0 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

Lmc SEP 3 0 2016 1:00pm 7 4 9 3 6

GENF 20.00 Front

APPENDIX C

SEDIMENT, PERIPHYTON AND BENTHIC INVERTEBRATE QUALITY DATA

Table C.1: Sediment chemistry data collected at reference and exposed areas, Minto Mine WUL, 2016.

Analyte		Units	CSQG[1]		Upper McGinty Creek (Reference)						Upper Minto Creek (Exposure)					
					URC-1	URC-2	URC-3	URC-4	URC-5	URC	UMC-1	UMC-2	UMC-3	UMC-4	UMC-5	UMC
			ISQG	PEL	26-Sep-16	26-Sep-16	26-Sep-16	26-Sep-16	26-Sep-16	26-Sep-16	28-Sep-16	28-Sep-16	28-Sep-16	28-Sep-16	28-Sep-16	28-Sep-16
Particle size, TKN, carbon analytes and pH	Loss on Ignition @ 550 °C	%	-	-	19	8.0	20	19	3.0	-	5.0	7.0	8.0	15	9.0	-
	pH (1:2 soil:water)	pH units	-	-	6.72	7.30	6.54	6.72	7.58	-	7.52	7.64	7.59	7.51	7.66	-
	Gravel (> 2 mm)	%	-	-	-	-	-	-	-	< 1.0	-	-	-	-	-	2.3
	Sand (2.0 mm - 0.063 mm)	%	-	-	-	-	-	-	-	42.7	-	-	-	-	-	55
	Silt (0.063 mm - 4 µm)	%	-	-	-	-	-	-	-	51.2	-	-	-	-	-	35
	Clay (< 4 µm)	%	-	-	-	-	-	-	-	6.1	-	-	-	-	-	7.2
	Total Kjeldahl Nitrogen (TKN)	%	-	-	0.20	0.35	0.50	0.40	0.073	-	0.13	0.27	0.28	0.28	0.17	-
	Inorganic Carbon	%	-	-	0.12	0.17	0.29	0.16	0.072	-	0.16	0.15	0.15	0.22	0.18	-
	Inorganic Carbon (as $CaCO_3$ Equivalent)	%	-	-	0.99	1.5	2.4	1.4	0.60	-	1.3	1.2	1.3	1.8	1.5	-
	Total Carbon by Combustion	%	-	-	6.0	4.0	9.6	6.6	1.4	-	2.2	2.4	4.9	4.9	3.3	-
	Total Organic Carbon	%	-	-	5.9	3.8	9.3	6.5	1.3	-	2.0	2.3	4.8	4.7	3.1	-
Total Metals	Aluminum (Al)	mg/kg	-	-	9,940	9,610	15,500	12,800	4,800	-	11,400	12,600	13,400	13,200	10,600	-
	Antimony (Sb)	mg/kg	-	-	0.40	0.35	0.56	0.44	0.19	-	0.46	0.54	0.51	0.59	0.45	-
	Arsenic (As)	mg/kg	5.9	17	6.1	8.1	7.5	10	4.6	-	5.5	5.8	6.2	6.3	5.7	-
	Barium (Ba)	mg/kg	-	-	195	185	309	246	100	-	193	257	230	266	181	-
	Beryllium (Be)	mg/kg	-	-	0.33	0.32	0.48	0.41	0.17	-	0.47	0.48	0.50	0.52	0.41	-
	Bismuth (Bi)	mg/kg	-	-	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	-	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	-
	Boron (B)	mg/kg	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	-
	Cadmium (Cd)	mg/kg	0.60	3.5	0.19	0.14	0.24	0.20	< 0.050	-	0.20	0.28	0.31	0.37	0.18	-
	Calcium (Ca)	mg/kg	-	-	8,650	8,040	10,200	8,800	3,840	-	7,460	8,650	9,730	10,400	8,480	-
	Chromium (Cr)	mg/kg	37	90	21	21	34	27	7.7	-	26	27	29	30	29	-
	Cobalt (Co)	mg/kg	-	-	8.9	9.3	12	11	4.5	-	9.8	11	12	12	10	-
	Copper (Cu)	mg/kg	36	197	22	18	33	25	7.2	-	155	226	270	334	97	-
	Iron (Fe)	mg/kg	-	-	21,000	24,100	31,300	30,100	12,700	-	24,100	25,600	26,800	26,600	23,800	-
	Lead (Pb)	mg/kg	35	91	4.7	4.2	6.5	5.2	2.2	-	5.8	6.3	6.9	7.0	5.8	-
	Lithium (Li)	mg/kg	-	-	6.6	6.5	9.5	8.3	3.6	-	8.0	9.1	9.5	9.5	7.5	-
	Magnesium (Mg)	mg/kg	-	-	3,910	3,820	5,130	4,450	1,920	-	5,980	6,780	7,140	7,070	6,210	-
	Manganese (Mn)	mg/kg	-	-	551	897	454	467	422	-	1,810	3,280	2,320	2,900	1,370	-
	Mercury (Hg)	mg/kg	0.17	0.49	0.060	0.043	0.087	0.069	0.015	-	0.035	0.050	0.050	0.050	0.029	-
	Molybdenum (Mo)	mg/kg	-	-	0.52	0.58	0.61	0.47	0.44	-	1.6	2.7	2.0	2.7	1.2	-
	Nickel (Ni)	mg/kg	-	-	16	17	23	19	7.3	-	25	27	29	31	28	-
	Phosphorus (P)	mg/kg	-	-	746	860	954	942	425	-	851	965	934	959	945	-
	Potassium (K)	mg/kg	-	-	620	660	930	870	370	-	1,510	1,750	1,920	1,760	1,300	-
	Selenium (Se)	mg/kg	-	-	0.45	0.45	0.66	0.60	0.22	-	0.49	0.57	0.85	1.0	0.39	-
	Silver (Ag)	mg/kg	-	-	< 0.10	< 0.10	0.11	< 0.10	< 0.10	-	< 0.10	0.15	0.15	0.18	< 0.10	-
	Sodium (Na)	mg/kg	-	-	178	203	265	258	111	-	335	349	370	355	357	-
	Strontium (Sr)	mg/kg	-	-	63	64	90	79	34	-	78	98	110	117	88	-
	Thallium (Tl)	mg/kg	-	-	0.060	0.057	0.096	0.084	< 0.050	-	0.086	0.097	0.11	0.11	0.081	-
	Tin (Sn)	mg/kg	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	-
	Titanium (Ti)	mg/kg	-	-	514	591	780	708	315	-	713	753	769	739	699	-
	Uranium (U)	mg/kg	-	-	1.3	1.4	1.5	1.1	0.48	-	0.90	1.1	1.4	1.6	1.1	-
	Vanadium (V)	mg/kg	-	-	44	46	63	54	27	-	55	57	59	59	56	-
	Zinc (Zn)	mg/kg	123	315	42	38	56	48	20	-	60	71	76	78	54	-

Indicates sediment concentration exceeding CSQG ISQG.

Indicates sediment concentration exceeding CSQG PEL.

[1] Canadian Sediment Quality Guidelines:
ISQG = interim sediment quality guideline; PEL = probable effect level (CCME 1999).

Table C.1: Sediment chemistry data collected at reference and exposed areas, Minto Mine WUL, 2016.

Analyte		Units	CSQG[1]		Lower Wolverine Creek (Reference)					Lower Minto Creek (Exposure)				
					LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
			ISQG	PEL	26-Sep-16	26-Sep-16	26-Sep-16	26-Sep-16	26-Sep-16	22-Sep-16	23-Sep-16	23-Sep-16	22-Sep-16	22-Sep-16
Particle size, TKN, carbon analytes and pH	Loss on Ignition @ 550 °C	%	-	-	16	4.0	18	21	17	8.0	14	13	17	12
	pH (1:2 soil:water)	pH units	-	-	6.86	7.37	7.07	6.89	6.76	8.05	8.04	8.07	7.97	8.04
	Gravel (> 2 mm)	%	-	-	6.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	Sand (2.0 mm - 0.063 mm)	%	-	-	58	51	8.6	22	17	22	28	38	29	37
	Silt (0.063 mm - 4 µm)	%	-	-	32	44	80	71	77	67	62	57	61	55
	Clay (< 4 µm)	%	-	-	3.7	4.7	12	6.6	6.6	11	10	4.8	9.9	7.9
	Total Kjeldahl Nitrogen (TKN)	%	-	-	0.42	0.10	0.35	0.40	0.49	0.22	0.43	0.38	0.51	0.39
	Inorganic Carbon	%	-	-	0.20	0.077	0.15	0.17	0.20	0.17	0.35	0.25	0.29	0.26
	Inorganic Carbon (as $CaCO_3$ Equivalent)	%	-	-	1.7	0.64	1.2	1.4	1.7	1.4	2.9	2.0	2.4	2.1
	Total Carbon by Combustion	%	-	-	8.7	1.8	6.4	7.6	9.2	3.7	7.2	6.5	8.8	6.3
	Total Organic Carbon	%	-	-	8.5	1.7	6.3	7.5	9.0	3.5	6.8	6.2	8.5	6.0
Total Metals	Aluminum (Al)	mg/kg	-	-	13,400	8,020	14,300	14,800	13,600	12,600	15,300	15,000	15,000	15,700
	Antimony (Sb)	mg/kg	-	-	0.47	0.28	0.45	0.49	0.45	0.48	0.62	0.60	0.65	0.61
	Arsenic (As)	mg/kg	5.9	17	5.2	4.8	7.2	6.1	8.2	7.1	9.5	9.2	9.7	8.9
	Barium (Ba)	mg/kg	-	-	214	97	215	211	235	221	310	290	321	304
	Beryllium (Be)	mg/kg	-	-	0.83	0.45	0.81	0.76	0.78	0.44	0.55	0.54	0.56	0.57
	Bismuth (Bi)	mg/kg	-	-	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20	< 0.20
	Boron (B)	mg/kg	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
	Cadmium (Cd)	mg/kg	0.60	3.5	0.29	0.086	0.24	0.24	0.28	0.17	0.29	0.27	0.32	0.26
	Calcium (Ca)	mg/kg	-	-	12,300	5,490	11,100	10,600	10,900	10,600	13,900	13,500	14,200	13,400
	Chromium (Cr)	mg/kg	37	90	44	26	47	49	47	32	37	37	37	38
	Cobalt (Co)	mg/kg	-	-	12	9.1	14	13	14	10	13	12	13	13
	Copper (Cu)	mg/kg	36	197	31	13	28	32	31	57	78	77	73	74
	Iron (Fe)	mg/kg	-	-	26,000	20,500	28,500	29,800	30,600	26,400	30,900	29,800	30,900	30,500
	Lead (Pb)	mg/kg	35	91	6.0	3.8	6.6	6.9	6.6	6.1	7.0	6.8	7.1	7.0
	Lithium (Li)	mg/kg	-	-	10	6.4	11	11	10	10	12	12	12	12
	Magnesium (Mg)	mg/kg	-	-	8,490	5,860	9,090	9,040	8,620	6,300	7,570	7,380	7,340	7,640
	Manganese (Mn)	mg/kg	-	-	480	360	776	300	511	977	1,740	1,470	1,830	1,410
	Mercury (Hg)	mg/kg	0.17	0.49	0.074	0.024	0.078	0.11	0.15	0.054	0.078	0.065	0.11	0.071
	Molybdenum (Mo)	mg/kg	-	-	0.63	0.46	0.59	0.52	0.51	0.66	0.87	0.87	0.94	0.81
	Nickel (Ni)	mg/kg	-	-	38	24	38	37	38	25	32	31	32	32
	Phosphorus (P)	mg/kg	-	-	902	859	1,110	1,150	1,130	864	962	908	973	882
	Potassium (K)	mg/kg	-	-	1,050	720	1,070	1,130	950	1,250	1,520	1,480	1,480	1,520
	Selenium (Se)	mg/kg	-	-	0.46	< 0.20	0.37	0.45	0.47	0.53	0.93	0.78	1.1	0.79
	Silver (Ag)	mg/kg	-	-	0.11	< 0.10	0.10	0.11	0.12	< 0.10	0.14	0.14	0.14	0.14
	Sodium (Na)	mg/kg	-	-	435	386	447	445	390	306	358	340	351	346
	Strontium (Sr)	mg/kg	-	-	122	51	112	102	107	95	131	124	138	124
	Thallium (Tl)	mg/kg	-	-	0.077	< 0.050	0.086	0.094	0.085	0.10	0.12	0.12	0.12	0.12
	Tin (Sn)	mg/kg	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
	Titanium (Ti)	mg/kg	-	-	806	787	916	809	680	711	700	728	689	749
	Uranium (U)	mg/kg	-	-	3.4	1.1	3.3	3.0	3.4	1.1	1.3	1.2	1.5	1.2
	Vanadium (V)	mg/kg	-	-	67	53	71	70	66	57	61	61	62	62
	Zinc (Zn)	mg/kg	123	315	53	39	59	59	56	54	65	64	67	66

Indicates sediment concentration exceeding CSQG ISQG.

Indicates sediment concentration exceeding CSQG PEL.

[1] Canadian Sediment Quality Guidelines:
ISQG = interim sediment quality guideline; PEL = probable effect level (CCME 1999).

Table C.2: Periphyton tissue quality results at reference and exposure areas, Minto Mine WUL, 2016[a].

Analyte		Units	Lower Wolverine Creek (Reference)							Lower Big Creek (Reference)							Lower Minto Creek (Exposure)						
			LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	Mean	Standard Deviation	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	Mean	Standard Deviation	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5	Mean	Standard Deviation
Physical Tests	Moisture	%	69	65.5	68	48	54	61	9.4	59	65	74	72	75	69	7.0	57	52	44	51	86	58	16
Total Metals	Total Aluminum (Al)	mg/kg dw	16,871	18,435	14,424	14,355	11,358	15,088	2,705	11,884	10,056	13,688	7,607	11,600	10,967	2,278	11,866	8,942	10,860	14,248	20,211	13,226	4,348
	Total Antimony (Sb)	mg/kg dw	0.047	0.040	0.037	0.035	0.023	0.037	0.0085	0.10	0.14	0.19	0.16	0.23	0.16	0.050	0.042	0.047	0.027	0.039	0.15	0.061	0.051
	Total Arsenic (As)	mg/kg dw	5.6	5.9	5.2	4.8	4.2	5.1	0.65	20	21	28	17	30	23	5.7	8.9	13	7.3	7.5	14	10	3.1
	Total Barium (Ba)	mg/kg dw	230	248	222	172	190	212	31	180	163	231	143	216	186	36	555	867	478	287	462	**530**	213
	Total Beryllium (Be)	mg/kg dw	0.67	0.74	0.67	0.58	0.59	0.65	0.068	0.49	0.45	0.59	0.34	0.50	0.48	0.089	0.43	0.42	0.39	0.43	0.70	0.47	0.13
	Total Bismuth (Bi)	mg/kg dw	0.088	0.094	0.094	0.072	0.069	0.084	0.012	0.67	0.89	1.2	0.59	1.3	0.93	0.31	0.10	0.088	0.086	0.10	0.16	0.11	0.032
	Total Boron (B)	mg/kg dw	4.9	4.3	4.0	2.4	2.0	3.5	1.3	2.9	2.6	4.2	2.8	4.4	3.4	0.85	7.2	8.2	5.2	4.2	7.5	6.5	1.7
	Total Cadmium (Cd)	mg/kg dw	0.18	0.19	0.18	0.14	0.17	0.17	0.019	0.18	0.18	0.25	0.13	0.21	0.19	0.044	0.31	0.57	0.23	0.19	0.41	0.34	0.15
	Total Calcium (Ca)	mg/kg dw	9,484	10,551	9,283	7,534	8,513	9,073	1,127	6,884	6,423	8,213	5,179	7,440	6,828	1,138	10,737	12,552	9,104	9,675	18,169	12,047	3,665
	Total Cesium (Cs)	mg/kg dw	1.6	1.8	1.5	1.2	0.81	1.4	0.38	2.3	2.0	2.9	1.7	2.6	2.3	0.49	0.84	0.59	0.66	1.0	1.7	0.95	0.42
	Total Chromium (Cr)	mg/kg dw	49	51	39	41	31	42	8.3	27	22	30	18	28	25	4.8	30	22	24	32	46	31	9.3
	Total Cobalt (Co)	mg/kg dw	13	14	14	13	11	13	1.4	8.9	7.9	10	6.6	8.9	8.4	1.3	16	25	13	11	17	16	5.1
	Total Copper (Cu)	mg/kg dw	24	26	24	20	18	22	3.4	27	29	41	36	40	35	6.4	41	38	33	39	73	45	16
	Total Iron (Fe)	mg/kg dw	28,806	30,725	26,231	25,048	20,991	26,360	3,728	21,570	18,507	23,726	16,500	23,160	20,693	3,099	23,963	21,369	20,789	26,016	40,986	26,625	8,297
	Total Lead (Pb)	mg/kg dw	5.6	6.1	5.7	5.4	4.3	5.4	0.68	7.7	7.5	9.6	6.0	8.2	7.8	1.3	5.0	4.4	4.5	5.5	8.4	5.6	1.6
	Total Lithium (Li)	mg/kg dw	11	12	11	10	8.6	11	1.3	9.4	8.1	10	6.3	8.4	8.5	1.5	11	8.0	9.3	11	15	11	2.4
	Total Magnesium (Mg)	mg/kg dw	10,452	11,101	9,751	9,249	8,147	9,740	1,134	6,643	5,746	7,110	4,607	6,160	6,053	957	6,452	5,581	6,075	7,256	10,423	7,157	1,925
	Total Manganese (Mn)	mg/kg dw	981	1,043	916	674	688	860	170	577	583	734	446	788	626	136	6,567	16,515	5,341	2,215	3,261	**6,780**	5,703
	Total Mercury (Hg)	mg/kg dw	0.060	0.040	0.036	0.025	0.032	0.038	0.013	0.031	0.21	0.046	0.022	0.044	0.072	0.081	0.029	0.030	0.020	0.027	0.059	0.033	0.015
	Total Molybdenum (Mo)	mg/kg dw	0.40	0.41	0.43	0.33	0.34	0.38	0.044	1.0	1.1	1.5	0.92	1.6	1.2	0.30	0.92	1.4	0.79	0.55	1.2	0.97	0.34
	Total Nickel (Ni)	mg/kg dw	40	42	38	37	31	38	4.0	22	19	25	15	22	21	3.5	32	28	25	27	40	31	6.1
	Total Phosphorus (P)	mg/kg dw	1,306	1,374	1,178	1,102	1,030	1,198	142	1,080	859	932	879	1,108	971	115	1,228	1,098	1,111	1,185	1,648	1,254	227
	Total Potassium (K)	mg/kg dw	1,432	1,458	1,084	1,037	767	1,156	291	1,355	1,496	1,589	1,282	2,228	1,590	376	1,477	1,452	1,165	1,396	3,415	1,781	922
	Total Rubidium (Rb)	mg/kg dw	15	16	13	11	8.3	13	3.1	13	11	16	9.0	14	13	2.7	10	7.7	8.4	12	20	12	5.0
	Total Selenium (Se)	mg/kg dw	0.60	0.59	0.49	0.34	0.33	0.47	0.13	0.23	0.27	0.37	0.24	0.43	0.31	0.090	1.3	1.2	0.89	0.86	1.9	**1.2**	0.44
	Total Sodium (Na)	mg/kg dw	416	420	461	351	306	391	62	357	299	388	261	353	331	51	256	239	294	301	420	302	71
	Total Strontium (Sr)	mg/kg dw	85	94	83	72	78	82	8.4	64	63	84	47	72	66	14	108	149	88	83	173	120	40
	Total Tellurium (Te)	mg/kg dw	< 0.026	0.024	0.018	< 0.031	0.013	0.022	0.0070	0.055	0.062	0.083	0.041	0.085	0.065	0.019	0.026	0.032	0.021	0.021	< 0.056	0.031	0.015
	Total Thallium (Tl)	mg/kg dw	0.094	0.10	0.078	0.077	0.055	0.082	0.019	0.11	0.10	0.15	0.078	0.12	0.11	0.026	0.081	0.068	0.067	0.098	0.16	0.094	0.038
	Total Tin (Sn)	mg/kg dw	0.78	0.55	0.72	0.38	0.45	0.58	0.17	0.42	0.37	0.64	0.51	0.48	0.49	0.10	0.43	0.32	0.42	0.37	0.92	0.49	0.24
	Total Uranium (U)	mg/kg dw	0.96	1.1	1.0	1.0	1.2	1.1	0.11	1.2	1.1	1.5	0.86	1.3	1.2	0.26	0.65	0.72	0.56	0.70	1.5	0.83	0.38
	Total Vanadium (V)	mg/kg dw	64	69	53	57	44	57	10	51	40	52	38	54	47	7.6	46	47	42	51	79	53	15
	Total Zinc (Zn)	mg/kg dw	66	70	60	58	45	60	9.5	58	54	66	44	61	56	8.4	53	51	51	64	92	62	18
	Total Zirconium (Zr)	mg/kg dw	14	15	14	11	11	13	1.8	7.5	7.2	9.0	5.7	8.3	7.5	1.2	9.5	8.8	8.6	8.6	14	9.9	2.2

Bold Indicates periphyton tissue concentration exceeding the higher reference mean by more than two times.

[a] If value was < method detection limit (MDL), summary statistics were calculated using 1x MDL (i.e. if result was < 0.048, summary statistics were calculated using the value 0.048).

Table C.3: Benthic tissue quality results at reference and exposure areas, Minto Mine WUL, 2016[a].

Analyte		Units	Lower Wolverine Creek (Reference)							Lower Big Creek (Reference)							Lower Minto Creek (Exposure)						
			LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	Mean	Standard Deviation	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	Mean	Standard Deviation	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5	Mean	Standard Deviation
Physical Tests	Moisture	%	61	71	65	69	74	68	5.0	73	75	77	70	69	73	3.3	75	74	76	74	77	75	1.5
Total Metals	Total Aluminum (Al)	mg/kg dw	2,636	979	2,169	2,141	883	1,762	784	2,880	2,020	2,416	2,164	3,100	2,516	462	1,462	1,602	2,611	2,314	1,632	1,924	507
	Total Antimony (Sb)	mg/kg dw	0.050	0.033	0.045	0.14	0.046	0.063	0.043	0.30	0.26	0.31	0.23	0.29	0.28	0.032	0.088	0.10	0.11	0.096	0.094	0.099	0.010
	Total Arsenic (As)	mg/kg dw	1.8	0.96	1.3	2.7	0.94	1.5	0.73	10	7.5	13	8.6	8.6	9.6	2.1	1.7	2.0	2.4	2.1	2.1	2.1	0.27
	Total Barium (Ba)	mg/kg dw	44	68	50	40	56	51	11	67	54	66	74	75	67	8.2	55	74	69	107	67	74	19
	Total Beryllium (Be)	mg/kg dw	0.19	0.057	0.15	0.18	0.075	0.13	0.058	0.16	0.14	0.15	0.14	0.21	0.16	0.030	0.063	0.073	0.11	0.084	0.064	0.078	0.017
	Total Bismuth (Bi)	mg/kg dw	0.010	0.0080	0.011	0.011	0.0079	0.010	0.0015	0.39	0.32	0.45	0.28	0.33	0.35	0.066	0.020	0.020	0.030	0.022	0.052	0.029	0.014
	Total Boron (B)	mg/kg dw	0.75	< 0.69	0.62	< 0.64	< 0.75	0.69	0.061	2.4	1.3	2.1	1.9	1.54	1.9	0.45	2.3	2.5	2.4	3.8	2.6	2.7	0.59
	Total Cadmium (Cd)	mg/kg dw	0.18	0.37	0.22	0.18	0.34	0.26	0.092	0.26	0.37	1.3	1.0	0.40	0.66	0.45	0.22	0.24	0.25	0.25	0.23	0.24	0.012
	Total Calcium (Ca)	mg/kg dw	3,256	1,681	3,239	3,462	2,449	2,817	744	2,618	2,577	3,190	2,466	3,633	2,897	499	2,574	2,996	3,418	2,693	2,232	2,783	448
	Total Cesium (Cs)	mg/kg dw	0.23	0.11	0.20	0.19	0.11	0.17	0.054	0.80	0.56	0.81	0.56	0.91	0.73	0.16	0.17	0.20	0.28	0.24	0.19	0.22	0.044
	Total Chromium (Cr)	mg/kg dw	9.1	6.9	12	12	7.1	9.4	2.4	14	10	12	13	11	12	1.5	6.8	7.2	20	9.7	7.0	10	5.7
	Total Cobalt (Co)	mg/kg dw	2.9	1.4	3.5	3.2	1.7	2.5	0.92	3.0	2.2	4.8	3.4	3.4	3.3	0.92	1.4	2.0	2.6	2.2	1.6	2.0	0.46
	Total Copper (Cu)	mg/kg dw	16	13	14	17	14	15	1.6	22	24	40	27	24	28	7.2	21	22	25	21	27	23	2.7
	Total Iron (Fe)	mg/kg dw	6,072	2,247	5,070	5,929	3,491	4,562	1,652	6,073	4,234	5,844	5,503	7,363	5,803	1,125	3,526	4,735	6,527	5,172	3,763	4,745	1,205
	Total Lead (Pb)	mg/kg dw	0.80	0.50	0.93	1.0	0.64	0.77	0.21	2.7	2.1	2.7	2.2	3.8	2.7	0.67	0.89	1.0	1.5	1.1	0.93	1.1	0.25
	Total Lithium (Li)	mg/kg dw	3.4	0.76	2.0	2.2	0.68	1.8	1.1	2.3	1.5	1.8	1.7	2.6	2.0	0.48	1.2	1.2	2.1	1.8	1.3	1.5	0.41
	Total Magnesium (Mg)	mg/kg dw	2,610	1,396	2,408	2,401	1,766	2,116	513	2,236	1,786	2,126	2,131	2,383	2,132	220	1,466	1,545	2,222	1,985	1,570	1,758	329
	Total Manganese (Mn)	mg/kg dw	264	615	355	260	430	385	147	255	225	335	336	421	314	77	328	557	481	425	361	430	92
	Total Mercury (Hg)	mg/kg dw	0.012	0.017	0.012	0.014	0.028	0.017	0.0065	0.020	0.019	0.029	0.030	0.019	0.024	0.0058	0.012	0.015	0.021	0.017	0.025	0.018	0.0050
	Total Molybdenum (Mo)	mg/kg dw	1.1	0.89	0.98	1.1	1.1	1.0	0.098	1.0	1.1	1.0	0.85	1.5	1.1	0.24	0.71	1.0	0.91	0.90	0.98	0.91	0.12
	Total Nickel (Ni)	mg/kg dw	9.8	5.0	7.9	10	6.0	7.8	2.3	8.1	7.3	8.4	9.3	8.8	8.4	0.74	4.9	5.3	10	7.4	5.3	6.6	2.3
	Total Phosphorus (P)	mg/kg dw	6,382	7,708	6,366	6,795	7,660	6,982	664	5,382	6,048	6,407	5,268	6,077	5,837	489	6,948	6,932	7,238	6,475	6,404	6,799	352
	Total Potassium (K)	mg/kg dw	5,943	6,875	5,690	5,897	6,792	6,240	551	6,291	6,855	6,623	5,268	5,691	6,146	657	6,386	6,553	6,109	7,395	7,588	6,806	649
	Total Rubidium (Rb)	mg/kg dw	3.1	2.2	2.3	2.3	2.2	2.4	0.37	4.4	3.7	6.9	5.2	4.7	5.0	1.2	3.4	3.3	3.9	4.2	3.2	3.6	0.44
	Total Selenium (Se)	mg/kg dw	4.5	4.7	4.5	4.3	4.6	4.5	0.13	0.65	1.1	1.1	1.2	1.4	1.1	0.28	1.7	1.9	2.0	1.7	2.3	1.9	0.27
	Total Sodium (Na)	mg/kg dw	2,044	2,188	1,980	2,215	2,219	2,129	110	2,393	2,722	3,078	2,141	2,035	2,474	429	2,807	2,727	2,623	2,487	2,474	2,624	146
	Total Strontium (Sr)	mg/kg dw	28	22	28	30	25	27	3.1	25	26	30	25	31	28	3.0	22	27	30	25	20	25	4.0
	Total Tellurium (Te)	mg/kg dw	< 0.010	< 0.014	< 0.011	< 0.013	< 0.015	< 0.013	-	0.028	0.025	0.034	0.023	0.026	0.027	0.0043	< 0.016	< 0.015	< 0.017	< 0.015	< 0.018	< 0.016	-
	Total Thallium (Tl)	mg/kg dw	0.012	0.0075	0.011	0.011	0.0074	0.0097	0.0021	0.034	0.029	0.041	0.030	0.039	0.035	0.0052	0.014	0.015	0.022	0.016	0.016	0.017	0.0029
	Total Tin (Sn)	mg/kg dw	1.6	1.3	2.3	1.8	1.4	1.7	0.39	3.4	2.9	4.1	2.4	1.6	2.9	0.96	2.8	2.8	6.6	3.9	3.0	3.8	1.6
	Total Uranium (U)	mg/kg dw	0.84	0.24	0.84	0.91	0.43	0.65	0.30	0.61	1.3	0.69	0.84	1.4	1.0	0.38	0.21	0.33	0.33	0.25	0.24	0.27	0.052
	Total Vanadium (V)	mg/kg dw	16	5.9	12	13	8.3	11	3.9	14	10	12	12	14	12	1.8	6.4	9.3	13	9.0	7.4	8.9	2.4
	Total Zinc (Zn)	mg/kg dw	70	95	76	75	98	83	13	58	63	100	95	76	79	19	90	95	96	130	118	106	17
	Total Zirconium (Zr)	mg/kg dw	2.8	1.4	2.5	2.7	2.8	2.4	0.60	3.2	2.5	3.0	2.9	3.3	3.0	0.32	1.7	1.9	2.7	1.9	1.7	2.0	0.44

Bold Indicates periphyton tissue concentration exceeding the higher reference mean by more than two times.

[a] If value was < method detection limit (MDL), summary statistics were calculated using 1x MDL (i.e. if result was < 0.048, summary statistics were calculated using the value 0.048).

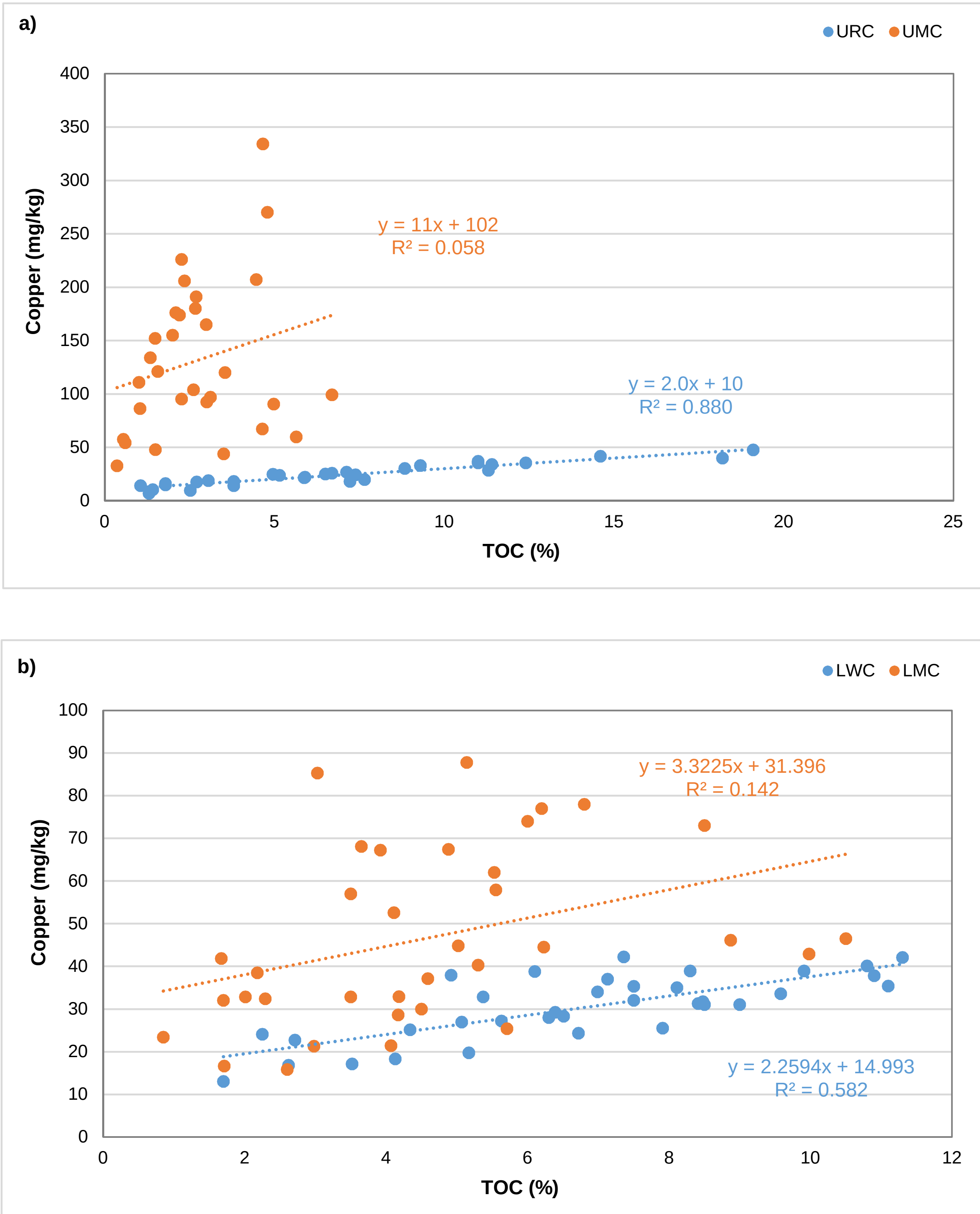
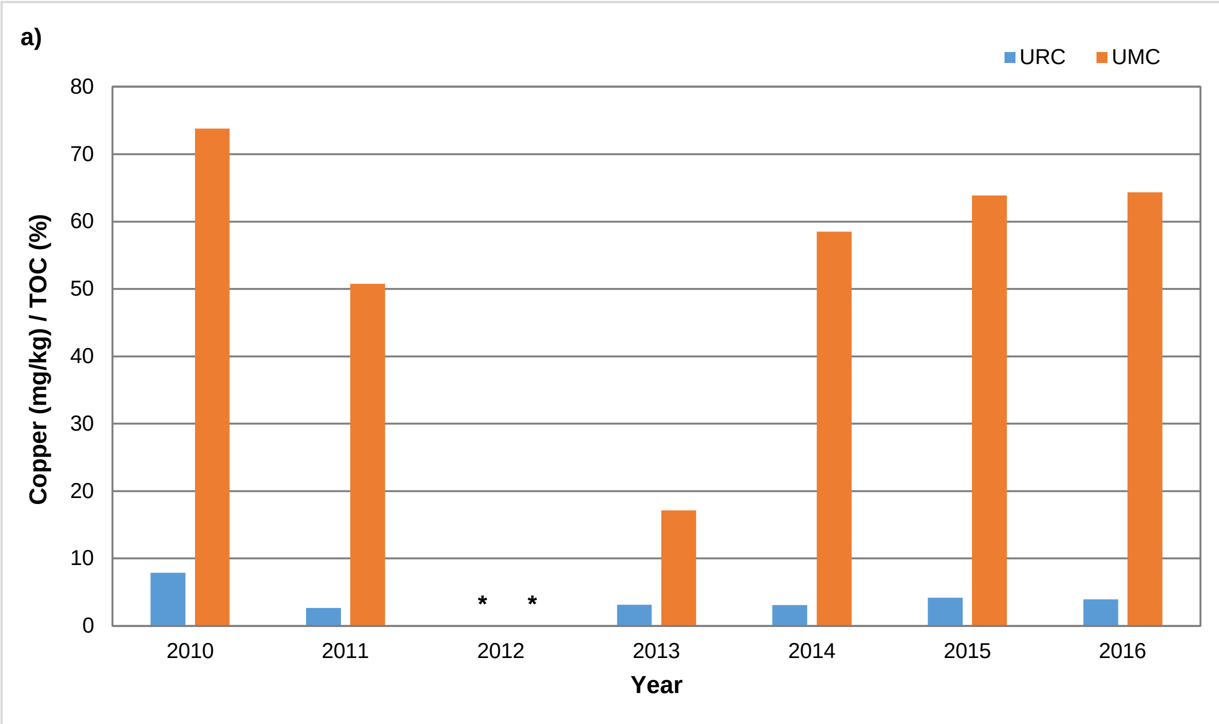


Figure C.1: Relationship between copper and percent TOC, a) upper McGinty (URC) and upper Minto creeks (UMC) and b) lower Wolverine (LWC) and lower Minto creeks (LMC), 2010-2016 (TOC was not collected in 2012).



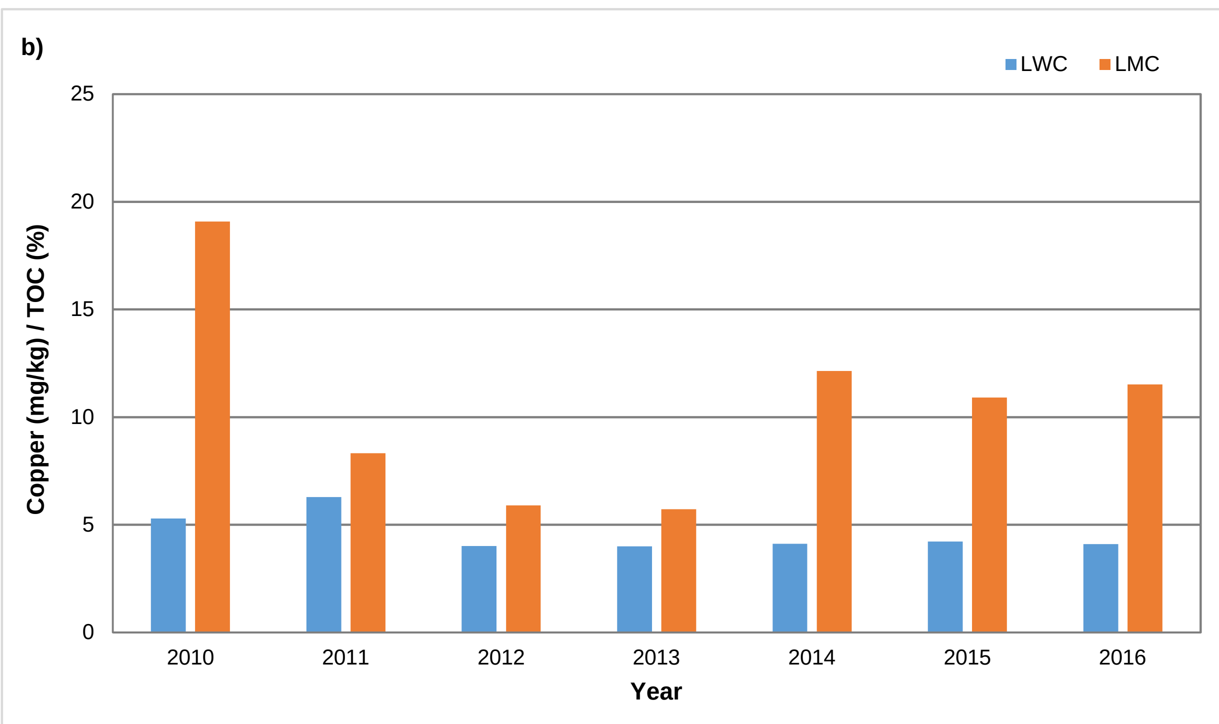


Figure C.2: Copper normalized to percent TOC at a) upper McGinty (URC) and upper Minto creeks (UMC) and b) lower Wolverine (LWC) and lower Minto creeks (LMC), 2010-2016.

* TOC was not collected

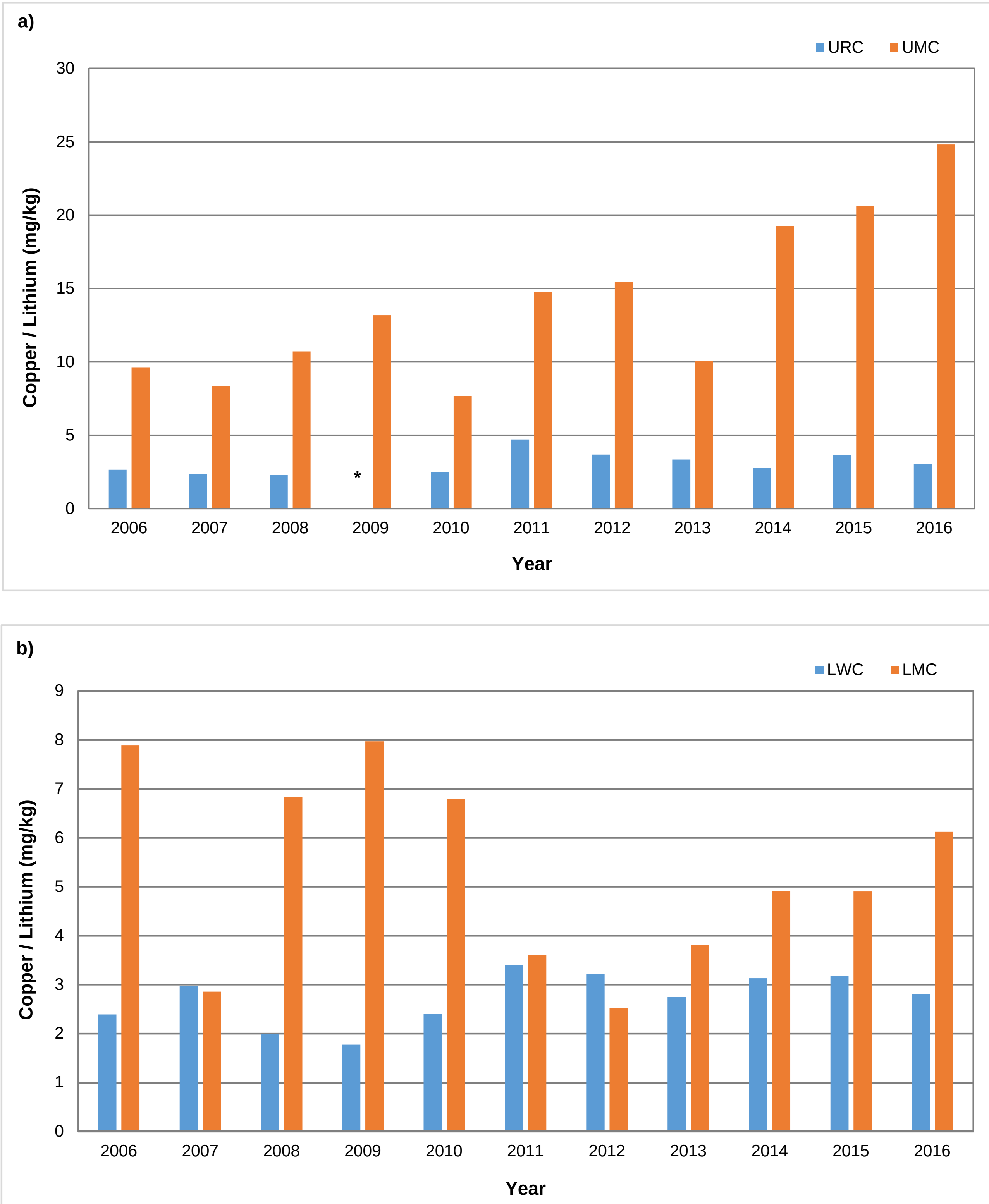


Figure C.3: Copper normalized to lithium at a) upper McGinty (URC) and upper Minto creeks (UMC) and b) lower Wolverine (LWC) and lower Minto creeks (LMC), 2006-2016.

* no data available

MINNOW ENVIRONMENTAL INC.
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Victoria BC V8T 2A2

Date Received: 30-SEP-16
Report Date: 11-OCT-16 17:41 (MT)
Version: FINAL

Client Phone: 250-595-1627

Certificate of Analysis

Lab Work Order #: L1837161

Project P.O. #: NOT SUBMITTED
Job Reference: MINNOW PROJECT 16.80
C of C Numbers:
Legal Site Desc:

Selam Worku
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte					
	Sample ID	L1837161-1	L1837161-2	L1837161-3	L1837161-4	L1837161-5
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	28-SEP-16	28-SEP-16	28-SEP-16	28-SEP-16	28-SEP-16
	Sampled Time					
	Client ID	UMC-1M	UMC-2M	UMC-3M	UMC-4M	UMC-5M
SOIL						
Physical Tests	Loss On Ignition @ 420 C (%)	5	7	8	15	9
	pH (1:2 soil:water) (pH)	7.52	7.64	7.59	7.51	7.66
Particle Size	% Gravel (>2mm) (%)					
	% Sand (2.0mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)					
	% Clay (<4um) (%)					
	Texture					
Leachable Anions & Nutrients	Total Kjeldahl Nitrogen (%)	0.126	0.274	0.279	0.278	0.172
Organic / Inorganic Carbon	Inorganic Carbon (%)	0.157	0.149	0.151	0.218	0.179
	Inorganic Carbon (as CaCO3 Equivalent) (%)	1.31	1.24	1.25	1.81	1.49
	Total Carbon by Combustion (%)	2.16	2.41	4.94	4.88	3.29
	Total Organic Carbon (%)	2.00	2.26	4.79	4.66	3.11
Metals	Aluminum (Al) (mg/kg)	11400	12600	13400	13200	10600
	Antimony (Sb) (mg/kg)	0.46	0.54	0.51	0.59	0.45
	Arsenic (As) (mg/kg)	5.52	5.77	6.18	6.29	5.71
	Barium (Ba) (mg/kg)	193	257	230	266	181
	Beryllium (Be) (mg/kg)	0.47	0.48	0.50	0.52	0.41
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)	0.204	0.279	0.312	0.367	0.177
	Calcium (Ca) (mg/kg)	7460	8650	9730	10400	8480
	Chromium (Cr) (mg/kg)	26.1	26.5	28.5	29.7	29.4
	Cobalt (Co) (mg/kg)	9.83	10.9	11.6	11.9	10.3
	Copper (Cu) (mg/kg)	155	226	270	334	97.1
	Iron (Fe) (mg/kg)	24100	25600	26800	26600	23800
	Lead (Pb) (mg/kg)	5.77	6.33	6.86	6.99	5.78
	Lithium (Li) (mg/kg)	8.0	9.1	9.5	9.5	7.5
	Magnesium (Mg) (mg/kg)	5980	6780	7140	7070	6210
	Manganese (Mn) (mg/kg)	1810	3280	2320	2900	1370
	Mercury (Hg) (mg/kg)	0.0349	0.0499	0.0499	0.0504	0.0287
	Molybdenum (Mo) (mg/kg)	1.56	2.74	2.02	2.71	1.22
	Nickel (Ni) (mg/kg)	24.5	27.1	29.0	30.6	27.8
	Phosphorus (P) (mg/kg)	851	965	934	959	945
	Potassium (K) (mg/kg)	1510	1750	1920	1760	1300
	Selenium (Se) (mg/kg)	0.49	0.57	0.85	1.04	0.39
	Silver (Ag) (mg/kg)	<0.10	0.15	0.15	0.18	<0.10

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837161-6	L1837161-7	L1837161-8	L1837161-9	L1837161-10
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	28-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16
	Sampled Time					
	Client ID	UMC	URC-1M	URC-2M	URC-3M	URC-4M
Grouping	**Analyte**					
SOIL						
Physical Tests	Loss On Ignition @ 420 C (%)		19	8	20	19
	pH (1:2 soil:water) (pH)		6.72	7.30	6.54	6.72
Particle Size	% Gravel (>2mm) (%)	2.3				
	% Sand (2.0mm - 0.063mm) (%)	55.1				
	% Silt (0.063mm - 4um) (%)	35.4				
	% Clay (<4um) (%)	7.2				
	Texture	Sandy loam				
Leachable Anions & Nutrients	Total Kjeldahl Nitrogen (%)		0.195	0.35	0.498 DLHC	0.398
Organic / Inorganic Carbon	Inorganic Carbon (%)		0.119	0.174	0.287	0.163
	Inorganic Carbon (as CaCO3 Equivalent) (%)		0.99	1.45	2.39	1.36
	Total Carbon by Combustion (%)		5.99	3.98	9.59	6.62
	Total Organic Carbon (%)		5.87	3.81	9.30	6.46
Metals	Aluminum (Al) (mg/kg)		9940	9610	15500	12800
	Antimony (Sb) (mg/kg)		0.40	0.35	0.56	0.44
	Arsenic (As) (mg/kg)		6.13	8.05	7.48	9.54
	Barium (Ba) (mg/kg)		195	185	309	246
	Beryllium (Be) (mg/kg)		0.33	0.32	0.48	0.41
	Bismuth (Bi) (mg/kg)		<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)		<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)		0.185	0.137	0.238	0.197
	Calcium (Ca) (mg/kg)		8650	8040	10200	8800
	Chromium (Cr) (mg/kg)		21.4	21.4	33.5	27.4
	Cobalt (Co) (mg/kg)		8.85	9.34	11.8	11.0
	Copper (Cu) (mg/kg)		21.8	18.1	33.2	25.1
	Iron (Fe) (mg/kg)		21000	24100	31300	30100
	Lead (Pb) (mg/kg)		4.71	4.24	6.47	5.22
	Lithium (Li) (mg/kg)		6.6	6.5	9.5	8.3
	Magnesium (Mg) (mg/kg)		3910	3820	5130	4450
	Manganese (Mn) (mg/kg)		551	897	454	467
	Mercury (Hg) (mg/kg)		0.0604	0.0426	0.0868	0.0691
	Molybdenum (Mo) (mg/kg)		0.52	0.58	0.61	0.47
	Nickel (Ni) (mg/kg)		15.8	16.5	22.5	19.2
	Phosphorus (P) (mg/kg)		746	860	954	942
	Potassium (K) (mg/kg)		620	660	930	870
	Selenium (Se) (mg/kg)		0.45	0.45	0.66	0.60
	Silver (Ag) (mg/kg)		<0.10	<0.10	0.11	<0.10

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1837161-11	L1837161-12	L1837161-13	L1837161-14	L1837161-15
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16
	Sampled Time					
	Client ID	URC-5M	URC	LWC-1M	LWC-1P	LWC-2M
Grouping	**Analyte**					
SOIL						
Physical Tests	Loss On Ignition @ 420 C (%)	3		16		4
	pH (1:2 soil:water) (pH)	7.58		6.86		7.37
Particle Size	% Gravel (>2mm) (%)		<1.0		6.0	
	% Sand (2.0mm - 0.063mm) (%)		42.7		58.1	
	% Silt (0.063mm - 4um) (%)		51.2		32.3	
	% Clay (<4um) (%)		6.1		3.7	
	Texture		Silt loam		Sandy loam	
Leachable Anions & Nutrients	Total Kjeldahl Nitrogen (%)	0.073		DLHC 0.423		0.099
Organic / Inorganic Carbon	Inorganic Carbon (%)	0.072		0.200		0.077
	Inorganic Carbon (as CaCO3 Equivalent) (%)	0.60		1.67		0.64
	Total Carbon by Combustion (%)	1.37		8.72		1.80
	Total Organic Carbon (%)	1.30		8.52		1.72
Metals	Aluminum (Al) (mg/kg)	4800		13400		8020
	Antimony (Sb) (mg/kg)	0.19		0.47		0.28
	Arsenic (As) (mg/kg)	4.56		5.21		4.81
	Barium (Ba) (mg/kg)	100		214		96.6
	Beryllium (Be) (mg/kg)	0.17		0.83		0.45
	Bismuth (Bi) (mg/kg)	<0.20		<0.20		<0.20
	Boron (B) (mg/kg)	<5.0		<5.0		<5.0
	Cadmium (Cd) (mg/kg)	<0.050		0.288		0.086
	Calcium (Ca) (mg/kg)	3840		12300		5490
	Chromium (Cr) (mg/kg)	7.74		44.2		26.4
	Cobalt (Co) (mg/kg)	4.47		12.4		9.06
	Copper (Cu) (mg/kg)	7.22		31.1		13.1
	Iron (Fe) (mg/kg)	12700		26000		20500
	Lead (Pb) (mg/kg)	2.21		6.00		3.83
	Lithium (Li) (mg/kg)	3.6		9.5		6.4
	Magnesium (Mg) (mg/kg)	1920		8490		5860
	Manganese (Mn) (mg/kg)	422		480		360
	Mercury (Hg) (mg/kg)	0.0154		0.0742		0.0237
	Molybdenum (Mo) (mg/kg)	0.44		0.63		0.46
	Nickel (Ni) (mg/kg)	7.29		38.0		23.9
	Phosphorus (P) (mg/kg)	425		902		859
	Potassium (K) (mg/kg)	370		1050		720
	Selenium (Se) (mg/kg)	0.22		0.46		<0.20
	Silver (Ag) (mg/kg)	<0.10		0.11		<0.10

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1837161-16	L1837161-17	L1837161-18	L1837161-19	L1837161-20
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16
	Sampled Time					
	Client ID	LWC-2P	LWC-3M	LWC-3P	LWC-4M	LWC-4P
SOIL						
Physical Tests	Loss On Ignition @ 420 C (%)		18		21	
	pH (1:2 soil:water) (pH)		7.07		6.89	
Particle Size	% Gravel (>2mm) (%)	<1.0		<1.0		<1.0
	% Sand (2.0mm - 0.063mm) (%)	50.9		8.6		22.3
	% Silt (0.063mm - 4um) (%)	44.4		79.6		71.1
	% Clay (<4um) (%)	4.7		11.7		6.6
	Texture	Sandy loam		Silt		Silt loam
Leachable Anions & Nutrients	Total Kjeldahl Nitrogen (%)		0.352		0.404	
Organic / Inorganic Carbon	Inorganic Carbon (%)		0.149		0.167	
	Inorganic Carbon (as CaCO3 Equivalent) (%)		1.24		1.39	
	Total Carbon by Combustion (%)		6.42		7.62	
	Total Organic Carbon (%)		6.27		7.45	
Metals	Aluminum (Al) (mg/kg)		14300		14800	
	Antimony (Sb) (mg/kg)		0.45		0.49	
	Arsenic (As) (mg/kg)		7.17		6.14	
	Barium (Ba) (mg/kg)		215		211	
	Beryllium (Be) (mg/kg)		0.81		0.76	
	Bismuth (Bi) (mg/kg)		<0.20		<0.20	
	Boron (B) (mg/kg)		<5.0		<5.0	
	Cadmium (Cd) (mg/kg)		0.243		0.244	
	Calcium (Ca) (mg/kg)		11100		10600	
	Chromium (Cr) (mg/kg)		47.3		48.6	
	Cobalt (Co) (mg/kg)		14.0		12.9	
	Copper (Cu) (mg/kg)		28.0		31.8	
	Iron (Fe) (mg/kg)		28500		29800	
	Lead (Pb) (mg/kg)		6.55		6.89	
	Lithium (Li) (mg/kg)		10.6		11.3	
	Magnesium (Mg) (mg/kg)		9090		9040	
	Manganese (Mn) (mg/kg)		776		300	
	Mercury (Hg) (mg/kg)		0.0778		0.108	
	Molybdenum (Mo) (mg/kg)		0.59		0.52	
	Nickel (Ni) (mg/kg)		38.3		36.5	
	Phosphorus (P) (mg/kg)		1110		1150	
	Potassium (K) (mg/kg)		1070		1130	
	Selenium (Se) (mg/kg)		0.37		0.45	
	Silver (Ag) (mg/kg)		0.10		0.11	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1837161-21	L1837161-22	L1837161-23	L1837161-24	L1837161-25
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16	22-SEP-16
	Sampled Time					
	Client ID	LWC-5M	LWC-5P	LWC-5MX	LWC-5PX	LMC-1M
SOIL						
Physical Tests	Loss On Ignition @ 420 C (%)	17		21		8
	pH (1:2 soil:water) (pH)	6.76		6.72		8.05
Particle Size	% Gravel (>2mm) (%)		<1.0		<1.0	
	% Sand (2.0mm - 0.063mm) (%)		16.7		15.8	
	% Silt (0.063mm - 4um) (%)		76.7		78.0	
	% Clay (<4um) (%)		6.6		6.2	
	Texture		Silt loam		Silt loam	
Leachable Anions & Nutrients	Total Kjeldahl Nitrogen (%)	0.485		0.426		DLHC 0.215
Organic / Inorganic Carbon	Inorganic Carbon (%)	0.203		0.159		0.166
	Inorganic Carbon (as CaCO3 Equivalent) (%)	1.69		1.32		1.38
	Total Carbon by Combustion (%)	9.22		8.47		3.71
	Total Organic Carbon (%)	9.02		8.31		3.54
Metals	Aluminum (Al) (mg/kg)	13600		14500		12600
	Antimony (Sb) (mg/kg)	0.45		0.48		0.48
	Arsenic (As) (mg/kg)	8.19		8.01		7.05
	Barium (Ba) (mg/kg)	235		235		221
	Beryllium (Be) (mg/kg)	0.78		0.82		0.44
	Bismuth (Bi) (mg/kg)	<0.20		<0.20		<0.20
	Boron (B) (mg/kg)	<5.0		<5.0		<5.0
	Cadmium (Cd) (mg/kg)	0.280		0.272		0.174
	Calcium (Ca) (mg/kg)	10900		11000		10600
	Chromium (Cr) (mg/kg)	47.2		48.6		32.3
	Cobalt (Co) (mg/kg)	13.7		13.8		10.2
	Copper (Cu) (mg/kg)	30.9		30.1		57.0
	Iron (Fe) (mg/kg)	30600		30800		26400
	Lead (Pb) (mg/kg)	6.64		6.69		6.07
	Lithium (Li) (mg/kg)	10.2		10.8		10.2
	Magnesium (Mg) (mg/kg)	8620		8790		6300
	Manganese (Mn) (mg/kg)	511		478		977
	Mercury (Hg) (mg/kg)	0.147		0.117		0.0543
	Molybdenum (Mo) (mg/kg)	0.51		0.54		0.66
	Nickel (Ni) (mg/kg)	37.5		37.5		25.2
	Phosphorus (P) (mg/kg)	1130		1170		864
	Potassium (K) (mg/kg)	950		1060		1250
	Selenium (Se) (mg/kg)	0.47		0.46		0.53
	Silver (Ag) (mg/kg)	0.12		0.11		<0.10

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837161-26	L1837161-27	L1837161-28	L1837161-29	L1837161-30
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	22-SEP-16	23-SEP-16	23-SEP-16	23-SEP-16	23-SEP-16
	Sampled Time					
	Client ID	LMC-1P	LMC-2M	LMC-2P	LMC-3M	LMC-3P
Grouping	**Analyte**					
SOIL						
Physical Tests	Loss On Ignition @ 420 C (%)		14		13	
	pH (1:2 soil:water) (pH)		8.04		8.07	
Particle Size	% Gravel (>2mm) (%)	<1.0		<1.0		<1.0
	% Sand (2.0mm - 0.063mm) (%)	22.0		27.6		37.8
	% Silt (0.063mm - 4um) (%)	67.1		62.1		57.4
	% Clay (<4um) (%)	10.8		10.3		4.8
	Texture	Silt loam		Silt loam		Silt loam
Leachable Anions & Nutrients	Total Kjeldahl Nitrogen (%)		0.432		0.379	
Organic / Inorganic Carbon	Inorganic Carbon (%)		0.353		0.245	
	Inorganic Carbon (as CaCO3 Equivalent) (%)		2.94		2.04	
	Total Carbon by Combustion (%)		7.17		6.48	
	Total Organic Carbon (%)		6.82		6.24	
Metals	Aluminum (Al) (mg/kg)		15300		15000	
	Antimony (Sb) (mg/kg)		0.62		0.60	
	Arsenic (As) (mg/kg)		9.48		9.16	
	Barium (Ba) (mg/kg)		310		290	
	Beryllium (Be) (mg/kg)		0.55		0.54	
	Bismuth (Bi) (mg/kg)		<0.20		<0.20	
	Boron (B) (mg/kg)		<5.0		<5.0	
	Cadmium (Cd) (mg/kg)		0.285		0.266	
	Calcium (Ca) (mg/kg)		13900		13500	
	Chromium (Cr) (mg/kg)		37.1		36.7	
	Cobalt (Co) (mg/kg)		12.6		12.4	
	Copper (Cu) (mg/kg)		78.0		76.5	
	Iron (Fe) (mg/kg)		30900		29800	
	Lead (Pb) (mg/kg)		6.98		6.81	
	Lithium (Li) (mg/kg)		12.1		11.9	
	Magnesium (Mg) (mg/kg)		7570		7380	
	Manganese (Mn) (mg/kg)		1740		1470	
	Mercury (Hg) (mg/kg)		0.0780		0.0650	
	Molybdenum (Mo) (mg/kg)		0.87		0.87	
	Nickel (Ni) (mg/kg)		31.7		31.3	
	Phosphorus (P) (mg/kg)		962		908	
	Potassium (K) (mg/kg)		1520		1480	
	Selenium (Se) (mg/kg)		0.93		0.78	
	Silver (Ag) (mg/kg)		0.14		0.14	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1837161-31 Sediment 22-SEP-16 LMC-5M	L1837161-32 Sediment 22-SEP-16 LMC-5P	L1837161-33 Sediment 22-SEP-16 LMC-4M	L1837161-34 Sediment 22-SEP-16 LMC-4P	
Grouping	**Analyte**					
SOIL						
Physical Tests	Loss On Ignition @ 420 C (%)	12		17		
	pH (1:2 soil:water) (pH)	8.04		7.97		
Particle Size	% Gravel (>2mm) (%)		<1.0		<1.0	
	% Sand (2.0mm - 0.063mm) (%)		37.1		28.7	
	% Silt (0.063mm - 4um) (%)		55.0		61.4	
	% Clay (<4um) (%)		7.9		9.9	
	Texture		Silt loam		Silt loam	
Leachable Anions & Nutrients	Total Kjeldahl Nitrogen (%)	0.386		0.508		
Organic / Inorganic Carbon	Inorganic Carbon (%)	0.256		0.288		
	Inorganic Carbon (as CaCO3 Equivalent) (%)	2.13		2.40		
	Total Carbon by Combustion (%)	6.27		8.80		
	Total Organic Carbon (%)	6.01		8.51		
Metals	Aluminum (Al) (mg/kg)	15700		15000		
	Antimony (Sb) (mg/kg)	0.61		0.65		
	Arsenic (As) (mg/kg)	8.87		9.65		
	Barium (Ba) (mg/kg)	304		321		
	Beryllium (Be) (mg/kg)	0.57		0.56		
	Bismuth (Bi) (mg/kg)	<0.20		<0.20		
	Boron (B) (mg/kg)	<5.0		<5.0		
	Cadmium (Cd) (mg/kg)	0.260		0.320		
	Calcium (Ca) (mg/kg)	13400		14200		
	Chromium (Cr) (mg/kg)	38.1		36.5		
	Cobalt (Co) (mg/kg)	12.6		12.7		
	Copper (Cu) (mg/kg)	73.8		72.8		
	Iron (Fe) (mg/kg)	30500		30900		
	Lead (Pb) (mg/kg)	7.04		7.09		
	Lithium (Li) (mg/kg)	12.4		11.9		
	Magnesium (Mg) (mg/kg)	7640		7340		
	Manganese (Mn) (mg/kg)	1410		1830		
	Mercury (Hg) (mg/kg)	0.0714		0.114		
	Molybdenum (Mo) (mg/kg)	0.81		0.94		
	Nickel (Ni) (mg/kg)	32.2		32.1		
	Phosphorus (P) (mg/kg)	882		973		
	Potassium (K) (mg/kg)	1520		1480		
	Selenium (Se) (mg/kg)	0.79		1.06		
	Silver (Ag) (mg/kg)	0.14		0.14		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837161-1	L1837161-2	L1837161-3	L1837161-4	L1837161-5
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	28-SEP-16	28-SEP-16	28-SEP-16	28-SEP-16	28-SEP-16
	Sampled Time					
	Client ID	UMC-1M	UMC-2M	UMC-3M	UMC-4M	UMC-5M
Grouping	**Analyte**					
SOIL						
Metals	Sodium (Na) (mg/kg)	335	349	370	355	357
	Strontium (Sr) (mg/kg)	77.6	98.3	110	117	88.3
	Thallium (Tl) (mg/kg)	0.086	0.097	0.106	0.110	0.081
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	713	753	769	739	699
	Uranium (U) (mg/kg)	0.901	1.09	1.41	1.61	1.07
	Vanadium (V) (mg/kg)	55.2	57.3	58.8	58.7	55.8
	Zinc (Zn) (mg/kg)	59.7	70.9	76.0	77.6	54.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837161-6	L1837161-7	L1837161-8	L1837161-9	L1837161-10
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	28-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16
	Sampled Time					
	Client ID	UMC	URC-1M	URC-2M	URC-3M	URC-4M
Grouping	**Analyte**					
SOIL						
Metals	Sodium (Na) (mg/kg)		178	203	265	258
	Strontium (Sr) (mg/kg)		63.0	64.0	89.8	79.3
	Thallium (Tl) (mg/kg)		0.060	0.057	0.096	0.084
	Tin (Sn) (mg/kg)		<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)		514	591	780	708
	Uranium (U) (mg/kg)		1.32	1.39	1.47	1.10
	Vanadium (V) (mg/kg)		43.8	46.0	63.2	53.8
	Zinc (Zn) (mg/kg)		42.2	38.3	55.5	48.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837161-11	L1837161-12	L1837161-13	L1837161-14	L1837161-15
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16
	Sampled Time					
	Client ID	URC-5M	URC	LWC-1M	LWC-1P	LWC-2M
Grouping	**Analyte**					
SOIL						
Metals	Sodium (Na) (mg/kg)	111		435		386
	Strontium (Sr) (mg/kg)	33.8		122		51.3
	Thallium (Tl) (mg/kg)	<0.050		0.077		<0.050
	Tin (Sn) (mg/kg)	<2.0		<2.0		<2.0
	Titanium (Ti) (mg/kg)	315		806		787
	Uranium (U) (mg/kg)	0.478		3.37		1.09
	Vanadium (V) (mg/kg)	27.2		66.7		52.5
	Zinc (Zn) (mg/kg)	19.5		53.0		38.7

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837161-16	L1837161-17	L1837161-18	L1837161-19	L1837161-20
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16
	Sampled Time					
	Client ID	LWC-2P	LWC-3M	LWC-3P	LWC-4M	LWC-4P
Grouping	**Analyte**					
SOIL						
Metals	Sodium (Na) (mg/kg)		447		445	
	Strontium (Sr) (mg/kg)		112		102	
	Thallium (Tl) (mg/kg)		0.086		0.094	
	Tin (Sn) (mg/kg)		<2.0		<2.0	
	Titanium (Ti) (mg/kg)		916		809	
	Uranium (U) (mg/kg)		3.25		3.04	
	Vanadium (V) (mg/kg)		71.2		69.7	
	Zinc (Zn) (mg/kg)		58.9		59.4	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837161-21	L1837161-22	L1837161-23	L1837161-24	L1837161-25
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	26-SEP-16	26-SEP-16	26-SEP-16	26-SEP-16	22-SEP-16
	Sampled Time					
	Client ID	LWC-5M	LWC-5P	LWC-5MX	LWC-5PX	LMC-1M
Grouping	**Analyte**					
SOIL						
Metals	Sodium (Na) (mg/kg)	390		435		306
	Strontium (Sr) (mg/kg)	107		109		95.0
	Thallium (Tl) (mg/kg)	0.085		0.092		0.095
	Tin (Sn) (mg/kg)	<2.0		<2.0		<2.0
	Titanium (Ti) (mg/kg)	680		787		711
	Uranium (U) (mg/kg)	3.39		3.33		1.07
	Vanadium (V) (mg/kg)	66.0		68.1		56.8
	Zinc (Zn) (mg/kg)	56.2		57.3		53.5

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1837161-26 Sediment 22-SEP-16 LMC-1P	L1837161-27 Sediment 23-SEP-16 LMC-2M	L1837161-28 Sediment 23-SEP-16 LMC-2P	L1837161-29 Sediment 23-SEP-16 LMC-3M	L1837161-30 Sediment 23-SEP-16 LMC-3P
Grouping	**Analyte**					
SOIL						
Metals	Sodium (Na) (mg/kg)		358		340	
	Strontium (Sr) (mg/kg)		131		124	
	Thallium (Tl) (mg/kg)		0.121		0.118	
	Tin (Sn) (mg/kg)		<2.0		<2.0	
	Titanium (Ti) (mg/kg)		700		728	
	Uranium (U) (mg/kg)		1.30		1.21	
	Vanadium (V) (mg/kg)		61.3		60.7	
	Zinc (Zn) (mg/kg)		65.4		63.5	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837161-31	L1837161-32	L1837161-33	L1837161-34	
	Description	Sediment	Sediment	Sediment	Sediment	
	Sampled Date	22-SEP-16	22-SEP-16	22-SEP-16	22-SEP-16	
	Sampled Time					
	Client ID	LMC-5M	LMC-5P	LMC-4M	LMC-4P	
Grouping	**Analyte**					
SOIL						
Metals	Sodium (Na) (mg/kg)	346		351		
	Strontium (Sr) (mg/kg)	124		138		
	Thallium (Tl) (mg/kg)	0.119		0.118		
	Tin (Sn) (mg/kg)	<2.0		<2.0		
	Titanium (Ti) (mg/kg)	749		689		
	Uranium (U) (mg/kg)	1.21		1.52		
	Vanadium (V) (mg/kg)	62.0		61.9		
	Zinc (Zn) (mg/kg)	65.7		66.8		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-TIC-PCT-SK	Soil	Total Inorganic Carbon in Soil	CSSS (2008) P216-217

A known quantity of acetic acid is consumed by reaction with carbonates in the soil. The pH of the resulting solution is measured and compared against a standard curve relating pH to weight of carbonate.

C-TOC-CALC-SK	Soil	Total Organic Carbon Calculation	CSSS (2008) 21.2

Total Organic Carbon (TOC) is calculated by the difference between total carbon (TC) and total inorganic carbon. (TIC)

C-TOT-LECO-SK	Soil	Total Carbon by combustion method	SSSA (1996) P. 973-974

The sample is ignited in a combustion analyzer where carbon in the reduced CO2 gas is determined using a thermal conductivity detector.

HG-200.2-CVAF-VA	Soil	Mercury in Soil by CVAFS	EPA 200.2/1631E (mod)

Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CVAFS.

IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO3 Equivalent	Calculation
LOI-420-SK	Soil	Loss on Ignition @ 420 C	CSSS (1978) METHOD 3.81

The dry-ash method involves the removal of organic matter by combustion at 420OC for 2 hours. Samples are dried prior to combustion.

Reference: McKeague, J.A. Soil Sampling and Methods of Analysis. Can. Soc. Soil Sci.(1978) method 3.81

MET-200.2-CCMS-VA	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A (mod)

Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CRC ICPMS.

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. This method does not dissolve all silicate materials and may result in a partial extraction. depending on the sample matrix, for some metals, including, but not limited to Al, Ba, Be, Cr, Sr, Ti, Tl, and V.

N-TOTKJ-COL-SK	Soil	Total Kjeldahl Nitrogen	CSSS (2008) 22.2.3

The soil is digested with sulfuric acid in the presence of CuSO4 and K2SO4 catalysts. Ammonia in the soil extract is determined colrimetrically at 660 nm.

PH-1:2-VA	Soil	pH in Soil (1:2 Soil:Water Extraction)	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

PSA-PIPET+GRAVEL-SK	Soil	Particle size - Sieve and Pipette	SSIR-51 METHOD 3.2.1

Particle size distribution is determined by a combination of techniques. Dry sieving is performed for coarse particles, wet sieving for sand particles and the pipette sedimentation method for clay particles.

Reference:

Burt, R. (2009). Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 5. Method 3.2.1.2.2. United States Department of Agriculture Natural Resources Conservation Service.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L1837161-COFC

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Report To	
Company:	Minnow Environmental Inc.
Contact:	Lisa Bowron
Address:	101 - 1025 Hillside Ave. Victoria, BC
Phone:	(250)595-1627 x21 Fax: (250) 595-1625
Invoice To	Same as Report ? ☐ Yes ☑ No
Hardcopy of Invoice with Report?	☑ Yes ☐ No
Company:	Minto Explorations Ltd
Contact:	Cindy Keehn
Address:	Suite 2100-510 West Georgia Street, Vancouver, BC
Phone:	604-684-8894 Fax: 604-688-2180
Lab Work Order # (lab use only)	

Report Format / Distribution	
☑ Standard ☐ Other	
☑ PDF ☑ Excel ☐ Digital ☐ Fax	
Email 1:	lbowron@minnow.ca
Email 2:	pstecko@minnow.ca
Email 3:	
Client / Project Information	
Job #:	Minnow Project [redacted] 16-80
PO / AFE:	
LSD:	
Quote #:	Q51327
ALS Contact:	~~Can Dang~~ Selam Worku
Sampler:	Lisa Bowron

Service Requested (Rush for routine analysis subject to availability)

- (●) Regular (Standard Turnaround Times - Business Days)
- ( ) Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ( ) Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ( ) Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Rescan Low Level Sediments	Inorganic Carbon	Total Carbon by combustion	Mercury by CVAFS	Loss on Ignition	pH in soil	Particle Size	Total Organic Carbon	Total Kjeldahl Nitrogen	**See Complete Quote #Q51327			Number of Containers
	UMC-1M	28-Sep-16	—	Sediment	✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	UMC-2M	28-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	UMC-3M	28-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	UMC-4M	28-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	UMC-5M	28-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	UMC	28-Sep-16	—								✓			✓			1
	URC-1M	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	URC-2M	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	URC-3M	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	URC-4M	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	URC-5M	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	URC	26-Sep-16	—								✓			✓			1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Small samples. The critical analyte of interest is selenium; please ensure best possible MDLs.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Lisa Bowron	Date (dd-mmm-yy) 29-Sep-16	Time (hh-mm) 13:22	Received by: [signature]	Date: Sept-29-16	Time: 1:25pm	Temperature: 0.4 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

time SEP 30 2016 1:00pm 7 4 9 3 6

L1837161-COFC

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Report To		Report Format / Distribution	
Company:	Minnow Environmental Inc.	☑ Standard ☐ Other	
Contact:	Lisa Bowron	☑ PDF ☑ Excel ☐ Digital ☐ Fax	
Address:	101 - 1025 Hillside Ave.	Email 1:	lbowron@minnow.ca
	Victoria, BC	Email 2:	pstecko@minnow.ca
Phone:	(250)595-1627 x21 Fax: (250) 595-1625	Email 3:	
Invoice To	Same as Report ? ☐ Yes ☑ No	**Client / Project Information**	
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Minnow Project ~~0072~~ 16-80
Company:	Minto Explorations Ltd	PO / AFE:	
Contact:	Cindy Keehn	LSD:	
Address:	Suite 2100-510 West Georgia Street, Vancouver, BC		
Phone:	604-684-8894 Fax: 604-688-2180	Quote #:	Q51327
Lab Work Order # (lab use only)		ALS Contact:	Selam ~~Can Dang~~ Worku
		Sampler:	Lisa Bowron

Service Requested (Rush for routine analysis subject to availability)

- ◉ Regular (Standard Turnaround Times - Business Days)
- ◯ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ◯ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ◯ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Rescan Low Level Sediments	Inorganic Carbon	Total Carbon by combustion	Mercury by CVAFS	Loss on Ignition	pH in soil	Particle Size	Total Organic Carbon	Total Kjeldahl Nitrogen	**See Complete Quote #Q51327			Number of Containers
	LWC-1M	26-Sep-16	—	Sediment	✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LWC-1P	26-Sep-16	—								✓			✓			1
	LWC-2M	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LWC-2P	26-Sep-16	—								✓			✓			1
	LWC-3M	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LWC-3P	26-Sep-16	—								✓			✓			1
	LWC-4M	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LWC-4P	26-Sep-16	—								✓			✓			1
	LWC-5M	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LWC-5P	26-Sep-16	—								✓			✓			1
	LWC-5MX	26-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LWC-5PX	26-Sep-16	—								✓			✓			1

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SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Lisa Bowron	29-Sep-16	13:22	[signature]	Sept-29-16	1:25pm	0.5 °C				

HMC SEP 30 2016 1:00PM 7 4 9 3 6

ALS Enviro

L1837161-COFC

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC #

Sediment

Report To	
Company:	Minnow Environmental Inc.
Contact:	Lisa Bowron
Address:	101 - 1025 Hillside Ave.
	Victoria, BC
Phone:	(250)595-1627 x21 Fax: (250) 595-1625
Invoice To	Same as Report ? ☐ Yes ☑ No
Hardcopy of Invoice with Report?	☑ Yes ☐ No
Company:	Minto Explorations Ltd
Contact:	Cindy Keehn
Address:	Suite 2100-510 West Georgia Street, Vancouver, BC
Phone:	604-684-8894 Fax: 604-688-2180
Lab Work Order # (lab use only)	

Report Format / Distribution	
☑ Standard	☐ Other
☑ PDF ☑ Excel	☐ Digital ☐ Fax
Email 1:	lbowron@minnow.ca
Email 2:	pstecko@minnow.ca
Email 3:	
Client / Project Information	
Job #:	Minnow Project 16-80
PO / AFE:	
LSD:	
Quote #:	Q51327
ALS Contact:	Selam Worku
Sampler:	Lisa Bowron

Service Requested (Rush for routine analysis subject to availability)

- ◉ Regular (Standard Turnaround Times - Business Days)
- ○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Rescan Low Level Sediments	Inorganic Carbon	Total Carbon by combustion	Mercury by CVAFS	Loss on Ignition	pH in soil	Particle Size	Total Organic Carbon	Total Kjeldahl Nitrogen	**See Complete Quote #Q51327			Number of Containers
	LMC-1M	22-Sep-16	—	Sediment	✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LMC-1P	22-Sep-16	—								✓			✓			1
	LMC-2M	23-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LMC-2P	23-Sep-16	—								✓			✓			1
	LMC-3M	23-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LMC-3P	23-Sep-16	—								✓			✓			1
	LMC-5M	22-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LMC-5P	22-Sep-16	—								✓			✓			1
	LMC-4M	22-Sep-16	—		✓	✓	✓	✓	✓	✓		✓	✓	✓			1
	LMC-4P	22-Sep-16	—								✓			✓			1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

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Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Lisa Bowron	29-Sep-16	13:22	[signature]	Sept 29-16	1:25pm	2.6 °C				

GENF 20.00 Front

Hmc SEP 30 2016 1:00pm 7 4 9 3 (

MINNOW ENVIRONMENTAL INC.
ATTN: Lisa Bowron
101 - 1025 Hillside Ave.
Victoria BC V8T 2A2

Date Received: 30-SEP-16
Report Date: 12-DEC-16 15:00 (MT)
Version: FINAL

Client Phone: 250-595-1627

Certificate of Analysis

Lab Work Order #: L1837190

Project P.O. #: NOT SUBMITTED
Job Reference: MINNOW PROJECT 16-80
C of C Numbers:
Legal Site Desc:

Selam Worku
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837190-1	L1837190-2	L1837190-3	L1837190-4	L1837190-5
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	24-SEP-16	24-SEP-16	23-SEP-16	23-SEP-16	23-SEP-16
	Sampled Time					
	Client ID	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	56.6	51.8	44.2	50.8	85.8
Metals	Aluminum (Al)-Total (mg/kg wwt)	5150	4310	6060	7010	2870
	Antimony (Sb)-Total (mg/kg wwt)	0.0184	0.0227	0.0150	0.0194	0.0214
	Arsenic (As)-Total (mg/kg wwt)	3.87	6.17	4.07	3.71	2.00
	Barium (Ba)-Total (mg/kg wwt)	241	418	267	141	65.6
	Beryllium (Be)-Total (mg/kg wwt)	0.188	0.202	0.215	0.211	0.0989
	Bismuth (Bi)-Total (mg/kg wwt)	0.0447	0.0424	0.0479	0.0504	0.0232
	Boron (B)-Total (mg/kg wwt)	3.12	3.95	2.91	2.05	1.07
	Cadmium (Cd)-Total (mg/kg wwt)	0.136	0.273	0.127	0.0933	0.0580
	Calcium (Ca)-Total (mg/kg wwt)	4660	6050	5080	4760	2580
	Cesium (Cs)-Total (mg/kg wwt)	0.365	0.284	0.371	0.490	0.235
	Chromium (Cr)-Total (mg/kg wwt)	13.0	10.7	13.6	15.9	6.50
	Cobalt (Co)-Total (mg/kg wwt)	6.87	11.9	7.31	5.65	2.38
	Copper (Cu)-Total (mg/kg wwt)	18.0	18.4	18.3	19.1	10.3
	Iron (Fe)-Total (mg/kg wwt)	10400	10300	11600	12800	5820
	Lead (Pb)-Total (mg/kg wwt)	2.17	2.13	2.53	2.70	1.19
	Lithium (Li)-Total (mg/kg wwt)	4.56	3.84	5.18	5.26	2.06
	Magnesium (Mg)-Total (mg/kg wwt)	2800	2690	3390	3570	1480
	Manganese (Mn)-Total (mg/kg wwt)	2850	7960	2980	1090	463
	Mercury (Hg)-Total (mg/kg wwt)	0.0127	0.0146	0.0112	0.0133	0.0084
	Molybdenum (Mo)-Total (mg/kg wwt)	0.400	0.688	0.443	0.270	0.167
	Nickel (Ni)-Total (mg/kg wwt)	13.8	13.7	13.9	13.3	5.75
	Phosphorus (P)-Total (mg/kg wwt)	533	529	620	583	234
	Potassium (K)-Total (mg/kg wwt)	641	700	650	687	485
	Rubidium (Rb)-Total (mg/kg wwt)	4.48	3.73	4.66	6.07	2.84
	Selenium (Se)-Total (mg/kg wwt)	0.558	0.567	0.494	0.425	0.275
	Sodium (Na)-Total (mg/kg wwt)	111	115	164	148	59.6
	Strontium (Sr)-Total (mg/kg wwt)	47.0	72.0	49.1	40.7	24.6
	Tellurium (Te)-Total (mg/kg wwt)	0.0115	0.0154	0.0117	0.0101	DLA <0.0080
	Thallium (Tl)-Total (mg/kg wwt)	0.0353	0.0327	0.0373	0.0482	0.0225
	Tin (Sn)-Total (mg/kg wwt)	0.186	0.152	0.237	0.184	0.131
	Uranium (U)-Total (mg/kg wwt)	0.281	0.348	0.313	0.345	0.214
	Vanadium (V)-Total (mg/kg wwt)	19.8	22.7	23.3	25.1	11.2
	Zinc (Zn)-Total (mg/kg wwt)	22.8	24.5	28.5	31.7	13.1
	Zirconium (Zr)-Total (mg/kg wwt)	4.14	4.26	4.79	4.25	1.95

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837190-6	L1837190-7	L1837190-8	L1837190-9	L1837190-10
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	26-SEP-16	25-SEP-16	25-SEP-16	25-SEP-16	25-SEP-16
	Sampled Time					
	Client ID	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	69.0	65.5	67.9	48.1	53.6
Metals	Aluminum (Al)-Total (mg/kg wwt)	5230	6360	4630	7450	5270
	Antimony (Sb)-Total (mg/kg wwt)	0.0145	0.0139	0.0119	0.0182	0.0109
	Arsenic (As)-Total (mg/kg wwt)	1.74	2.02	1.67	2.47	1.97
	Barium (Ba)-Total (mg/kg wwt)	71.4	85.5	71.2	89.1	88.0
	Beryllium (Be)-Total (mg/kg wwt)	0.209	0.255	0.216	0.299	0.272
	Bismuth (Bi)-Total (mg/kg wwt)	0.0274	0.0326	0.0302	0.0372	0.0320
	Boron (B)-Total (mg/kg wwt)	1.52	1.50	1.27	1.24	0.94
	Cadmium (Cd)-Total (mg/kg wwt)	0.0559	0.0672	0.0584	0.0747	0.0795
	Calcium (Ca)-Total (mg/kg wwt)	2940	3640	2980	3910	3950
	Cesium (Cs)-Total (mg/kg wwt)	0.504	0.612	0.473	0.644	0.378
	Chromium (Cr)-Total (mg/kg wwt)	15.1	17.7	12.5	21.1	14.2
	Cobalt (Co)-Total (mg/kg wwt)	4.16	4.95	4.40	6.62	4.91
	Copper (Cu)-Total (mg/kg wwt)	7.47	9.04	7.55	10.3	8.27
	Iron (Fe)-Total (mg/kg wwt)	8930	10600	8420	13000	9740
	Lead (Pb)-Total (mg/kg wwt)	1.75	2.11	1.84	2.78	2.00
	Lithium (Li)-Total (mg/kg wwt)	3.47	4.22	3.47	5.37	4.00
	Magnesium (Mg)-Total (mg/kg wwt)	3240	3830	3130	4800	3780
	Manganese (Mn)-Total (mg/kg wwt)	304	360	294	350	319
	Mercury (Hg)-Total (mg/kg wwt)	0.0185	0.0137	0.0114	0.0132	0.0149
	Molybdenum (Mo)-Total (mg/kg wwt)	0.125	0.142	0.139	0.173	0.159
	Nickel (Ni)-Total (mg/kg wwt)	12.3	14.5	12.2	19.4	14.5
	Phosphorus (P)-Total (mg/kg wwt)	405	474	378	572	478
	Potassium (K)-Total (mg/kg wwt)	444	503	348	538	356
	Rubidium (Rb)-Total (mg/kg wwt)	4.60	5.64	4.03	5.89	3.85
	Selenium (Se)-Total (mg/kg wwt)	0.187	0.202	0.158	0.176	0.154
	Sodium (Na)-Total (mg/kg wwt)	129	145	148	182	142
	Strontium (Sr)-Total (mg/kg wwt)	26.4	32.4	26.7	37.2	36.0
	Tellurium (Te)-Total (mg/kg wwt)	<0.0080 DLA	0.0082	0.0059	<0.016 DLA	0.0058
	Thallium (Tl)-Total (mg/kg wwt)	0.0290	0.0359	0.0250	0.0400	0.0255
	Tin (Sn)-Total (mg/kg wwt)	0.241	0.191	0.232	0.195	0.211
	Uranium (U)-Total (mg/kg wwt)	0.299	0.384	0.337	0.523	0.577
	Vanadium (V)-Total (mg/kg wwt)	19.8	23.8	16.9	29.6	20.3
	Zinc (Zn)-Total (mg/kg wwt)	20.5	24.3	19.3	30.2	21.1
	Zirconium (Zr)-Total (mg/kg wwt)	4.28	5.16	4.37	5.81	5.02

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837190-11	L1837190-12	L1837190-13	L1837190-14	L1837190-15
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	27-SEP-16	27-SEP-16	24-SEP-16	24-SEP-16	27-SEP-16
	Sampled Time					
	Client ID	LBC-1PT	LBC-2PT	LBC-3	LBC-3X	LBC-4
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	58.6	64.5	73.7	68.7	72.0
Metals	Aluminum (Al)-Total (mg/kg wwt)	4920	3570	3600	4390	2130
	Antimony (Sb)-Total (mg/kg wwt)	0.0408	0.0482	0.0509	0.0528	0.0436
	Arsenic (As)-Total (mg/kg wwt)	8.15	7.55	7.45	9.34	4.66
	Barium (Ba)-Total (mg/kg wwt)	74.7	57.7	60.7	74.3	40.0
	Beryllium (Be)-Total (mg/kg wwt)	0.204	0.160	0.155	0.192	0.0964
	Bismuth (Bi)-Total (mg/kg wwt)	0.279	0.315	0.324	0.552	0.166
	Boron (B)-Total (mg/kg wwt)	1.22	0.91	1.11	1.32	0.77
	Cadmium (Cd)-Total (mg/kg wwt)	0.0730	0.0625	0.0647	0.0829	0.0358
	Calcium (Ca)-Total (mg/kg wwt)	2850	2280	2160	2690	1450
	Cesium (Cs)-Total (mg/kg wwt)	0.932	0.720	0.766	0.934	0.462
	Chromium (Cr)-Total (mg/kg wwt)	11.1	7.93	8.00	9.74	5.14
	Cobalt (Co)-Total (mg/kg wwt)	3.70	2.80	2.60	3.21	1.84
	Copper (Cu)-Total (mg/kg wwt)	11.2	10.2	10.8	13.5	10.2
	Iron (Fe)-Total (mg/kg wwt)	8930	6570	6240	7630	4620
	Lead (Pb)-Total (mg/kg wwt)	3.20	2.68	2.53	3.01	1.69
	Lithium (Li)-Total (mg/kg wwt)	3.91	2.88	2.67	3.37	1.75
	Magnesium (Mg)-Total (mg/kg wwt)	2750	2040	1870	2280	1290
	Manganese (Mn)-Total (mg/kg wwt)	239	207	193	254	125
	Mercury (Hg)-Total (mg/kg wwt)	0.0128	0.0762	0.0120	0.0149	0.0062
	Molybdenum (Mo)-Total (mg/kg wwt)	0.413	0.396	0.397	0.502	0.257
	Nickel (Ni)-Total (mg/kg wwt)	8.98	6.85	6.51	8.03	4.31
	Phosphorus (P)-Total (mg/kg wwt)	447	305	245	314	246
	Potassium (K)-Total (mg/kg wwt)	561	531	418	526	359
	Rubidium (Rb)-Total (mg/kg wwt)	5.39	3.96	4.20	5.13	2.53
	Selenium (Se)-Total (mg/kg wwt)	0.094	0.096	0.098	0.118	0.067
	Sodium (Na)-Total (mg/kg wwt)	148	106	102	125	73.0
	Strontium (Sr)-Total (mg/kg wwt)	26.5	22.4	22.2	27.3	13.1
	Tellurium (Te)-Total (mg/kg wwt)	0.0227	0.0221	0.0219	0.0255	0.0114
	Thallium (Tl)-Total (mg/kg wwt)	0.0451	0.0367	0.0393	0.0474	0.0218
	Tin (Sn)-Total (mg/kg wwt)	0.175	0.133	0.169	0.185	0.144
	Uranium (U)-Total (mg/kg wwt)	0.492	0.378	0.405	0.512	0.240
	Vanadium (V)-Total (mg/kg wwt)	21.0	14.1	13.7	16.9	10.5
	Zinc (Zn)-Total (mg/kg wwt)	23.9	19.1	17.3	21.4	12.2
	Zirconium (Zr)-Total (mg/kg wwt)	3.09	2.54	2.36	2.88	1.60

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1837190-16 Tissue 27-SEP-16 LBC-5				
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	75.0				
Metals	Aluminum (Al)-Total (mg/kg wwt)	2900				
	Antimony (Sb)-Total (mg/kg wwt)	0.0568				
	Arsenic (As)-Total (mg/kg wwt)	7.48				
	Barium (Ba)-Total (mg/kg wwt)	53.9				
	Beryllium (Be)-Total (mg/kg wwt)	0.126				
	Bismuth (Bi)-Total (mg/kg wwt)	0.315				
	Boron (B)-Total (mg/kg wwt)	1.09				
	Cadmium (Cd)-Total (mg/kg wwt)	0.0530				
	Calcium (Ca)-Total (mg/kg wwt)	1860				
	Cesium (Cs)-Total (mg/kg wwt)	0.647				
	Chromium (Cr)-Total (mg/kg wwt)	7.01				
	Cobalt (Co)-Total (mg/kg wwt)	2.22				
	Copper (Cu)-Total (mg/kg wwt)	9.94				
	Iron (Fe)-Total (mg/kg wwt)	5790				
	Lead (Pb)-Total (mg/kg wwt)	2.05				
	Lithium (Li)-Total (mg/kg wwt)	2.10				
	Magnesium (Mg)-Total (mg/kg wwt)	1540				
	Manganese (Mn)-Total (mg/kg wwt)	197				
	Mercury (Hg)-Total (mg/kg wwt)	0.0111				
	Molybdenum (Mo)-Total (mg/kg wwt)	0.394				
	Nickel (Ni)-Total (mg/kg wwt)	5.42				
	Phosphorus (P)-Total (mg/kg wwt)	277				
	Potassium (K)-Total (mg/kg wwt)	557				
	Rubidium (Rb)-Total (mg/kg wwt)	3.54				
	Selenium (Se)-Total (mg/kg wwt)	0.108				
	Sodium (Na)-Total (mg/kg wwt)	88.2				
	Strontium (Sr)-Total (mg/kg wwt)	17.9				
	Tellurium (Te)-Total (mg/kg wwt)	0.0213				
	Thallium (Tl)-Total (mg/kg wwt)	0.0309				
	Tin (Sn)-Total (mg/kg wwt)	0.120				
	Uranium (U)-Total (mg/kg wwt)	0.334				
	Vanadium (V)-Total (mg/kg wwt)	13.5				
	Zinc (Zn)-Total (mg/kg wwt)	15.2				
	Zirconium (Zr)-Total (mg/kg wwt)	2.08				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Aluminum (Al)-Total	DUP-H	L1837190-8
Duplicate	Antimony (Sb)-Total	DUP-H	L1837190-8
Duplicate	Beryllium (Be)-Total	DUP-H	L1837190-8
Duplicate	Cesium (Cs)-Total	DUP-H	L1837190-8
Duplicate	Cobalt (Co)-Total	DUP-H	L1837190-8
Duplicate	Magnesium (Mg)-Total	DUP-H	L1837190-8
Duplicate	Molybdenum (Mo)-Total	DUP-H	L1837190-8
Duplicate	Rubidium (Rb)-Total	DUP-H	L1837190-8
Duplicate	Vanadium (V)-Total	DUP-H	L1837190-8
Duplicate	Zirconium (Zr)-Total	DUP-H	L1837190-8
Certified Reference Material	Sodium (Na)-Total	RM-H	L1837190-1, -10, -2, -3

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
DUP-H	Duplicate results outside ALS DQO, due to sample heterogeneity.
RM-H	Reference Material recovery was above ALS DQO. Non-detected sample results are considered reliable. Other results, if reported, have been qualified.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
HG-WET-CVAFS-N-VA	Tissue	Mercury in Tissue by CVAFS (WET)	EPA 200.3, EPA 245.7

This method is conducted following British Columbia Lab Manual method "Metals in Animal Tissue and Vegetation (Biota) - Prescriptive". Tissue samples are homogenized and sub-sampled prior to hotblock digestion with nitric and hydrochloric acids, in combination with addition of hydrogen peroxide. Analysis is by atomic fluorescence spectrophotometry or atomic absorption spectrophotometry, adapted from US EPA Method 245.7.

HG-WET-MICR-CVAF-VA	Tissue	Mercury in Tissue by CVAFS Micro (WET)	EPA 200.3, EPA 245.7

This method is adapted from US EPA Method 200.3 "Sample Procedures for Spectrochemical Determination of Total Recoverable Elements in Biological Tissues" (1996). Tissue samples are homogenized and sub-sampled prior to hotblock digestion with nitric and hydrochloric acids, in combination with repeated additions of hydrogen peroxide. Analysis is by atomic fluorescence spectrophotometry or atomic absorption spectrophotometry, adapted from US EPA Method 245.7.

MET-WET-CCMS-N-VA	Tissue	Metals in Tissue by CRC ICPMS (WET)	EPA 200.3/6020A

This method is conducted following British Columbia Lab Manual method "Metals in Animal Tissue and Vegetation (Biota) - Prescriptive". Tissue samples are homogenized and sub-sampled prior to hotblock digestion with nitric and hydrochloric acids, in combination with addition of hydrogen peroxide. Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

Method Limitation: This method employs a strong acid/peroxide digestion, and is intended to provide a conservative estimate of bio-available metals. Near complete recoveries are achieved for most toxicologically important metals, but elements associated with recalcitrant minerals may be only partially recovered.

MET-WET-MICR-HRMS-VA	Tissue	Metals in Tissue by HR-ICPMS Micro (WET)	EPA 200.3/200.8

Trace metals in tissue are analyzed by high resolution inductively coupled plasma mass spectrometry (HR-ICPMS) modified from US EPA Method 200.8, (Revision 5.5). The sample preparation procedure is modified from US EPA 200.3. Analytical results are reported on wet weight basis.

Method Limitation: This method employs a strong acid/peroxide digestion, and is intended to provide a conservative estimate of bio-available metals. Near complete recoveries are achieved for most toxicologically important metals, but elements associated with recalcitrant minerals may be only partially recovered.

MOISTURE-TISS-VA	Tissue	% Moisture in Tissues	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Page 1 of 2

Pendleton

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Minnow Environmental Inc.	☑ Standard ☐ Other		● Regular (Standard Turnaround Times - Business Days)
Contact:	Lisa Bowron	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	101 - 1025 Hillside Ave.	Email 1:	lbowron@minnow.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Victoria, BC	Email 2:	pstecko@minnow.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(250)595-1627 x21 Fax: (250) 595-1625	Email 3:		Analysis Request
Invoice To	Same as Report ? ☐ Yes ☑ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Minnow Project ~~0075~~ 16-80	
Company:	Minto Exploration Ltd	PO / AFE:		
Contact:	Cindy Keehn	LSD:		
Address:	Suite 2100 - 510 West Georgia St., Vancouver, BC			
Phone:	604-684-8894 Fax: 604-688-2180	Quote #:	Q51327	
Lab Work Order # (lab use only)		ALS Contact:	Selam ~~Can Dang~~ Worku	Sampler: Lisa Bowron

L1837190-COFC

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Moisture (%)	High Resolution ICP-MS scan	Mercury in Tissue by CVAFS		**See Complete Quote #Q51327								Number of Containers
	LMC-1	24-Sep-16	—	Tissue	X	X	X		X								1
	LMC-2	24-Sep-16	—		X	X	X		X								1
	LMC-3	23-Sep-16	—		X	X	X		X								1
	LMC-4	23-Sep-16	—		X	X	X		X								1
	LMC-5	23-Sep-16	—		X	X	X		X								1
	LWC-1	26-Sep-16	—		X	X	X		X								1
	LWC-2	25-Sep-16	—		X	X	X		X								1
	LWC-3	25-Sep-16	—		X	X	X		X								1
	LWC-4	25-Sep-16	—		X	X	X		X								1
	LWC-5	25-Sep-16	—		X	X	X		X								1
	LBC-1PT } Both samples in Whirl	27-Sep-16	—		X	X	X		X								1
	LBC-2PT } packs inside small ziplocs	27-Sep-16	—		X	X	X		X								1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Small samples. The critical analyte of interest is selenium; please ensure best possible MDLs. Benthic samples

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)		
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Lisa Bowron	24-Sep-16	13:22	[signature]	Sept-29-16	1:25pm	2.5 °C		SEP 30 2016		

[signature] SEP 30 2016 1:00PM 7 4 9 3 5

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

ALS Environmental

COC # ____________

Pemberton

Report To	
Company:	Minnow Environmental Inc.
Contact:	Lisa Bowron
Address:	101 - 1025 Hillside Ave.
	Victoria, BC
Phone:	(250)595-1627 x21 Fax: (250) 595-1625
Invoice To	Same as Report ? ☐ Yes ☑ No
Hardcopy of Invoice with Report?	☑ Yes ☐ No
Company:	Minto Exploration Ltd
Contact:	Cindy Keehn
Address:	Suite 2100 - 510 West Georgia St., Vancouver, BC
Phone:	604-684-8894 Fax: 604-688-2180
Lab Work Order # (lab use only)	[redacted]

Report Format / Distribution	
☑ Standard ☐ Other	
☑ PDF ☑ Excel ☐ Digital ☐ Fax	
Email 1:	lbowron@minnow.ca
Email 2:	pstecko@minnow.ca
Email 3:	
Client / Project Information	
Job #:	Minnow Project 16-90
PO / AFE:	
LSD:	
Quote #:	Q51327
ALS Contact:	Selam Worku
Sampler:	Lisa Bowron

Service Requested (Rush for routine analysis subject to availability)

- ◉ Regular (Standard Turnaround Times - Business Days)
- ○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Moisture (%)	High Resolution ICP-MS scan	Mercury in Tissue by CVAFS		**See Complete Quote #Q51327	Number of Containers
[redacted]	LBC-3	24-Sep-16	–	Tissue	X	X	X		X	~~2~~ 1
[redacted]	LBC-3X	24-Sep-16	–		X	X	X		X	~~3~~ 1
[redacted]	LBC-4	27-Sep-16	–		X	X	X		X	1
[redacted]	LBC-5	27-Sep-16	–		X	X	X		X	1

L1837190-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Small samples. The critical analyte of interest is selenium; please ensure best possible MDLs. Benthic samples.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.
Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Lisa Bowron	27-Sep-16	8:22	[signature]	Sept-29-16 SEP 30 2016		0.5 °C				

HMC SEP 3 0 2016 1:00PM 14936

MINNOW ENVIRONMENTAL INC.
ATTN: Lisa Bowron
101 - 1025 Hillside Ave.
Victoria BC V8T 2A2

Date Received: 30-SEP-16
Report Date: 12-DEC-16 15:03 (MT)
Version: FINAL

Client Phone: 250-595-1627

Certificate of Analysis

Lab Work Order #: L1837212

Project P.O. #: NOT SUBMITTED
Job Reference: MINNOW PROJECT 16-80
C of C Numbers:
Legal Site Desc:

Selam Worku
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837212-1	L1837212-2	L1837212-3	L1837212-4	L1837212-5
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	22-SEP-16	27-SEP-16	24-SEP-16	27-SEP-16	27-SEP-16
	Sampled Time					
	Client ID	LBC-1BT	LBC-2BT	LBC-3	LBC-4	LBC-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	72.5	75.2	76.9	70.2	68.9
Metals	Aluminum (Al)-Total (mg/kg wwt)	792	501	558	645	964
	Antimony (Sb)-Total (mg/kg wwt)	0.0833	0.0648	0.0716	0.0695	0.0895
	Arsenic (As)-Total (mg/kg wwt)	2.87	1.85	2.94	2.56	2.67
	Barium (Ba)-Total (mg/kg wwt)	18.3	13.5	15.2	22.1	23.2
	Beryllium (Be)-Total (mg/kg wwt)	0.0443	0.0336	0.0338	0.0428	0.0652
	Bismuth (Bi)-Total (mg/kg wwt)	0.107	0.0784	0.103	0.0824	0.103
	Boron (B)-Total (mg/kg wwt)	0.67	0.32	0.49	0.56	0.48
	Cadmium (Cd)-Total (mg/kg wwt)	0.0716	0.0917	0.290	0.309	0.123
	Calcium (Ca)-Total (mg/kg wwt)	720	639	737	735	1130
	Cesium (Cs)-Total (mg/kg wwt)	0.220	0.138	0.186	0.166	0.282
	Chromium (Cr)-Total (mg/kg wwt)	3.90	2.52	2.83	3.80	3.53
	Cobalt (Co)-Total (mg/kg wwt)	0.819	0.553	1.10	1.00	1.05
	Copper (Cu)-Total (mg/kg wwt)	6.16	5.97	9.27	8.11	7.58
	Iron (Fe)-Total (mg/kg wwt)	1670	1050	1350	1640	2290
	Lead (Pb)-Total (mg/kg wwt)	0.734	0.516	0.616	0.662	1.18
	Lithium (Li)-Total (mg/kg wwt)	0.63	0.36	0.42	0.50	0.82
	Magnesium (Mg)-Total (mg/kg wwt)	615	443	491	635	741
	Manganese (Mn)-Total (mg/kg wwt)	70.2	55.7	77.5	100	131
	Mercury (Hg)-Total (mg/kg wwt)	0.0054	0.0047	0.0068	0.0090	0.0060
	Molybdenum (Mo)-Total (mg/kg wwt)	0.285	0.266	0.233	0.252	0.463
	Nickel (Ni)-Total (mg/kg wwt)	2.22	1.82	1.93	2.77	2.73
	Phosphorus (P)-Total (mg/kg wwt)	1480	1500	1480	1570	1890
	Potassium (K)-Total (mg/kg wwt)	1730	1700	1530	1570	1770
	Rubidium (Rb)-Total (mg/kg wwt)	1.21	0.924	1.60	1.56	1.45
	Selenium (Se)-Total (mg/kg wwt)	0.180	0.262	0.255	0.347	0.443
	Sodium (Na)-Total (mg/kg wwt)	658	675	711	638	633
	Strontium (Sr)-Total (mg/kg wwt)	6.89	6.39	6.97	7.58	9.78
	Tellurium (Te)-Total (mg/kg wwt)	0.0077	0.0061	0.0079	0.0069	0.0081
	Thallium (Tl)-Total (mg/kg wwt)	0.00937	0.00717	0.00943	0.00907	0.0122
	Tin (Sn)-Total (mg/kg wwt)	0.942	0.726	0.940	0.710	0.489
	Uranium (U)-Total (mg/kg wwt)	0.169	0.333	0.160	0.251	0.450
	Vanadium (V)-Total (mg/kg wwt)	3.74	2.37	2.66	3.64	4.34
	Zinc (Zn)-Total (mg/kg wwt)	15.9	15.7	23.2	28.4	23.6
	Zirconium (Zr)-Total (mg/kg wwt)	0.869	0.613	0.701	0.868	1.03

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837212-6	L1837212-7	L1837212-8	L1837212-9	L1837212-10
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	24-SEP-16	24-SEP-16	24-SEP-16	23-SEP-16	24-SEP-16
	Sampled Time					
	Client ID	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	75.1	73.6	76.1	73.9	77.2
Metals	Aluminum (Al)-Total (mg/kg wwt)	364	423	624	604	372
	Antimony (Sb)-Total (mg/kg wwt)	0.0220	0.0274	0.0273	0.0251	0.0214
	Arsenic (As)-Total (mg/kg wwt)	0.417	0.534	0.581	0.549	0.471
	Barium (Ba)-Total (mg/kg wwt)	13.8	19.5	16.4	27.9	15.2
	Beryllium (Be)-Total (mg/kg wwt)	0.0156	0.0194	0.0251	0.0219	0.0147
	Bismuth (Bi)-Total (mg/kg wwt)	0.0049	0.0053	0.0072	0.0057	0.0118
	Boron (B)-Total (mg/kg wwt)	0.57	0.67	0.57	0.98	0.60
	Cadmium (Cd)-Total (mg/kg wwt)	0.0555	0.0640	0.0601	0.0658	0.0534
	Calcium (Ca)-Total (mg/kg wwt)	641	791	817	703	509
	Cesium (Cs)-Total (mg/kg wwt)	0.0431	0.0518	0.0672	0.0630	0.0440
	Chromium (Cr)-Total (mg/kg wwt)	1.70	1.90	4.81	2.54	1.60
	Cobalt (Co)-Total (mg/kg wwt)	0.361	0.534	0.617	0.564	0.357
	Copper (Cu)-Total (mg/kg wwt)	5.18	5.68	5.88	5.44	6.11
	Iron (Fe)-Total (mg/kg wwt)	878	1250	1560	1350	858
	Lead (Pb)-Total (mg/kg wwt)	0.222	0.270	0.363	0.300	0.213
	Lithium (Li)-Total (mg/kg wwt)	0.29	0.31	0.49	0.48	0.29
	Magnesium (Mg)-Total (mg/kg wwt)	365	408	531	518	358
	Manganese (Mn)-Total (mg/kg wwt)	81.7	147	115	111	82.3
	Mercury (Hg)-Total (mg/kg wwt)	0.0031	0.0039	0.0050	0.0045	0.0057
	Molybdenum (Mo)-Total (mg/kg wwt)	0.178	0.272	0.218	0.234	0.224
	Nickel (Ni)-Total (mg/kg wwt)	1.21	1.41	2.47	1.92	1.21
	Phosphorus (P)-Total (mg/kg wwt)	1730	1830	1730	1690	1460
	Potassium (K)-Total (mg/kg wwt)	1590	1730	1460	1930	1730
	Rubidium (Rb)-Total (mg/kg wwt)	0.835	0.881	0.932	1.10	0.721
	Selenium (Se)-Total (mg/kg wwt)	0.419	0.494	0.474	0.448	0.534
	Sodium (Na)-Total (mg/kg wwt)	699	720	627	649	564
	Strontium (Sr)-Total (mg/kg wwt)	5.58	7.16	7.16	6.49	4.50
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg wwt)	0.00361	0.00409	0.00523	0.00428	0.00354
	Tin (Sn)-Total (mg/kg wwt)	0.686	0.729	1.58	1.01	0.674
	Uranium (U)-Total (mg/kg wwt)	0.0531	0.0867	0.0778	0.0653	0.0549
	Vanadium (V)-Total (mg/kg wwt)	1.60	2.46	3.01	2.34	1.69
	Zinc (Zn)-Total (mg/kg wwt)	22.3	25.1	23.0	33.9	27.0
	Zirconium (Zr)-Total (mg/kg wwt)	0.414	0.491	0.653	0.486	0.387

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837212-11	L1837212-12	L1837212-13	L1837212-14	L1837212-15
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	26-SEP-16	25-SEP-16	25-SEP-16	25-SEP-16	25-SEP-16
	Sampled Time					
	Client ID	LWC-1	LWC-2	LWC-3	LWC-4	LWC-4X
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	61.3	71.2	64.5	68.8	63.4
Metals	Aluminum (Al)-Total (mg/kg wwt)	1020	282	770	668	945
	Antimony (Sb)-Total (mg/kg wwt)	0.0195	0.0095	0.0161	0.0434	0.0210
	Arsenic (As)-Total (mg/kg wwt)	0.685	0.276	0.455	0.839	0.896
	Barium (Ba)-Total (mg/kg wwt)	16.9	19.5	17.9	12.4	22.8
	Beryllium (Be)-Total (mg/kg wwt)	0.0716	0.0165	0.0517	0.0546	0.0908
	Bismuth (Bi)-Total (mg/kg wwt)	0.0039	0.0023	0.0039	0.0033	0.0060
	Boron (B)-Total (mg/kg wwt)	0.29	<0.20	0.22	<0.20	0.34
	Cadmium (Cd)-Total (mg/kg wwt)	0.0695	0.106	0.0766	0.0554	0.0693
	Calcium (Ca)-Total (mg/kg wwt)	1260	484	1150	1080	1730
	Cesium (Cs)-Total (mg/kg wwt)	0.0891	0.0307	0.0699	0.0578	0.239
	Chromium (Cr)-Total (mg/kg wwt)	3.51	1.98	4.15	3.74	2.84
	Cobalt (Co)-Total (mg/kg wwt)	1.12	0.414	1.23	0.991	1.38
	Copper (Cu)-Total (mg/kg wwt)	6.25	3.88	4.90	5.33	5.96
	Iron (Fe)-Total (mg/kg wwt)	2350	647	1800	1850	2670
	Lead (Pb)-Total (mg/kg wwt)	0.309	0.143	0.330	0.313	0.526
	Lithium (Li)-Total (mg/kg wwt)	1.30	0.22	0.70	0.68	0.86
	Magnesium (Mg)-Total (mg/kg wwt)	1010	402	855	749	979
	Manganese (Mn)-Total (mg/kg wwt)	102	177	126	81.1	142
	Mercury (Hg)-Total (mg/kg wwt)	0.0048	0.0050	0.0044	0.0045	0.0056
	Molybdenum (Mo)-Total (mg/kg wwt)	0.438	0.257	0.349	0.336	0.376
	Nickel (Ni)-Total (mg/kg wwt)	3.81	1.44	2.80	3.15	3.64
	Phosphorus (P)-Total (mg/kg wwt)	2470	2220	2260	2120	2570
	Potassium (K)-Total (mg/kg wwt)	2300	1980	2020	1840	2200
	Rubidium (Rb)-Total (mg/kg wwt)	1.19	0.641	0.832	0.731	1.60
	Selenium (Se)-Total (mg/kg wwt)	1.74	1.34	1.61	1.35	1.40
	Sodium (Na)-Total (mg/kg wwt)	791	630	703	691	682
	Strontium (Sr)-Total (mg/kg wwt)	10.9	6.28	9.98	9.27	23.0
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg wwt)	0.00457	0.00216	0.00380	0.00343	0.00670
	Tin (Sn)-Total (mg/kg wwt)	0.628	0.371	0.807	0.551	0.500
	Uranium (U)-Total (mg/kg wwt)	0.325	0.0685	0.298	0.284	0.288
	Vanadium (V)-Total (mg/kg wwt)	6.21	1.70	4.11	3.96	6.66
	Zinc (Zn)-Total (mg/kg wwt)	27.2	27.5	27.0	23.4	27.2
	Zirconium (Zr)-Total (mg/kg wwt)	1.10	0.400	0.878	0.844	1.08

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1837212-16				
	Description	Tissue				
	Sampled Date	24-SEP-16				
	Sampled Time					
	Client ID	LWC-5				
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	73.5				
Metals	Aluminum (Al)-Total (mg/kg wwt)	234				
	Antimony (Sb)-Total (mg/kg wwt)	0.0121				
	Arsenic (As)-Total (mg/kg wwt)	0.249				
	Barium (Ba)-Total (mg/kg wwt)	14.8				
	Beryllium (Be)-Total (mg/kg wwt)	0.0200				
	Bismuth (Bi)-Total (mg/kg wwt)	0.0021				
	Boron (B)-Total (mg/kg wwt)	<0.20				
	Cadmium (Cd)-Total (mg/kg wwt)	0.0909				
	Calcium (Ca)-Total (mg/kg wwt)	649				
	Cesium (Cs)-Total (mg/kg wwt)	0.0302				
	Chromium (Cr)-Total (mg/kg wwt)	1.89				
	Cobalt (Co)-Total (mg/kg wwt)	0.439				
	Copper (Cu)-Total (mg/kg wwt)	3.76				
	Iron (Fe)-Total (mg/kg wwt)	925				
	Lead (Pb)-Total (mg/kg wwt)	0.170				
	Lithium (Li)-Total (mg/kg wwt)	0.18				
	Magnesium (Mg)-Total (mg/kg wwt)	468				
	Manganese (Mn)-Total (mg/kg wwt)	114				
	Mercury (Hg)-Total (mg/kg wwt)	0.0074				
	Molybdenum (Mo)-Total (mg/kg wwt)	0.292				
	Nickel (Ni)-Total (mg/kg wwt)	1.58				
	Phosphorus (P)-Total (mg/kg wwt)	2030				
	Potassium (K)-Total (mg/kg wwt)	1800				
	Rubidium (Rb)-Total (mg/kg wwt)	0.575				
	Selenium (Se)-Total (mg/kg wwt)	1.22				
	Sodium (Na)-Total (mg/kg wwt)	588				
	Strontium (Sr)-Total (mg/kg wwt)	6.73				
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040				
	Thallium (Tl)-Total (mg/kg wwt)	0.00197				
	Tin (Sn)-Total (mg/kg wwt)	0.363				
	Uranium (U)-Total (mg/kg wwt)	0.115				
	Vanadium (V)-Total (mg/kg wwt)	2.19				
	Zinc (Zn)-Total (mg/kg wwt)	26.0				
	Zirconium (Zr)-Total (mg/kg wwt)	0.736				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Aluminum (Al)-Total	DUP-H	L1837212-16
Duplicate	Antimony (Sb)-Total	DUP-H	L1837212-16
Duplicate	Beryllium (Be)-Total	DUP-H	L1837212-16
Duplicate	Cesium (Cs)-Total	DUP-H	L1837212-16
Duplicate	Cobalt (Co)-Total	DUP-H	L1837212-16
Duplicate	Magnesium (Mg)-Total	DUP-H	L1837212-16
Duplicate	Molybdenum (Mo)-Total	DUP-H	L1837212-16
Duplicate	Rubidium (Rb)-Total	DUP-H	L1837212-16
Duplicate	Vanadium (V)-Total	DUP-H	L1837212-16
Duplicate	Zirconium (Zr)-Total	DUP-H	L1837212-16

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DUP-H	Duplicate results outside ALS DQO, due to sample heterogeneity.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
HG-WET-MICR-CVAF-VA	Tissue	Mercury in Tissue by CVAFS Micro (WET)	EPA 200.3, EPA 245.7

This method is adapted from US EPA Method 200.3 "Sample Procedures for Spectrochemical Determination of Total Recoverable Elements in Biological Tissues" (1996). Tissue samples are homogenized and sub-sampled prior to hotblock digestion with nitric and hydrochloric acids, in combination with repeated additions of hydrogen peroxide. Analysis is by atomic fluorescence spectrophotometry or atomic absorption spectrophotometry, adapted from US EPA Method 245.7.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-WET-MICR-HRMS-VA	Tissue	Metals in Tissue by HR-ICPMS Micro (WET)	EPA 200.3/200.8

Trace metals in tissue are analyzed by high resolution inductively coupled plasma mass spectrometry (HR-ICPMS) modified from US EPA Method 200.8, (Revision 5.5). The sample preparation procedure is modified from US EPA 200.3. Analytical results are reported on wet weight basis.

Method Limitation: This method employs a strong acid/peroxide digestion, and is intended to provide a conservative estimate of bio-available metals. Near complete recoveries are achieved for most toxicologically important metals, but elements associated with recalcitrant minerals may be only partially recovered.

ALS Test Code	Matrix	Test Description	Method Reference**
MOISTURE-TISS-VA	Tissue	% Moisture in Tissues	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Page 1 of 2

Benthic

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Minnow Environmental Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Lisa Bowron	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	101 - 1025 Hillside Ave.	Email 1:	lbowron@minnow.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Victoria, BC	Email 2:	pstecko@minnow.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(250)595-1627 x21 Fax: (250) 595-1625	Email 3:		Analysis Request
Invoice To	Same as Report ? ☐ Yes ☑ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Minnow Project ~~0025~~ 16-80	
Company:	Minto Exploration Ltd	PO / AFE:		
Contact:	Cindy Keehn	LSD:		
Address:	Suite 2100 - 510 West Georgia St., Vancouver, BC			
Phone:	604-684-8894 Fax: 604-688-2180	Quote #:	Q51327	
Lab Work Order # (lab use only)		ALS Contact:	Selam ~~Gang Bang~~ Worku	Sampler: Lisa Bowron

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Moisture (%)	High Resolution ICP-MS scan	Mercury in Tissue by CVAFS		**See Complete Quote #Q51327								Number of Containers
	LBC-1BT	22-Sep-16	—	Tissue	X	X	X		X								1
	LBC-2BT	27-Sep-16	—		X	X	X		X								1
	LBC-3	24-Sep-16	—		X	X	X		X								1
	LBC-4	27-Sep-16	—		X	X	X		X								1
	LBC-5	27-Sep-16	—		X	X	X		X								1
	LMC-1	24-Sep-16	—		X	X	X		X								1
	LMC-2	24-Sep-16	—		X	X	X		X								1
	LMC-3	24-Sep-16	—		X	X	X		X								1
	LMC-4	23-Sep-16	—		X	X	X		X								1
	LMC-5	24-Sep-16	—		X	X	X		X								1
	LWC-1	26-Sep-16	—		X	X	X		X								
	LWC-2	25-Sep-16	—		X	X	X		X								1

L1837212-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Small samples. The critical analyte of interest is selenium; please ensure best possible MDLs. Benthic samples.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Lisa Bowron	Date (dd-mmm-yy) 29-Sep-16	Time (hh-mm) 13:22	Received by: [signature]	Date: Sept 29-16	Time: 11:25pm	Temperature: 2.0 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

HMC SEP 30 2016 1:00pm 74936

Chain of Custody / Analytical Request Form

~~Canada Toll Free: 1 800 668 9878~~

www.alsglobal.com

COC # ______

Benthic

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Minnow Environmental Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Lisa Bowron	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	101 - 1025 Hillside Ave.	Email 1:	lbowron@minnow.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Victoria, BC	Email 2:	pstecko@minnow.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(250)595-1627 x21 Fax: (250) 595-1625	Email 3:		

Invoice To	Same as Report ? ☐ Yes ☑ No	Client / Project Information	
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Minnow Project ~~0000~~ 16-80
Company:	Minto Exploration Ltd	PO / AFE:	
Contact:	Cindy Keehn	LSD:	
Address:	Suite 2100 - 510 West Georgia St., Vancouver, BC		
Phone:	604-684-8894 Fax: 604-688-2180	Quote #:	Q51327
Lab Work Order # (lab use only)		ALS Contact:	Selam ~~Can Dang~~ Worku
		Sampler:	Lisa Bowron

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Moisture (%)	High Resolution ICP-MS scan	Mercury in Tissue by CVAFS		**See Complete Quote #Q51327	Number of Containers
	LWC-3	25-Sep-16		Tissue	X	X	X		X	1
	LWC-4	25-Sep-16			X	X	X		X	1
	LWC-4X	25-Sep-16			X	X	X		X	1
	LWC-5	24-Sep-16			X	X	X		X	1

L1837212-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Small samples. The critical analyte of interest is selenium; please ensure best possible MDLs. Benthic samples.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Lisa Bowron	29-Sep-16	13:22	[signature]	Sept-29-16	1:25pm	2.0 °C				
			HMC	SEP 3 0 2016	1:00pm					

7 4 9 7 6

APPENDIX D

PERIPHYTON COMMUNITY DATA

Table D.1: Density of periphyton community sampled at lower Wolverine Creek (reference) and lower Minto Creek (exposure), Minto Mine WUL, 2016. All data are presented as cells/cm^2.

Sample Location		Lower Wolverine Creek					Lower Minto Creek				
		LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Sample Date		26-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	24-Sep-16	24-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16
Group	**Genera and species**										
Cyanophyte	Phormidium autumnale Agardh	-	-	1,148	646	517	345	431	2,153	431	6,029
	Heteroleibeinia profunda Komarek	-	-	-	-	7,063	7,580	1,723	2,584	2,692	6,546
	Homoeothrix varians Komarek & Kalina	-	-	-	-	-	1,034	-	27,132	-	-
	Pseudoanabaena sp.	-	3,732	-	-	9,130	-	1,723	3,445	-	-
	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	574	574	2,584	2,799	345	-	-	-	54	-
Chlorophyte	Mougeotia sp.	-	-	-	-	-	-	-	-	-	517
	Ulothrix zonata Kutzing	-	-	-	2,153	-	-	-	-	-	1,034
Diatoms	Navicula minima Grunow	-	-	-	-	-	172	108	-	-	-
	Achnanthes minutissima Kutzing	-	-	861	646	-	13,953	16,688	17,011	2,207	24,634
	Eucocconeis sp.	574	-	-	-	-	1,206	108	-	-	345
	Nitzschia linearis W. Smith	3,732	861	2,010	1,292	517	861	-	2,369	754	345
	Encyonema silesiacum (Bleisch) D.G. Mann	574	574	861	431	1,034	689	1,292	2,153	323	689
	Navicula radiosa Kutzing	-	-	-	646	-	172	431	215	54	172
	Cocconies disculus Schum.	574	861	861	-	861	1,206	1,507	7,752	5,491	2,584
	Anomoenies vitrea Ross	287	574	574	861	1,206	517	2,046	1,723	2,584	7,580
	Denticula elegans Kutzing	-	-	-	-	-	517	-	-	-	-
	Navicula exigua (Greg.) Muller	-	-	-	-	-	1,378	-	-	54	-
	Fragilaria capucina Grunow	2,010	1,148	2,584	7,106	689	172	1,077	1,292	1,346	517
	Diatoma vulgare Bory	51,392	57,996	50,244	25,409	21,189	-	323	-	-	-
	Gomphonema minutum	-	287	-	-	-	-	1,400	11,197	215	1,378
	Navicula pupula Kutzing	-	-	-	-	-	-	323	-	-	-
	Meridion circulare Agardh	287	-	574	-	345	-	215	-	-	345
	Surirella ovata Kutzing	-	-	-	-	-	-	-	215	-	-
	Cymbella minuta Kutzing	-	574	-	-	-	-	-	-	162	345
	Synedra acus v. radians (Kutzing) Hustedt	-	-	-	-	689	-	-	-	754	345
	Synedra ulna (Nitzsch) Ehrenberg	-	-	-	-	345	-	-	-	-	-
	Cyclotella pseudostelligera	-	-	-	-	-	-	-	-	-	2,067
	Cymbella prostrata (Berkeley) Cleve	-	574	-	-	172	-	-	-	-	172
	Fragilaria pinata Ehrenberg	287	-	-	-	-	-	-	-	-	-
	Nitzschia filiformis (W. Smith) Hustedt	287	-	-	-	-	-	-	-	-	-
	Didymosphenia geminata Schmidt	287	-	-	-	172	-	-	-	-	-
	Fragilaria construens (Ehrenberg) Grunow	-	-	-	861	-	-	-	-	-	-
	Nitzschia clausii Hantzsch	-	-	-	-	172	-	-	-	-	-
	Hannaea arcus Patrick	-	-	-	-	172	-	-	-	-	-
Red Algae	Audouinella / Chantransia stage. Red alga	-	3,445	7,752	-	-	19,638	431	1,723	-	-

Table D.2: Biomass of periphyton community sampled at lower Wolverine Creek (reference) and lower Minto Creek (exposure), Minto Mine WUL, 2016. All data are presented as µg/cm^2.

Sample Location		Lower Wolverine Creek					Lower Minto Creek				
		LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Sample Date		26-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	24-Sep-16	24-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16
Group	**Genera and species**										
Cyanophyte	Phormidium autumnale Agardh	-	-	3.3	1.9	1.5	1.3	1.4	6.3	1.7	24
	Heteroleibeinia profunda Komarek	-	-	-	-	0.47	0.50	0.087	0.20	0.18	0.42
	Homoeothrix varians Komarek & Kalina	-	-	-	-	-	0.19	-	3.7	-	-
	Pseudoanabaena sp.	-	0.046	-	-	0.11	-	0.037	0.073	-	-
	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	0.14	0.078	0.40	0.45	0.063	-	-	-	0.0060	-
Chlorophyte	Mougeotia sp.	-	-	-	-	-	-	-	-	-	1.2
	Ulothrix zonata Kutzing	-	-	-	27	-	-	-	-	-	13
Diatoms	Navicula minima Grunow	-	-	-	-	-	0.0079	0.0045	-	-	-
	Achnanthes minutissima Kutzing	-	-	0.060	0.046	-	0.99	1.2	1.2	0.17	1.7
	Eucocconeis sp.	3.0	-	-	-	-	6.1	0.56	-	-	1.7
	Nitzschia linearis W. Smith	1.9	0.41	0.87	0.62	0.30	0.42	-	0.56	0.19	0.081
	Encyonema silesiacum (Bleisch) D.G. Mann	0.68	0.68	0.96	0.51	1.2	0.81	1.4	2.5	0.38	0.81
	Navicula radiosa Kutzing	-	-	-	1.1	-	0.33	0.77	0.39	0.10	0.29
	Cocconies disculus Schum.	0.91	1.3	1.4	-	1.4	1.9	2.4	13	11	4.4
	Anomoenies vitrea Ross	0.089	0.18	0.18	0.25	0.35	0.16	0.67	0.57	0.84	2.4
	Denticula elegans Kutzing	-	-	-	-	-	0.23	-	-	-	-
	Navicula exigua (Greg.) Muller	-	-	-	-	-	0.67	-	-	0.011	-
	Fragilaria capucina Grunow	2.5	1.3	3.1	8.7	0.72	0.17	1.0	0.72	1.6	0.57
	Diatoma vulgare Bory	12	14	12	6.0	4.8	-	0.076	-	-	-
	Gomphonema minutum	-	0.12	-	-	-	-	0.61	4.9	0.10	0.59
	Navicula pupula Kutzing	-	-	-	-	-	-	0.076	-	-	-
	Meridion circulare Agardh	0.35	-	0.87	-	0.45	-	0.44	-	-	0.71
	Surirella ovata Kutzing	-	-	-	-	-	-	-	1.5	-	-
	Cymbella minuta Kutzing	-	0.21	-	-	-	-	-	-	0.048	0.11
	Synedra acus v. radians (Kutzing) Hustedt	-	-	-	-	0.045	-	-	-	0.060	0.03
	Synedra ulna (Nitzsch) Ehrenberg	-	-	-	-	0.71	-	-	-	-	-
	Cyclotella pseudostelligera	-	-	-	-	-	-	-	-	-	2.0
	Cymbella prostrata (Berkeley) Cleve	-	7.4	-	-	2.3	-	-	-	-	6.0
	Fragilaria pinata Ehrenberg	0.012	-	-	-	-	-	-	-	-	-
	Nitzschia filiformis (W. Smith) Hustedt	0.047	-	-	-	-	-	-	-	-	-
	Didymosphenia geminata Schmidt	13	-	-	-	9.0	-	-	-	-	-
	Fragilaria construens (Ehrenberg) Grunow	-	-	-	0.065	-	-	-	-	-	-
	Nitzschia clausii Hantzsch	-	-	-	-	0.076	-	-	-	-	-
	Hannaea arcus Patrick	-	-	-	-	0.089	-	-	-	-	-
Red Algae	Audouinella / Chantransia stage. Red alga	-	0.97	5.2	-	-	11	0.12	0.45	-	-

Table D.3: Summary statistics for periphyton density collected at lower Wolverine Creek and lower Minto Creek stations, Minto Mine WUL, 2016. All data are presented as cells/cm^2.

Sample Location		Lower Wolverine Creek (Reference)					Lower Minto Creek (Exposure)				
		Mean	Median	Minimum	Maximum	Standard Deviation	Mean	Median	Minimum	Maximum	Standard Deviation
Group	**Genera and species**										
Cyanophyte	Phormidium autumnale Agardh	770	646	517	1,148	334	1,878	431	345	6,029	2,442
	Heteroleibeinia profunda Komarek	7,063	7,063	7,063	7,063	-	4,225	2,692	1,723	7,580	2,643
	Homoeothrix varians Komarek & Kalina	-	-	-	-	-	14,083	14,083	1,034	27,132	18,454
	Pseudoanabaena sp.	6,431	6,431	3,732	9,130	3,817	2,584	2,584	1,723	3,445	1,218
	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	1,375	574	345	2,799	1,208	54	54	54	54	-
Chlorophyte	Mougeotia sp.	-	-	-	-	-	517	517	517	517	-
	Ulothrix zonata Kutzing	2,153	2,153	2,153	2,153	-	1,034	1,034	1,034	1,034	-
Diatoms	Navicula minima Grunow	-	-	-	-	-	140	140	108	172	46
	Achnanthes minutissima Kutzing	754	754	646	861	152	14,899	16,688	2,207	24,634	8,130
	Eucocconeis sp.	574	574	574	574	-	553	345	108	1,206	578
	Nitzschia linearis W. Smith	1,682	1,292	517	3,732	1,274	1,082	807	345	2,369	886
	Encyonema silesiacum (Bleisch) D.G. Mann	695	574	431	1,034	246	1,029	689	323	2,153	718
	Navicula radiosa Kutzing	646	646	646	646	-	209	172	54	431	138
	Cocconies disculus Schum.	790	861	574	861	144	3,708	2,584	1,206	7,752	2,824
	Anomoenies vitrea Ross	701	574	287	1,206	348	2,890	2,046	517	7,580	2,729
	Denticula elegans Kutzing	-	-	-	-	-	517	517	517	517	-
	Navicula exigua (Greg.) Muller	-	-	-	-	-	716	716	54	1,378	936
	Fragilaria capucina Grunow	2,707	2,010	689	7,106	2,567	881	1,077	172	1,346	514
	Diatoma vulgare Bory	41,246	50,244	21,189	57,996	16,715	323	323	323	323	-
	Gomphonema minutum	287	287	287	287	-	3,548	1,389	215	11,197	5,130
	Navicula pupula Kutzing	-	-	-	-	-	323	323	323	323	-
	Meridion circulare Agardh	402	345	287	574	152	280	280	215	345	91
	Surirella ovata Kutzing	-	-	-	-	-	215	215	215	215	-
	Cymbella minuta Kutzing	574	574	574	574	-	253	253	162	345	129
	Synedra acus v. radians (Kutzing) Hustedt	689	689	689	689	-	549	549	345	754	289
	Synedra ulna (Nitzsch) Ehrenberg	345	345	345	345	-	-	-	-	-	-
	Cyclotella pseudostelligera	-	-	-	-	-	2,067	2,067	2,067	2,067	-
	Cymbella prostrata (Berkeley) Cleve	373	373	172	574	284	172	172	172	172	-
	Fragilaria pinata Ehrenberg	287	287	287	287	-	-	-	-	-	-
	Nitzschia filiformis (W. Smith) Hustedt	287	287	287	287	-	-	-	-	-	-
	Didymosphenia geminata Schmidt	230	230	172	287	81	-	-	-	-	-
	Fragilaria construens (Ehrenberg) Grunow	861	861	861	861	-	-	-	-	-	-
	Nitzschia clausii Hantzsch	172	172	172	172	-	-	-	-	-	-
	Hannaea arcus Patrick	172	172	172	172	-	-	-	-	-	-
Red Algae	Audouinella / Chantransia stage. Red alga	5,599	5,599	3,445	7,752	3,045	7,264	1,723	431	19,638	10,736

Table D.4: Summary statistics for periphyton biomass collected at lower Wolverine Creek and lower Minto Creek stations, Minto Mine WUL, 2016. All data are presented as µg/cm^2.

Sample Location		Lower Wolverine Creek (Reference)					Lower Minto Creek (Exposure)				
		Mean	Median	Minimum	Maximum	Standard Deviation	Mean	Median	Minimum	Maximum	Standard Deviation
Group	**Genera and species**										
Cyanophyte	Phormidium autumnale Agardh	2.2	1.9	1.5	3.3	0.92	6.9	1.7	1.3	24	9.7
	Heteroleibeinia profunda Komarek	0.47	0.47	0.47	0.47	-	0.28	0.20	0.087	0.50	0.18
	Homoeothrix varians Komarek & Kalina	-	-	-	-	-	2.0	2.0	0.19	3.7	2.5
	Pseudoanabaena sp.	0.079	0.079	0.046	0.11	0.047	0.055	0.055	0.037	0.073	0.026
	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	0.22	0.14	0.063	0.45	0.18	0.0060	0.0060	0.0060	0.0060	-
Chlorophyte	Mougeotia sp.	-	-	-	-	-	1.2	1.2	1.2	1.2	-
	Ulothrix zonata Kutzing	27	27	27	27	-	13	13	13	13	-
Diatoms	Navicula minima Grunow	-	-	-	-	-	0.0062	0.0062	0.0045	0.0079	0.0024
	Achnanthes minutissima Kutzing	0.053	0.053	0.046	0.060	0.010	1.1	1.2	0.17	1.7	0.57
	Eucocconeis sp.	3.0	3.0	3.0	3.0	-	2.8	1.7	0.56	6.1	2.9
	Nitzschia linearis W. Smith	0.83	0.62	0.30	1.9	0.66	0.31	0.31	0.081	0.56	0.22
	Encyonema silesiacum (Bleisch) D.G. Mann	0.81	0.68	0.51	1.2	0.28	1.2	0.81	0.38	2.5	0.81
	Navicula radiosa Kutzing	1.1	1.1	1.1	1.1	-	0.38	0.33	0.10	0.77	0.24
	Cocconies disculus Schum.	1.2	1.4	0.91	1.4	0.22	6.6	4.4	1.9	13	5.2
	Anomoenies vitrea Ross	0.21	0.18	0.089	0.35	0.10	0.92	0.67	0.16	2.4	0.84
	Denticula elegans Kutzing	-	-	-	-	-	0.23	0.23	0.23	0.23	-
	Navicula exigua (Greg.) Muller	-	-	-	-	-	0.34	0.34	0.011	0.67	0.46
	Fragilaria capucina Grunow	3.3	2.5	0.72	8.7	3.2	0.82	0.72	0.17	1.6	0.55
	Diatoma vulgare Bory	9.9	12	4.8	14	4.2	0.076	0.076	0.076	0.076	-
	Gomphonema minutum	0.12	0.12	0.12	0.12	-	1.5	0.60	0.10	4.9	2.2
	Navicula pupula Kutzing	-	-	-	-	-	0.076	0.076	0.076	0.076	-
	Meridion circulare Agardh	0.56	0.45	0.35	0.87	0.27	0.57	0.57	0.44	0.71	0.19
	Surirella ovata Kutzing	-	-	-	-	-	1.5	1.5	1.5	1.5	-
	Cymbella minuta Kutzing	0.21	0.21	0.21	0.21	-	0.077	0.077	0.048	0.11	0.041
	Synedra acus v. radians (Kutzing) Hustedt	0.045	0.045	0.045	0.045	-	0.043	0.043	0.026	0.060	0.024
	Synedra ulna (Nitzsch) Ehrenberg	0.71	0.71	0.71	0.71	-	-	-	-	-	-
	Cyclotella pseudostelligera	-	-	-	-	-	2.0	2.0	2.0	2.0	-
	Cymbella prostrata (Berkeley) Cleve	4.9	4.9	2.3	7.4	3.6	6.0	6.0	6.0	6.0	-
	Fragilaria pinata Ehrenberg	0.012	0.012	0.012	0.012	-	-	-	-	-	-
	Nitzschia filiformis (W. Smith) Hustedt	0.047	0.047	0.047	0.047	-	-	-	-	-	-
	Didymosphenia geminata Schmidt	11	11	9.0	13	2.6	-	-	-	-	-
	Fragilaria construens (Ehrenberg) Grunow	0.065	0.065	0.065	0.065	-	-	-	-	-	-
	Nitzschia clausii Hantzsch	0.076	0.076	0.076	0.076	-	-	-	-	-	-
	Hannaea arcus Patrick	0.089	0.089	0.089	0.089	-	-	-	-	-	-
Red Algae	Audouinella / Chantransia stage. Red alga	3.1	3.1	0.97	5.2	3.0	3.9	0.45	0.12	11	6.3

Table D.5: Presence/absence of periphyton taxa at lower Wolverine Creek (reference) and lower Minto Creek (exposure), Minto Mine WUL, 2016.

Sample Location		Lower Wolverine Creek					Lower Minto Creek				
		LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Group	**Genera and species**										
Cyanophyte	Phormidium autumnale Agardh	0	0	1	1	1	1	1	1	1	1
	Heteroleibeinia profunda Komarek	0	0	0	0	1	1	1	1	1	1
	Homoeothrix varians Komarek & Kalina	0	0	0	0	0	1	0	1	0	0
	Pseudoanabaena sp.	0	1	0	0	1	0	1	1	0	0
	Leptolyngbya lemnetica (Anaga.) Anagnostidis and Komarek	1	1	1	1	1	0	0	0	1	0
Chlorophyte	Mougeotia sp.	0	0	0	0	0	0	0	0	0	1
	Ulothrix zonata Kutzing	0	0	0	1	0	0	0	0	0	1
Diatoms	Navicula minima Grunow	0	0	0	0	0	1	1	0	0	0
	Achnanthes minutissima Kutzing	0	0	1	1	0	1	1	1	1	1
	Eucocconeis sp.	1	0	0	0	0	1	1	0	0	1
	Nitzschia linearis W. Smith	1	1	1	1	1	1	0	1	1	1
	Encyonema silesiacum (Bleisch) D.G. Mann	1	1	1	1	1	1	1	1	1	1
	Navicula radiosa Kutzing	0	0	0	1	0	1	1	1	1	1
	Cocconies disculus Schum.	1	1	1	0	1	1	1	1	1	1
	Anomoenies vitrea Ross	1	1	1	1	1	1	1	1	1	1
	Denticula elegans Kutzing	0	0	0	0	0	1	0	0	0	0
	Navicula exigua (Greg.) Muller	0	0	0	0	0	1	0	0	1	0
	Fragilaria capucina Grunow	1	1	1	1	1	1	1	1	1	1
	Diatoma vulgare Bory	1	1	1	1	1	0	1	0	0	0
	Gomphonema minutum	0	1	0	0	0	0	1	1	1	1
	Navicula pupula Kutzing	0	0	0	0	0	0	1	0	0	0
	Meridion circulare Agardh	1	0	1	0	1	0	1	0	0	1
	Surirella ovata Kutzing	0	0	0	0	0	0	0	1	0	0
	Cymbella minuta Kutzing	0	1	0	0	0	0	0	0	1	1
	Synedra acus v. radians (Kutzing) Hustedt	0	0	0	0	1	0	0	0	1	1
	Synedra ulna (Nitzsch) Ehrenberg	0	0	0	0	1	0	0	0	0	0
	Cyclotella pseudostelligera	0	0	0	0	0	0	0	0	0	1
	Cymbella prostrata (Berkeley) Cleve	0	1	0	0	1	0	0	0	0	1
	Fragilaria pinata Ehrenberg	1	0	0	0	0	0	0	0	0	0
	Nitzschia filiformis (W. Smith) Hustedt	1	0	0	0	0	0	0	0	0	0
	Didymosphenia geminata Schmidt	1	0	0	0	1	0	0	0	0	0
	Fragilaria construens (Ehrenberg) Grunow	0	0	0	1	0	0	0	0	0	0
	Nitzschia clausii Hantzsch	0	0	0	0	1	0	0	0	0	0
	Hannaea arcus Patrick	0	0	0	0	1	0	0	0	0	0
Red Algae	Audouinella / Chantransia stage. Red alga	0	1	1	0	0	1	1	1	0	0
	Total	**12**	**12**	**11**	**11**	**17**	**15**	**16**	**14**	**14**	**18**

PERIPHYTON COMMUNITY ANALYSIS

PROVIDED BY:

PLANKTON R US INC.

(WINNIPEG, MB)

Epilithic algal biomass (μg/cm2) for **Minto WUL Monitoring 2016** (for Lisa Minnow Environmental Inc.)

R = QAQC recount **Calculations based on scraped sample area of 125 cm^2**

Project	Location	date	Cyanobacteria $\mu g/cm^2$	Chlorophyte $\mu g/cm^2$	Diatom $\mu g/cm^2$	Red Algae $\mu g/cm^2$	Total $\mu g/cm^2$
1680	LMC-1	24/Sep/16	2.02	0.00	11.82	11.19	25.02
1680	LMC-2	24/Sep/16	1.47	0.00	9.24	0.12	10.83
1680	LMC-3	23/Sep/16	10.29	0.00	25.37	0.45	36.11
1680	LMC-4	23/Sep/16	1.90	0.00	14.50	0.00	16.40
1680	LMC-4R	23/Sep/16	2.51	0.00	14.10	0.00	16.61
1680	LMC-5	23/Sep/16	24.29	14.18	21.48	0.00	59.95
1680	LWC-1	26/Sep/16	0.14	0.00	34.25	0.00	34.38
1680	LWC-2	25/Sep/16	0.12	0.00	25.85	0.97	26.95
1680	LWC-3	25/Sep/16	3.68	0.00	19.71	5.20	28.58
1680	LWC-4	25/Sep/16	2.33	27.06	17.30	0.00	46.69
1680	LWC-5	25/Sep/16	2.18	0.00	21.45	0.00	23.63

Epilithic algal density (cells/cm2) for **Minto WUL Monitoring 2016** (for Lisa Minnow Environmental Inc.)

R = QAQC recount

Project	**Location**	**date**	**Cyanobacteria cells/cm^2**	**Chlorophyte cells/cm^2**	**Diatom cells/cm^2**	**Red Algae cells/cm^2**	**Total cells/cm^2**
1680	LMC-1	24/Sep/16	8958	0	20844	19638	49440
1680	LMC-2	24/Sep/16	3876	0	25517	431	29823
1680	LMC-3	23/Sep/16	35314	0	43928	1723	80965
1680	LMC-4	23/Sep/16	3176	0	13943	0	17119
1680	LMC-4R	23/Sep/16	2961	0	14212	0	17173
1680	LMC-5	23/Sep/16	12575	1550	41516	0	55642
1680	LWC-1	26/Sep/16	574	0	60293	0	60867
1680	LWC-2	25/Sep/16	4307	0	63451	3445	71203
1680	LWC-3	25/Sep/16	3732	0	58570	7752	70055
1680	LWC-4	25/Sep/16	3445	2153	37252	0	42851
1680	LWC-5	25/Sep/16	17054	0	27562	0	44617

Epilithic algal species data **for Minto WUL Monitoring 2016** (for Lisa Minnow Environmental Inc.)

**** 1st number in species code = group 1=cyanophyte 2=chlorophyte 4=chrysophyte 5=diatoms 8= red algae**
**** total daily biomass is sum of all species on a date**

R = QAQC recount

Project	Location	Date	Species code	Speceis name	density cells/cm^2	biomass µg/cm^2	length µ	width µ	cell volume µ^3
1680	LMC-1	24-Sep-16	1122	Phormidium autumnale Agardh	345	1.32	136.00	6.00	3845.30
1680	LMC-1	24-Sep-16	1131	Heteroleibeinia profunda Komarek	7580	0.50	19.00	2.10	65.80
1680	LMC-1	24-Sep-16	1239	Homoeothrix varians Komarek & Kalina	1034	0.19	41.00	2.40	185.50
1680	LMC-1	24-Sep-16	5306	Navicula minima Grunow	172	0.01	11.00	4.00	46.10
1680	LMC-1	24-Sep-16	5702	Achnanthes minutissima Kutzing	13953	0.99	17.00	4.00	71.20
1680	LMC-1	24-Sep-16	5726	Eucocconeis sp.	1206	6.11	40.00	22.00	5068.40
1680	LMC-1	24-Sep-16	5768	Nitzschia linearis W. Smith	861	0.42	52.00	6.00	490.10
1680	LMC-1	24-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	689	0.81	30.00	10.00	1178.10
1680	LMC-1	24-Sep-16	5870	Navicula radiosa Kutzing	172	0.33	74.00	10.00	1937.30
1680	LMC-1	24-Sep-16	5875	Cocconies disculus Schum.	1206	1.92	31.00	14.00	1590.70
1680	LMC-1	24-Sep-16	5882	Anomoenies vitrea Ross	517	0.16	33.00	6.00	311.00
1680	LMC-1	24-Sep-16	5902	Denticula elegans Kutzing	517	0.23	26.00	8.00	435.60
1680	LMC-1	24-Sep-16	5910	Navicula exigua (Greg.) Muller	1378	0.67	32.00	7.60	483.90
1680	LMC-1	24-Sep-16	5916	Fragilaria capucina Grunow	172	0.17	103.00	6.00	970.80
1680	LMC-1	24-Sep-16	8001	Audouinella / Chantransia stage. Red alga	19638	11.19	17.00	8.00	569.70
1680	LMC-2	24-Sep-16	1077	Pseudoanabaena sp.	1723	0.04	3.00	3.00	21.20
1680	LMC-2	24-Sep-16	1122	Phormidium autumnale Agardh	431	1.35	111.00	6.00	3138.50
1680	LMC-2	24-Sep-16	1131	Heteroleibeinia profunda Komarek	1723	0.09	16.00	2.00	50.30
1680	LMC-2	24-Sep-16	5306	Navicula minima Grunow	108	0.00	10.00	4.00	41.90
1680	LMC-2	24-Sep-16	5702	Achnanthes minutissima Kutzing	16688	1.16	16.60	4.00	69.50
1680	LMC-2	24-Sep-16	5726	Eucocconeis sp.	108	0.56	41.00	22.00	5195.10
1680	LMC-2	24-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	1292	1.43	28.10	10.00	1103.50
1680	LMC-2	24-Sep-16	5860	Diatoma vulgare Bory	323	0.08	25.00	6.00	235.60
1680	LMC-2	24-Sep-16	5870	Navicula radiosa Kutzing	431	0.77	68.00	10.00	1780.20
1680	LMC-2	24-Sep-16	5873	Gomphonema minutum	1400	0.61	26.00	8.00	435.60
1680	LMC-2	24-Sep-16	5875	Cocconies disculus Schum.	1507	2.40	31.00	14.00	1590.70
1680	LMC-2	24-Sep-16	5882	Anomoenies vitrea Ross	2046	0.67	35.00	6.00	329.90
1680	LMC-2	24-Sep-16	5887	Navicula pupula Kutzing	323	0.08	24.90	6.00	234.70
1680	LMC-2	24-Sep-16	5916	Fragilaria capucina Grunow	1077	1.05	103.00	6.00	970.80
1680	LMC-2	24-Sep-16	5986	Meridion circulare Agardh	215	0.44	40.00	14.00	2052.50
1680	LMC-2	24-Sep-16	8001	Audouinella / Chantransia stage. Red alga	431	0.12	15.00	6.00	282.70
1680	LMC-3	23-Sep-16	1077	Pseudoanabaena sp.	3445	0.07	3.00	3.00	21.20
1680	LMC-3	23-Sep-16	1122	Phormidium autumnale Agardh	2153	6.27	103.00	6.00	2912.30
1680	LMC-3	23-Sep-16	1131	Heteroleibeinia profunda Komarek	2584	0.20	22.00	2.10	76.20
1680	LMC-3	23-Sep-16	1239	Homoeothrix varians Komarek & Kalina	27132	3.75	44.00	2.00	138.20
1680	LMC-3	23-Sep-16	5702	Achnanthes minutissima Kutzing	17011	1.20	16.90	4.00	70.80
1680	LMC-3	23-Sep-16	5768	Nitzschia linearis W. Smith	2369	0.56	56.00	4.00	234.60
1680	LMC-3	23-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	2153	2.45	29.00	10.00	1138.80
1680	LMC-3	23-Sep-16	5866	Surirella ovata Kutzing	215	1.49	46.00	24.00	6936.60
1680	LMC-3	23-Sep-16	5870	Navicula radiosa Kutzing	215	0.39	69.40	10.00	1816.90
1680	LMC-3	23-Sep-16	5873	Gomphonema minutum	11197	4.86	25.90	8.00	434.00
1680	LMC-3	23-Sep-16	5875	Cocconies disculus Schum.	7752	13.13	33.00	14.00	1693.30
1680	LMC-3	23-Sep-16	5882	Anomoenies vitrea Ross	1723	0.57	35.00	6.00	329.90
1680	LMC-3	23-Sep-16	5916	Fragilaria capucina Grunow	646	0.04	61.00	2.00	63.90
1680	LMC-3	23-Sep-16	5916	Fragilaria capucina Grunow	646	0.68	111.00	6.00	1046.20
1680	LMC-3	23-Sep-16	8001	Audouinella / Chantransia stage. Red alga	1723	0.45	14.00	6.00	263.90
1680	LMC-4	23-Sep-16	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis ar	54	0.01	99.00	1.20	112.00
1680	LMC-4	23-Sep-16	1122	Phormidium autumnale Agardh	431	1.72	141.00	6.00	3986.70
1680	LMC-4	23-Sep-16	1131	Heteroleibeinia profunda Komarek	2692	0.18	21.00	2.00	66.00
1680	LMC-4	23-Sep-16	5311	Cymbella minuta Kutzing	162	0.05	15.40	7.00	296.30
1680	LMC-4	23-Sep-16	5519	Synedra acus v. radians (Kutzing) Hustedt	754	0.06	76.00	2.00	79.60
1680	LMC-4	23-Sep-16	5702	Achnanthes minutissima Kutzing	2207	0.17	18.00	4.00	75.40
1680	LMC-4	23-Sep-16	5768	Nitzschia linearis W. Smith	754	0.19	61.00	4.00	255.50
1680	LMC-4	23-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	323	0.38	29.60	10.00	1162.40
1680	LMC-4	23-Sep-16	5870	Navicula radiosa Kutzing	54	0.10	71.00	10.00	1858.80
1680	LMC-4	23-Sep-16	5873	Gomphonema minutum	215	0.10	26.90	8.00	450.70
1680	LMC-4	23-Sep-16	5875	Cocconies disculus Schum.	5491	10.99	39.00	14.00	2001.20
1680	LMC-4	23-Sep-16	5882	Anomoenies vitrea Ross	2584	0.84	34.40	6.00	324.20
1680	LMC-4	23-Sep-16	5910	Navicula exigua (Greg.) Muller	54	0.01	22.00	6.00	207.30
1680	LMC-4	23-Sep-16	5916	Fragilaria capucina Grunow	1346	1.62	128.00	6.00	1206.40
1680	LMC-4R	23-Sep-16	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis ar	108	0.01	101.00	1.20	114.20
1680	LMC-4R	23-Sep-16	1122	Phormidium autumnale Agardh	646	2.36	129.00	6.00	3647.40
1680	LMC-4R	23-Sep-16	1131	Heteroleibeinia profunda Komarek	2207	0.15	21.00	2.00	66.00
1680	LMC-4R	23-Sep-16	5311	Cymbella minuta Kutzing	54	0.02	15.40	7.00	296.30
1680	LMC-4R	23-Sep-16	5519	Synedra acus v. radians (Kutzing) Hustedt	485	0.04	76.00	2.00	79.60
1680	LMC-4R	23-Sep-16	5523	Synedra ulna (Nitzsch) Ehrenberg	54	0.12	240.00	6.00	2261.90
1680	LMC-4R	23-Sep-16	5702	Achnanthes minutissima Kutzing	1938	0.15	18.00	4.00	75.40
1680	LMC-4R	23-Sep-16	5768	Nitzschia linearis W. Smith	861	0.22	61.00	4.00	255.50
1680	LMC-4R	23-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	431	0.50	29.60	10.00	1162.40
1680	LMC-4R	23-Sep-16	5873	Gomphonema minutum	215	0.10	26.90	8.00	450.70
1680	LMC-4R	23-Sep-16	5875	Cocconies disculus Schum.	6083	10.61	34.00	14.00	1744.60
1680	LMC-4R	23-Sep-16	5882	Anomoenies vitrea Ross	2745	0.89	34.40	6.00	324.20
1680	LMC-4R	23-Sep-16	5884	Gomphonema angustum Agardh	108	0.12	44.00	10.00	1151.90
1680	LMC-4R	23-Sep-16	5910	Navicula exigua (Greg.) Muller	162	0.03	22.00	6.00	207.30
1680	LMC-4R	23-Sep-16	5916	Fragilaria capucina Grunow	1077	1.30	128.00	6.00	1206.40
1680	LMC-5	23-Sep-16	1122	Phormidium autumnale Agardh	6029	23.87	140.00	6.00	3958.40
1680	LMC-5	23-Sep-16	1131	Heteroleibeinia profunda Komarek	6546	0.42	18.60	2.10	64.40
1680	LMC-5	23-Sep-16	2205	Mougeotia sp.	517	1.19	46.00	8.00	2312.20
1680	LMC-5	23-Sep-16	2511	Ulothrix zonata Kutzing	1034	12.99	40.00	20.00	12566.40
1680	LMC-5	23-Sep-16	5311	Cymbella minuta Kutzing	345	0.11	16.00	7.00	307.90
1680	LMC-5	23-Sep-16	5508	Cyclotella pseudostelligera	2067	2.04	13.60	13.60	987.80
1680	LMC-5	23-Sep-16	5519	Synedra acus v. radians (Kutzing) Hustedt	345	0.03	71.00	2.00	74.40
1680	LMC-5	23-Sep-16	5702	Achnanthes minutissima Kutzing	24634	1.74	16.90	4.00	70.80
1680	LMC-5	23-Sep-16	5726	Eucocconeis sp.	345	1.75	40.00	22.00	5068.40

Epilithic algal species data **for Minto WUL Monitoring 2016** (for Lisa Minnow Environmental Inc.)

**** 1st number in species code = group 1=cyanophyte 2=chlorophyte 4=chrysophyte 5=diatoms 8= red algae**
**** total daily biomass is sum of all species on a date**

R = QAQC recount

1680	LMC-5	23-Sep-16	5768	Nitzschia linearis W. Smith	345	0.08	56.00	4.00	234.60
1680	LMC-5	23-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	689	0.81	30.00	10.00	1178.10
1680	LMC-5	23-Sep-16	5865	Cymbella prostrata (Berkeley) Cleve	172	6.03	99.00	30.00	34989.50
1680	LMC-5	23-Sep-16	5870	Navicula radiosa Kutzing	172	0.29	65.00	10.00	1701.70
1680	LMC-5	23-Sep-16	5873	Gomphonema minutum	1378	0.59	25.40	8.00	425.60
1680	LMC-5	23-Sep-16	5875	Cocconies disculus Schum.	2584	4.39	33.10	14.00	1698.40
1680	LMC-5	23-Sep-16	5882	Anomoenies vitrea Ross	7580	2.36	33.00	6.00	311.00
1680	LMC-5	23-Sep-16	5916	Fragilaria capucina Grunow	517	0.57	116.00	6.00	1093.30
1680	LMC-5	23-Sep-16	5986	Meridion circulare Agardh	345	0.71	40.00	14.00	2052.50
1680	LWC-1	26-Sep-16	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis ar	574	0.14	210.00	1.20	237.50
1680	LWC-1	26-Sep-16	5726	Eucocconeis sp.	574	2.98	41.00	22.00	5195.10
1680	LWC-1	26-Sep-16	5768	Nitzschia linearis W. Smith	3732	1.93	55.00	6.00	518.40
1680	LWC-1	26-Sep-16	5825	Fragilaria pinata Ehrenberg	287	0.01	10.00	4.00	41.90
1680	LWC-1	26-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	574	0.68	30.00	10.00	1178.10
1680	LWC-1	26-Sep-16	5857	Nitzschia filiformis (W. Smith) Hustedt	287	0.05	39.00	4.00	163.40
1680	LWC-1	26-Sep-16	5860	Diatoma vulgare Bory	51392	12.11	25.00	6.00	235.60
1680	LWC-1	26-Sep-16	5875	Cocconies disculus Schum.	574	0.91	31.00	14.00	1590.70
1680	LWC-1	26-Sep-16	5880	Didymosphenia geminata Schmidt	287	12.66	130.00	36.00	44108.00
1680	LWC-1	26-Sep-16	5882	Anomoenies vitrea Ross	287	0.09	33.00	6.00	311.00
1680	LWC-1	26-Sep-16	5916	Fragilaria capucina Grunow	2010	2.46	130.00	6.00	1225.20
1680	LWC-1	26-Sep-16	5986	Meridion circulare Agardh	287	0.35	39.00	11.00	1235.40
1680	LWC-2	25-Sep-16	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis ar	574	0.08	120.00	1.20	135.70
1680	LWC-2	25-Sep-16	1077	Pseudoanabaena sp.	3732	0.05	2.50	2.50	12.30
1680	LWC-2	25-Sep-16	5311	Cymbella minuta Kutzing	574	0.21	16.00	7.60	362.90
1680	LWC-2	25-Sep-16	5768	Nitzschia linearis W. Smith	861	0.41	50.00	6.00	471.20
1680	LWC-2	25-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	574	0.68	30.00	10.00	1178.10
1680	LWC-2	25-Sep-16	5860	Diatoma vulgare Bory	57996	14.21	26.00	6.00	245.00
1680	LWC-2	25-Sep-16	5865	Cymbella prostrata (Berkeley) Cleve	574	7.41	96.00	18.50	12902.50
1680	LWC-2	25-Sep-16	5873	Gomphonema minutum	287	0.12	24.00	8.00	402.10
1680	LWC-2	25-Sep-16	5875	Cocconies disculus Schum.	861	1.34	30.30	14.00	1554.80
1680	LWC-2	25-Sep-16	5882	Anomoenies vitrea Ross	574	0.18	33.00	6.00	311.00
1680	LWC-2	25-Sep-16	5916	Fragilaria capucina Grunow	1148	1.31	121.00	6.00	1140.40
1680	LWC-2	25-Sep-16	8001	Audouinella / Chantransia stage. Red alga	3445	0.97	15.00	6.00	282.70
1680	LWC-3	25-Sep-16	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis ar	2584	0.40	136.00	1.20	153.80
1680	LWC-3	25-Sep-16	1122	Phormidium autumnale Agardh	1148	3.28	101.00	6.00	2855.70
1680	LWC-3	25-Sep-16	5702	Achnanthes minutissima Kutzing	861	0.06	16.60	4.00	69.50
1680	LWC-3	25-Sep-16	5768	Nitzschia linearis W. Smith	2010	0.87	46.00	6.00	433.50
1680	LWC-3	25-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	861	0.96	28.30	10.00	1111.30
1680	LWC-3	25-Sep-16	5860	Diatoma vulgare Bory	50244	12.31	26.00	6.00	245.00
1680	LWC-3	25-Sep-16	5875	Cocconies disculus Schum.	861	1.37	31.00	14.00	1590.70
1680	LWC-3	25-Sep-16	5882	Anomoenies vitrea Ross	574	0.18	33.00	6.00	311.00
1680	LWC-3	25-Sep-16	5916	Fragilaria capucina Grunow	2584	3.09	127.00	6.00	1196.90
1680	LWC-3	25-Sep-16	5986	Meridion circulare Agardh	574	0.87	40.00	12.00	1508.00
1680	LWC-3	25-Sep-16	8001	Audouinella / Chantransia stage. Red alga	7752	5.20	20.00	8.00	670.20
1680	LWC-4	25-Sep-16	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis ar	2799	0.45	141.00	1.20	159.50
1680	LWC-4	25-Sep-16	1122	Phormidium autumnale Agardh	646	1.88	103.00	6.00	2912.30
1680	LWC-4	25-Sep-16	2511	Ulothrix zonata Kutzing	2153	27.06	40.00	20.00	12566.40
1680	LWC-4	25-Sep-16	5516	Fragilaria construens (Ehrenberg) Grunow	861	0.06	18.00	4.00	75.40
1680	LWC-4	25-Sep-16	5702	Achnanthes minutissima Kutzing	646	0.05	16.90	4.00	70.80
1680	LWC-4	25-Sep-16	5768	Nitzschia linearis W. Smith	1292	0.62	51.00	6.00	480.70
1680	LWC-4	25-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	431	0.51	30.00	10.00	1178.10
1680	LWC-4	25-Sep-16	5860	Diatoma vulgare Bory	25409	5.99	25.00	6.00	235.60
1680	LWC-4	25-Sep-16	5870	Navicula radiosa Kutzing	646	1.12	66.00	10.00	1727.90
1680	LWC-4	25-Sep-16	5882	Anomoenies vitrea Ross	861	0.25	31.30	6.00	295.00
1680	LWC-4	25-Sep-16	5916	Fragilaria capucina Grunow	7106	8.71	130.00	6.00	1225.20
1680	LWC-5	25-Sep-16	1057	Leptolyngbya lemnetica (Anaga.) Anagnostidis ar	345	0.06	161.00	1.20	182.10
1680	LWC-5	25-Sep-16	1077	Pseudoanabaena sp.	9130	0.11	2.50	2.50	12.30
1680	LWC-5	25-Sep-16	1122	Phormidium autumnale Agardh	517	1.53	105.00	6.00	2968.80
1680	LWC-5	25-Sep-16	1131	Heteroleibeinia profunda Komarek	7063	0.47	21.00	2.00	66.00
1680	LWC-5	25-Sep-16	5519	Synedra acus v. radians (Kutzing) Hustedt	689	0.05	63.00	2.00	66.00
1680	LWC-5	25-Sep-16	5523	Synedra ulna (Nitzsch) Ehrenberg	345	0.71	220.00	6.00	2073.50
1680	LWC-5	25-Sep-16	5541	Nitzschia clausii Hantzsch	172	0.08	47.00	6.00	443.00
1680	LWC-5	25-Sep-16	5768	Nitzschia linearis W. Smith	517	0.30	61.00	6.00	574.90
1680	LWC-5	25-Sep-16	5836	Encyonema silesiacum (Bleisch) D.G. Mann	1034	1.22	30.00	10.00	1178.10
1680	LWC-5	25-Sep-16	5860	Diatoma vulgare Bory	21189	4.79	24.00	6.00	226.20
1680	LWC-5	25-Sep-16	5865	Cymbella prostrata (Berkeley) Cleve	172	2.30	85.00	20.00	13351.80
1680	LWC-5	25-Sep-16	5875	Cocconies disculus Schum.	861	1.37	31.00	14.00	1590.70
1680	LWC-5	25-Sep-16	5880	Didymosphenia geminata Schmidt	172	9.02	125.00	40.00	52359.90
1680	LWC-5	25-Sep-16	5882	Anomoenies vitrea Ross	1206	0.35	31.00	6.00	292.20
1680	LWC-5	25-Sep-16	5916	Fragilaria capucina Grunow	689	0.72	111.00	6.00	1046.20
1680	LWC-5	25-Sep-16	5917	Hannaea arcus Patrick	172	0.09	55.00	6.00	518.40
1680	LWC-5	25-Sep-16	5986	Meridion circulare Agardh	345	0.45	35.00	12.00	1319.50

APPENDIX E

BENTHIC INVERTEBRATE COMMUNITY DATA

Table E.1: Benthic Invertebrates collected by Hess sampler and screened through a 500 µm sieve. Values reported as number of organisms per sample, Minto Mine WUL, 2016.

Invertebrate	Lower Wolverine Creek (Reference)					Lower Big Creek (Reference)					Lower Minto Creek (Exposure)				
	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Phylum: Arthropoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Order: Collembola	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-
Family: Onychiuridae	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Subphylum: Hexapoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class: Insecta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Order: Ephemeroptera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family: Baetidae	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-
Acentrella	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Baetis	2	-	-	2	2	-	5	-	-	16	-	-	-	-	-
Baetis tricaudatus group	4	1	2	5	2	2	2	48	12	36	-	1	-	-	-
Baetis bicaudatus	10	1	6	5	2	6	35	10	8	36	-	-	-	1	-
Family: Ephemerellidae	-	-	2	-	3	-	2	4	1	-	-	-	-	-	-
Drunella	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drunella grandis group	-	-	1	-	-	8	9	2	1	2	-	-	-	-	-
Drunella doddsii	2	2	7	-	1	2	-	-	-	-	-	-	-	-	-
Ephemerella	-	-	-	1	-	-	-	6	-	12	-	-	-	-	-
Family: Heptageniidae	8	3	3	6	17	10	2	72	2	26	-	-	-	1	-
Order: Plecoptera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family: Capniidae	3	4	4	7	17	66	37	224	20	62	1	1	2	5	1
Isocapnia	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Family: Chloroperlidae	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Alloperla	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Haploperla	3	-	2	4	5	-	1	-	-	4	-	-	-	-	-
Sweltsa	-	1	1	3	1	-	1	-	-	4	-	-	-	-	-
Family: Nemouridae	-	-	-	-	-	-	-	-	-	-	7	11	42	61	38
Nemoura	-	-	-	-	-	-	-	2	-	-	18	27	75	48	51
Ostrocerca	-	-	-	-	-	-	-	2	-	-	1	1	4	4	8
Zapada	-	-	-	-	1	-	-	-	-	2	-	-	-	-	-
Zapada oregonensis group	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Zapada cinctipes	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Family: Perlodidae	6	8	4	14	17	-	2	-	1	-	-	-	-	-	-
Isoperla	7	3	11	12	23	-	-	2	-	-	-	-	-	-	-
Skwala	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Family: Taeniopterygidae	-	-	1	2	-	-	-	-	1	2	-	-	-	-	-
Order: Trichoptera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family: Glossosomatidae	1	1	6	4	-	-	-	2	-	4	-	-	-	-	-
Glossosoma	1	2	21	7	1	-	1	2	1		-	-	-	-	-
Family: Limnephilidae	1	-	1	1	-	2	-	-	-	2	-	-	15	8	7
Dicosmoecus	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1
Ecclisomyia	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-

Table E.1: Benthic Invertebrates collected by Hess sampler and screened through a 500 µm sieve. Values reported as number of organisms per sample, Minto Mine WUL, 2016.

Invertebrate	Lower Wolverine Creek (Reference)					Lower Big Creek (Reference)					Lower Minto Creek (Exposure)				
	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Family: Rhyacophilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhyacophila	2	5	1	1	4	-	-	-	-	-	-	-	1	-	-
Rhyacophila brunnea/vemna group	3	-	5	1	2	2	2	-	-	-	-	-	-	-	-
Order: Diptera	-	2	-	2	-	-	-	-	-	-	-	-	1	-	-
Family: Ceratopogonidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Culicoides	-	-	-	-	-	-	-	-	-	-	-	5	2	-	3
Family: Chironomidae	3	14	13	2	6	12	10	14	-	-	1	2	3	2	2
Subfamily: Chironominae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tribe: Chironomini	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chironomus	-	-	1	-	-	-	-	6	-	-	-	-	-	-	-
Polypedilum	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Tribelos	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tribe: Tanytarsini	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Micropsectra	-	-	-	-	1	4	3	-	-	6	1	5	11	8	10
Neozavrelia	-	-	-	-	-	6	-	4	-	14	-	-	-	-	-
Rheotanytarsus	-	-	-	-	3	230	181	104	-	102	-	-	-	-	-
Stempellina	-	2	-	-	2	-	-	10	3	2	-	-	-	-	2
Subfamily: Diamesinae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tribe: Diamesini	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diamesa	4	-	2	1	1	10	105	52	1	140	-	-	-	-	-
Pagastia	6	6	7	8	3	34	18	8	1	38	-	-	-	-	-
Potthastia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potthastia longimana group	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Pseudodiamesa	-	2	-	-	-	14	4	2	-	12	-	2	1	-	-
Subfamily: Orthocladiinae	-	-	-	-	-	-	1	-	-	-	2	1	-	3	-
Brillia sp.	-	-	1	-	-	-	3	-	-	-	6	1	-	-	-
Chaetocladius	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Corynoneura	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Diplocladius cultriger	-	-	-	-	-	-	-	-	-	-	1	1	7	2	-
Eukiefferiella	1	1	1	-	1	4	8	12	-	30	58	52	42	-	30
Hydrobaenus	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
Limnophyes sp.	-	-	-	-	-	-	-	-	-	-	4	-	1	2	-
Lopescladius	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Metriocnemus	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Orthocladius complex	7	17	-	1	3	54	80	50	8	118	48	120	84	150	116
Parakiefferiella	-	-	-	-	-	-	-	4	-	6	5	4	46	2	6
Paraphaenocladius	-	-	-	-	-	-	-	2	-	-	36	-	5	7	7
Pseudosmittia	-	-	-	-	-	8	11	10	-	2	-	-	-	-	-
Rheocricotopus	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-
Synorthocladius	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Tvetenia	-	-	-	-	-	-	4	6	-	6	-	-	-	-	-
Zalutschia	-	-	-	-	-	-	1	-	-	6	-	-	-	3	1

Table E.1: Benthic Invertebrates collected by Hess sampler and screened through a 500 µm sieve. Values reported as number of organisms per sample, Minto Mine WUL, 2016.

Invertebrate	Lower Wolverine Creek (Reference)					Lower Big Creek (Reference)					Lower Minto Creek (Exposure)				
	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Subfamily: Tanypodinae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tribe: Pentaneurini	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thienemannimyia group	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Tribe: Procladiini	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Procladius	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Family: Empididae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chelifera/ Metachela	-	-	-	-	1	18	4	-	1	12	-	-	-	-	-
Clinocera	-	-	-	-	-	-	-	-	-	-	1	8	6	3	-
Clinocera Unknown Genus A	1	1	1	2	3	2	-	-	-	-	-	1	-	-	-
Neoplasta	-	1	-	-	-	-	2	-	-	-	-	-	1	-	-
Roederiodes	-	-	-	-	-	-	4	4	-	6	-	-	-	-	-
Family: Muscidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnophora sp.	-	-	-	-	-	-	-	-	-	-	-	-	10	1	-
Family: Psychodidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pericoma/Telmatoscopus sp.	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Family: Simuliidae	-	-	-	1	-	-	2	-	-	4	1	-	-	-	-
Prosimulium	-	-	-	-	-	-	-	8	5	14	-	-	-	-	-
Simulium	1	-	-	1	-	-	-	-	1	-	1	-	-	8	7
Family: Tipulidae	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Antocha	-	1	-	-	-	20	20	2	1	12	-	-	-	-	-
Dicranota	-	-	1	9	3	12	1	12	3	4	-	5	10	6	19
Erioptera	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-
Hesperoconopa	4	20	8	14	5	6	-	2	-	-	-	-	-	-	-
Hexatoma	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Tipula	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-
Order: Thysanoptera	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Subphylum: Chelicerata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class: Arachnida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Order: Trombidiformes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
Family: Hygrobatidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hygrobates	-	-	-	-	-	4	2	-	-	16	-	-	-	-	-
Family: Lebertiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lebertia	-	4	-	2	1	38	51	8	3	100	-	-	-	-	-
Family: Sperchontidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sperchon	-	-	1	-	-	30	9	4	-	30	-	7	3	6	6
Order: Sarcoptiformes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Order: Oribatida	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Class: Malacostraca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Order: Isopoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family: Sphaeromatidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gnorimosphaeroma	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-

Table E.1: Benthic Invertebrates collected by Hess sampler and screened through a 500 µm sieve. Values reported as number of organisms per sample, Minto Mine WUL, 2016.

Invertebrate	Lower Wolverine Creek (Reference)					Lower Big Creek (Reference)					Lower Minto Creek (Exposure)				
	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Phylum: Mollusca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class: Gastropoda	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Phylum: Annelida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subphylum: Clitellata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class:Oligochaeta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Order: Lumbriculida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family: Lumbriculidae	92	62	204	9	194	32	70	130	36	100	10	38	5	-	-
Rhynchelmis	-	-	2	-	-	-	-	2	4	4	-	-	1	-	-
Order: Tubificida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Family: Enchytraeidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Enchytraeus	-	-	-	1	-	-	5	-	4	-	-	-	-	-	-
Family: Naididae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nais	-	-	-	-	-	232	90	-	4	40	-	-	-	-	-
Tubifex	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subfamily: Tubificinae without hair chaetae	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals:	**178**	**167**	**321**	**133**	**330**	**878**	**789**	**848**	**124**	**1038**	**207**	**295**	**379**	**332**	**321**

Table E.2: Benthic invertebrate community metrics by station for samples collected by Hess sampler, Minto Mine WUL, 2016.

Area	Station	Density (organisms/m^2)	Number of Taxa	BC Distance to LWC Median	BC Distance to LBC Median	BC Distance to Combined Reference Median	Simpson's Diversity	Simpson's Evenness[a]	Ephemeroptera (%)	Plecoptera (%)	Trichoptera (%)	EPT (%)	Chironomids (%)	Oligochaeta (%)	CA Axis-1 (33.6%)	CA Axis-2 (24.2%)
Lower Wolverine Creek (Reference)	LWC-1	178	21	0.095	0.68	0.19	0.71	0.17	15	12	4.5	31	12	53	-96	153
	LWC-2	167	23	0.27	0.70	0.30	0.82	0.24	4.2	11	4.8	20	25	38	-89	160
	LWC-3	321	23	0.34	0.77	0.46	0.57	0.10	6.9	7.2	11	25	7.8	64	-121	194
	LWC-4	133	26	0.51	0.84	0.53	0.92	0.46	14	33	11	58	9.0	7.5	-105	164
	LWC-5	330	29	0.37	0.72	0.41	0.63	0.09	8.5	20	2.4	31	6.1	59	-114	177
Lower Big Creek (Reference)	LBC-1	878	31	0.85	0.40	0.79	0.84	0.21	3.2	7.5	0.46	11	44	30	-78	-121
	LBC-2	789	35	0.78	0.22	0.69	0.89	0.25	7.0	5.2	0.38	13	54	21	-68	-82
	LBC-3	848	38	0.73	0.34	0.67	0.87	0.20	17	27	0.71	45	34	16	-72	-4.9
	LBC-4	124	23	0.55	0.67	0.35	0.85	0.28	19	19	0.81	39	10	39	-78	52
	LBC-5	1,038	37	0.78	0.30	0.73	0.93	0.37	12	7.3	0.58	20	47	14	-46	-46
Lower Minto Creek (Exposure)	LMC-1	207	18	0.91	0.82	0.86	0.82	0.31	0	13	0	13	79	4.8	249	27
	LMC-2	295	20	0.79	0.73	0.75	0.77	0.22	0.34	14	0	14	64	13	176	27
	LMC-3	379	22	0.94	0.82	0.90	0.85	0.30	0	32	4.2	37	53	1.6	270	21
	LMC-4	332	20	0.95	0.82	0.90	0.72	0.18	0.60	36	2.4	39	54	0	238	5.5
	LMC-5	321	16	0.97	0.81	0.91	0.80	0.31	0	31	2.5	33	54	0	240	10

[a] Calculated as recommended by Environment Canada 2012.

Table E.3: Summary of Benthic Invertebrate Community Characteristics, and Statistical Comparisons Among Areas, Minto Mine WUL, 2016.

	Overall 3-group ANOVA				3-group ANOVA Post-hoc Comparisons[1,2]				2-group ANOVA for Estimation of Effect Size		
Metric	**Test Type**	**Significant Difference Among Areas?**	**p-value**	**Power**	**(I) Area**	**(J) Area**	**Significant Difference Between Areas?**	**p-value**	**Power**	**Magnitude of Difference (# of SDs)[3]**	**Minimum Detectable Effect Size (# of SDs)[4]**
Density (Individuals/m^2)	ANOVA	YES	0.006	0.954	lower Wolverine Creek	lower Minto Creek	NO	1.000	0.434	-	1.7
					lower Big Creek	lower Minto Creek	YES	0.025	0.784	1.2	-
					lower Big Creek	lower Wolverine Creek	YES	0.008	0.883	1.4	-
Number of Taxa	ANOVA	YES	0.001	0.997	lower Wolverine Creek	lower Minto Creek	NO	0.217	0.862	-	1.7
					lower Big Creek	lower Minto Creek	YES	0.001	0.100	2.2	-
					lower Big Creek	lower Wolverine Creek	YES	0.024	0.803	1.4	-
EPT (%)	ANOVA	NO	0.698	0.172	lower Wolverine Creek	lower Minto Creek	NO	1.000	0.164	-	1.8
					lower Big Creek	lower Minto Creek	NO	1.000	0.104	-	1.8
					lower Big Creek	lower Wolverine Creek	NO	1.000	0.184	-	1.9
Chironomids (%)	ANOVA	YES	< 0.001	1.000	lower Wolverine Creek	lower Minto Creek	YES	< 0.001	1.000	6.4	-
					lower Big Creek	lower Minto Creek	YES	0.042	0.740	1.3	-
					lower Big Creek	lower Wolverine Creek	YES	0.020	0.883	1.5	-
Oligochaeta (%)	ANOVA	YES	0.001	0.992	lower Wolverine Creek	lower Minto Creek	YES	0.001	0.968	1.8	-
					lower Big Creek	lower Minto Creek	YES	0.020	0.964	1.9	-
					lower Big Creek	lower Wolverine Creek	NO	0.462	0.508	-	3.3
BC Distance to LWC Median	ANOVA	YES	< 0.001	1.000	lower Wolverine Creek	lower Minto Creek	YES	< 0.001	1.000	4.0	-
					lower Big Creek	lower Minto Creek	NO	0.106	1.000	-	1.6
					lower Big Creek	lower Wolverine Creek	YES	< 0.001	0.998	3.6	-
BC Distance to LBC Median	Kruskal-Wallis	YES	0.006	-	lower Wolverine Creek	lower Minto Creek	NO	0.175	-	-	-
					lower Big Creek	lower Minto Creek	YES	0.009	-	-	-
					lower Big Creek	lower Wolverine Creek	YES	0.009	-	-	-
BC Distance to Combined Reference Median	Kruskal-Wallis	YES	0.005	-	lower Wolverine Creek	lower Minto Creek	YES	0.009	-	-	-
					lower Big Creek	lower Minto Creek	YES	0.016	-	-	-
					lower Big Creek	lower Wolverine Creek	YES	0.047	-	-	-
Simpson's Diversity	ANOVA	YES	0.068	0.673	lower Wolverine Creek	lower Minto Creek	YES	0.056	0.219	0.44	-
					lower Big Creek	lower Minto Creek	YES	0.016	0.885	2.4	-
					lower Big Creek	lower Wolverine Creek	YES	0.098	0.655	4.2	-
Simpson's Evenness	ANOVA	NO	0.670	0.180	lower Wolverine Creek	lower Minto Creek	NO	1.000	0.170	-	-
					lower Big Creek	lower Minto Creek	NO	1.000	0.100	-	-
					lower Big Creek	lower Wolverine Creek	NO	1.000	0.164	-	-
CA Axis-1 (33.6%)	ANOVA	YES	< 0.001	1.000	lower Wolverine Creek	lower Minto Creek	YES	< 0.001	1.000	1.9	-
					lower Big Creek	lower Minto Creek	YES	< 0.001	1.000	3.4	-
					lower Big Creek	lower Wolverine Creek	YES	0.080	0.991	1.5	-
CA Axis-2 (24.2%)	ANOVA	YES	< 0.001	1.000	lower Wolverine Creek	lower Minto Creek	YES	< 0.001	1.000	21	-
					lower Big Creek	lower Minto Creek	NO	0.323	0.550	-	3.1
					lower Big Creek	lower Wolverine Creek	YES	0.005	1.000	7.0	-

Highlighted values indicate significance at the p < 0.10 level.

[1] p-value obtained from post-hoc analysis of 1-way ANOVA among all areas (post-hoc analyses protected for multiple comparisons).

[2] Bonferroni post-hoc Test or Tamhane's T2 Test (where variances were found to be heterogeneous by Levene's Test). Individual Mann-Whitney U-tests were conducted between sites if data could not be normalized.

[3] Magnitude calculated by comparing the difference between the reference and exposure area means to the reference area standard deviation (SD) [(exposure mean - reference mean) / standard deviation of the reference mean].

[4] Minimum effect size detectable calculated based on variance as square root of MSE from ANOVA and alpha = beta = 0.10. Minimum effect size reported as the minimum number of standard deviations detectable based on reference area standard deviation.

Table E.4: Benthic Analyses - ANOVA results, Minto Mine WUL, 2016.

Dependent Variable	Mean Square	F (ANOVA)	p-value	Observed Power
Density (Individuals/m^2)	45,974	8.2	0.006	0.954
Number of Taxa	17	14	0.001	0.997
EPT (%)	204	0.37	0.698	0.172
Chironomids (%)	158	19	< 0.001	1.000
Oligochaetes (%)	2.7	12	0.001	0.992
Simpson's Diversity	0.0076	3.4	0.068	0.673
Simpson's Evenness	0.010	0.41	0.670	0.180
BC Distance to LWC Median	0.014	34	< 0.001	1.000
BC Distance to LBC Median	-	-	0.006	-
BC Distance to Combined Reference Median	-	-	0.005	-
CA Axis-1 (33.6%)	521	333	< 0.001	1.000
CA Axis-2 (24.2%)	1,621	36	< 0.001	1.000
Median Intermediate Axis Length (cm)	0.11	1.4	0.285	0.369
Median Embeddedness (%)	0.0010	0.11	0.901	0.120
Water Velocity (m/s)	-	-	0.903	-
Depth (m)	-	-	0.011	-
Temperature (°C)	-	-	0.022	-
DO (%)	12	5.7	0.018	0.759
Specific Conductivity (µS/cm)	-	-	0.002	-
pH	0.043	2.3	0.149	0.363
% cobble	-	-	0.703	-
% gravel	-	-	0.917	-
% sand and finer	-	-	0.497	-

Indicates p-value < 0.10.

Table E.5: Correspondence analysis axes results and station scores using benthic invertebrate abundances at the lowest practical level of taxonomic resolution.

	CA Axis-1 (33.6%)	CA Axis-2 (24.2%)
Eigenvalue	0.647	0.465
Relative Inertia (%)	33.6	24.2
Monte Carlo p-value	0.001	0.003
LWC-1	-96.1	153.4
LWC-2	-89.0	160.3
LWC-3	-121.1	194.5
LWC-4	-104.8	163.8
LWC-5	-113.6	176.5
LBC-1	-78.5	-120.8
LBC-2	-67.5	-82.1
LBC-3	-71.7	-4.9
LBC-4	-78.3	51.8
LBC-5	-46.3	-46.4
LMC-1	248.9	27.4
LMC-2	176.4	27.4
LMC-3	270.0	21.3
LMC-4	238.3	5.5
LMC-5	239.7	9.6

Table E.6: Pearson correlation of station Correspondence Analysis (CA) axes scores with benthic taxa.

Invertebrate	CA Axis-1 (33.6%)		CA Axis-2 (24.2%)	
	Pearson r-value	p-value	Pearson r-value	p-value
Baetidae	-0.404	0.135	-0.364	0.182
Drunella grandis group	-0.329	0.231	-0.665	0.007
Drunella doddsii	-0.427	0.113	0.477	0.072
Ephemerella	-0.198	0.478	-0.292	0.290
Heptageniidae	-0.343	0.211	-0.152	0.590
Capniidae	-0.303	0.272	-0.375	0.169
Chloroperlidae	-0.564	0.029	0.411	0.128
Nemouridae	0.874	0.000	-0.220	0.431
Perlodidae	-0.527	0.043	0.759	0.001
Taeniopterygidae	-0.381	0.162	0.182	0.515
Glossosomatidae	-0.426	0.114	0.522	0.046
Limnephilidae	0.651	0.009	-0.207	0.458
Rhyacophila	-0.598	0.019	0.703	0.003
Culicoides	0.582	0.023	-0.137	0.627
Micropsectra	0.748	0.001	-0.500	0.058
Neozavrelia	-0.220	0.430	-0.480	0.070
Rheotanytarsus	-0.327	0.234	-0.737	0.002
Stempellina	-0.241	0.388	-0.090	0.750
Diamesa	-0.262	0.346	-0.507	0.054
Pagastia	-0.446	0.096	-0.510	0.052
Pseudodiamesa	-0.240	0.389	-0.650	0.009
Brillia	0.302	0.274	-0.174	0.536
Diplocladius cultriger	0.630	0.012	-0.128	0.648
Eukiefferiella	0.731	0.002	-0.331	0.228
Limnophyes	0.638	0.010	-0.130	0.645
Orthocladius complex	0.698	0.004	-0.669	0.006
Parakiefferiella	0.550	0.034	-0.161	0.567
Paraphaenocladius	0.598	0.019	-0.126	0.656
Pseudosmittia	-0.315	0.252	-0.637	0.011
Tvetenia	-0.260	0.348	-0.456	0.087
Zalutschia	0.104	0.713	-0.379	0.164
Chelifera/ Metachela	-0.266	0.338	-0.622	0.013
Clinocera	0.649	0.009	-0.142	0.614
Clinocerinae Unknown Genus A	-0.496	0.060	0.458	0.086
Neoplasta	-0.027	0.924	-0.218	0.435
Roederiodes	-0.254	0.361	-0.479	0.071
Simuliidae	0.059	0.834	-0.392	0.149
Antocha	-0.304	0.270	-0.711	0.003
Dicranota	0.329	0.230	-0.389	0.152
Hesperoconopa	-0.521	0.047	0.589	0.021
Hygrobates	-0.176	0.529	-0.427	0.112
Lebertia	-0.265	0.339	-0.568	0.027
Sperchon	-0.081	0.775	-0.715	0.003
Lumbriculidae	-0.642	0.010	0.421	0.118
Enchytraeus	-0.271	0.328	-0.241	0.386
Nais	-0.244	0.381	-0.636	0.011

Indicates absolute r-values > 0.50.

Indicates p-value < 0.05.

Table E.7: Intermediate axis length and embeddedness of 100 rocks washed during Hess sampling at benthic invertebrate stations, Minto Mine WUL, 2016.

Rock Number	Lower Wolverine Creek									
	LWC-1		LWC-2		LWC-3		LWC-4		LWC-5	
	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)
1	9.9		6.3		10.2		4.4		4.2	
2	3.4		4.6		7.6		2.7		3.2	
3	4.0		10.1		5.0		5.0		10.1	
4	5.8		3.9		4.8		11.0		7.4	
5	7.7		6.3		2.5		5.3		10.4	
6	3.0		3.6		4.8		9.2		3.7	
7	5.0		6.6		5.7		5.2		4.0	
8	4.5		5.2		2.5		7.9		3.5	
9	4.0		7.9		13.2		6.0		4.0	
10	2.3	0	4.5	25	7.6	0	5.3	0	10.8	0
11	5.0		4.8		7.8		5.4		4.2	
12	4.6		11.3		5.7		7.2		10.9	
13	3.2		3.3		7.5		4.7		4.6	
14	3.2		5.0		6.6		7.5		9.4	
15	2.6		6.3		6.7		10.2		8.9	
16	9.5		4.7		6.3		9.1		6.3	
17	4.6		2.9		5.0		3.8		11.4	
18	4.8		4.7		3.5		3.2		3.0	
19	4.2		8.7		4.3		3.6		3.5	
20	3.7	25	13.2	50	3.4	0	5.0	25	2.7	25
21	4.4		10.3		4.6		3.8		4.7	
22	4.4		5.6		3.4		2.7		7.6	
23	7.6		14.1		3.2		6.2		9.8	
24	5.5		4.8		2.4		4.9		4.8	
25	4.1		6.2		3.1		3.7		9.7	
26	3.7		4.3		8.0		4.5		5.7	
27	3.0		3.6		6.8		6.2		6.4	
28	2.0		9.9		5.4		4.7		3.7	
29	2.0		9.8		5.6		2.7		4.7	
30	3.7	50	7.3	0	3.9	25	5.1	25	4.8	25
31	2.0		5.2		5.9		4.1		4.2	
32	3.4		5.8		6.3		2.8		5.1	
33	4.1		7.5		3.6		4.6		3.3	
34	2.7		8.6		4.1		4.7		3.0	
35	2.1		2.4		4.9		4.1		8.2	
36	2.2		7.3		4.4		6.1		3.3	
37	9.6		5.1		6.5		4.7		4.8	
38	8.8		4.7		3.0		2.7		7.1	
39	4.0		3.7		2.4		3.3		3.9	
40	3.7	0	7.7	0	3.4	25	2.8	25	3.4	25
41	2.5		6.6		4.0		3.5		3.2	
42	2.8		3.7		4.0		5.5		3.1	
43	1.9		5.4		2.4		4.3		7.9	
44	4.0		5.5		7.6		3.7		3.7	
45	5.0		6.5		3.7		2.5		3.4	
46	3.6		5.2		4.4		3.6		6.0	
47	3.1		2.0		3.4		3.0		7.2	
48	3.1		1.9		7.5		2.9		3.8	
49	2.7		5.9		2.5		1.9		3.2	
50	2.2	50	6.4	50	5.2	0	3.1	0	3.1	25
51	3.2		5.3		4.4		5.0		5.7	
52	2.2		6.2		3.2		4.8		3.5	
53	5.5		3.9		3.4		6.4		3.0	
54	4.0		2.9		3.0		5.6		3.8	
55	4.6		10.6		3.1		3.1		2.0	
56	3.0		5.2		7.0		1.8		2.8	
57	2.5		5.6		4.8		2.1		5.9	
58	4.2		3.5		6.0		2.8		3.1	
59	2.1		3.6		5.8		3.8		8.2	
60	2.0	25	4.2	25	3.6	0	7.3	25	9.1	25
61	4.2		4.0		4.6		2.4		2.8	
62	1.9		5.0		4.7		3.8		2.3	
63	2.1		3.8		3.1		5.5		2.5	
64	3.5		3.8		2.6		5.9		3.5	
65	9.0		6.2		1.8		4.7		2.6	
66	4.2		4.9		5.5		5.0		2.8	
67	5.2		6.0		5.4		5.5		4.6	
68	2.5		5.5		6.3		3.3		2.0	
69	4.1		6.1		9.5		4.2		3.8	
70	4.6	25	3.8	50	8.5	0	2.9	25	2.8	0
71	4.3		6.5		4.2		3.7		2.5	
72	2.2		4.7		3.2		2.2		2.0	
73	3.2		4.0		2.8		3.3		7.9	
74	3.0		3.7		1.7		4.3		2.8	
75	3.1		5.1		1.8		2.2		1.4	
76	5.3		4.5		2.8		2.3		3.1	
77	5.8		6.0		2.4		4.0		2.0	
78	5.0		2.8		2.9		4.2		1.8	
79	2.8		3.0		1.7		2.7		2.1	
80	8.0	0	5.3	50	4.5	25	2.7	0	1.2	0
81	2.9		3.1		2.6		2.7		2.5	
82	5.5		3.3		3.2		4.8		2.8	
83	4.0		5.3		5.0		5.1		2.7	
84	4.5		4.1		6.3		1.9		2.2	
85	5.1		3.1		2.7		2.0		4.9	
86	5.5		2.8		4.3		3.3		2.7	
87	3.7		2.7		1.6		3.0		3.4	
88	3.1		4.6		2.0		2.5		2.5	
89	2.5		2.4		3.4		6.8		5.1	
90	2.0	25	2.6	25	2.9	25	6.7	0	2.2	25
91	4.8		3.8		2.5		8.1		3.6	
92	3.1		2.1		2.2		2.5		1.0	
93	2.2		1.1		3.0		4.3		2.2	
94	3.3		1.4		2.6		7.0		1.8	
95	7.7		1.9		1.7		3.6		1.9	
96	3.5		1.4		2.3		4.0		1.6	
97	2.3		1.7		2.1		6.2		0.8	
98	2.0		1.1		1.9		4.9		4.7	
99	2.2		0.6		1.2		2.3		4.2	
100	3.2	0	0.7	0	1.8	0	3.0	0	3.3	25
Minimum	**1.9**		**0.6**		**1.2**		**1.8**		**0.8**	
Maximum	**9.9**		**14.1**		**13.2**		**11.0**		**11.4**	
Mean	**4.0**		**5.0**		**4.4**		**4.4**		**4.4**	
Geometric mean	**3.7**		**4.4**		**3.9**		**4.1**		**3.8**	
Median	**3.7**	**25**	**4.8**	**25**	**4.0**	**0**	**4.2**	**13**	**3.5**	**25**

Note: intermediate axis length is the second longest axis on a rock. Embeddedness refers to how deeply the rock is surrounded or buried by other substrate

Table E.7: Intermediate axis length and embeddedness of 100 rocks washed during Hess sampling at benthic invertebrate stations, Minto Mine WUL, 2016.

Rock Number	Lower Big Creek									
	LBC-1		LBC-2		LBC-3		LBC-4		LBC-5	
	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)
1	11.7		9.7		4.3		4.8		7.3	
2	7.3		7.5		4.8		4.1		9.7	
3	10.8		4.6		5.3		5.0		7.0	
4	6.6		4.4		5.3		4.5		4.0	
5	10.9		2.8		12.3		8.1		3.6	
6	4.6		4.0		8.3		2.9		4.4	
7	4.2		5.5		8.1		1.9		2.5	
8	5.9		6.2		5.9		3.8		3.2	
9	6.4		6.4		7.5		2.5		2.5	
10	4.6	75	3.2	50	10.3	0	3.7	0	7.6	0
11	7.6		5.3		5.1		6.1		6.1	
12	5.0		6.1		6.6		4.2		6.3	
13	3.3		6.5		9.1		3.6		4.1	
14	7.3		3.7		3.9		3.9		4.7	
15	5.5		3.4		8.7		6.4		2.8	
16	3.2		3.7		4.7		2.1		4.2	
17	3.0		3.8		7.4		4.2		2.6	
18	6.0		5.9		3.7		6.4		3.1	
19	10.4		5.0		6.7		5.3		9.2	
20	2.8	75	6.0	50	4.2	0	4.1	50	6.2	25
21	5.8		4.4		3.9		2.5		6.0	
22	3.2		5.1		4.3		2.5		4.1	
23	8.1		5.2		4.5		2.2		4.5	
24	3.5		2.7		4.4		2.1		1.7	
25	2.0		6.0		6.0		4.6		2.0	
26	9.0		3.9		6.2		3.8		4.6	
27	6.3		10.5		4.1		2.6		3.0	
28	4.2		5.2		3.8		4.0		4.5	
29	2.5		2.4		3.4		5.2		3.1	
30	2.6	25	6.5	25	5.0	0	2.7	50	3.1	25
31	3.7		8.7		5.7		3.3		3.2	
32	5.6		6.8		4.8		3.6		2.0	
33	2.7		4.8		4.0		3.9		7.7	
34	2.7		6.2		8.0		3.6		5.1	
35	4.2		7.0		7.0		6.3		3.3	
36	2.9		2.8		3.5		2.3		1.8	
37	3.3		4.6		3.0		4.7		1.9	
38	2.4		2.8		1.7		7.9		3.5	
39	4.0		4.0		2.9		8.7		2.6	
40	3.2	25	7.0	25	3.7	25	6.8	0	4.5	0
41	1.9		4.8		3.6		3.6		3.9	
42	2.0		3.6		3.7		9.5		2.5	
43	2.2		6.8		9.8		2.8		3.5	
44	4.3		2.8		6.9		5.5		2.5	
45	8.5		5.2		7.7		8.9		10.2	
46	2.3		3.4		7.7		3.2		4.6	
47	4.9		3.6		4.6		4.5		4.6	
48	3.0		2.1		4.9		2.2		4.0	
49	3.0		2.1		2.6		3.2		2.4	
50	5.3	25	2.4	25	3.9	0	5.0	0	2.2	0
51	2.1		7.7		2.5		4.1		3.0	
52	4.3		5.7		5.8		3.6		3.4	
53	4.6		4.0		5.5		2.0		3.9	
54	4.9		4.7		4.0		4.9		2.3	
55	4.2		2.3		3.8		2.3		3.0	
56	4.0		5.1		3.7		2.6		4.5	
57	4.5		5.3		2.9		3.8		3.2	
58	2.2		3.7		3.6		2.5		5.5	
59	4.3		3.7		8.8		3.2		2.9	
60	2.5	0	4.0	0	3.6	25	4.1	50	2.8	0
61	3.0		6.3		4.9		4.5		3.6	
62	3.5		5.8		4.6		2.4		3.8	
63	2.0		2.7		3.8		5.0		2.7	
64	2.2		3.9		11.4		3.2		3.2	
65	2.4		4.6		3.7		4.0		3.3	
66	3.3		2.1		5.8		2.3		2.5	
67	2.9		3.5		3.1		3.2		2.2	
68	2.0		2.2		2.5		2.2		2.4	
69	3.8		2.6		3.8		3.4		2.8	
70	3.5	25	5.4	50	2.0	25	9.0	25	2.5	50
71	3.1		5.0		2.9		4.8		3.9	
72	1.8		3.2		3.8		3.3		7.0	
73	3.6		4.1		3.1		4.0		2.6	
74	1.9		2.8		2.9		4.9		2.8	
75	1.8		3.4		3.5		2.7		3.1	
76	2.2		2.0		5.8		2.1		3.5	
77	5.3		2.0		2.6		3.2		4.2	
78	2.0		1.9		2.5		4.4		2.7	
79	3.5		2.0		3.3		5.2		2.5	
80	8.1	50	2.0	0	3.0	0	3.5	0	3.3	0
81	6.5		1.9		3.1		4.2		6.1	
82	5.3		2.7		3.0		2.2		4.4	
83	6.4		1.9		3.5		2.0		4.2	
84	3.7		2.2		3.3		4.4		3.4	
85	7.3		2.6		2.7		2.4		4.7	
86	5.5		2.1		3.6		2.0		2.8	
87	2.0		2.7		3.0		3.0		3.1	
88	6.4		2.8		2.3		3.3		2.7	
89	8.0		2.2		2.7		6.1		3.9	
90	4.1	25	3.2	25	1.3	25	7.6	0	4.9	50
91	7.5		2.8		3.6		5.7		3.1	
92	3.5		2.7		1.6		3.3		3.8	
93	4.0		2.2		3.2		2.3		3.1	
94	4.5		3.1		2.7		2.8		3.1	
95	3.3		1.9		1.6		2.1		3.4	
96	9.2		2.3		1.9		4.6		2.1	
97	3.4		2.3		2.2		3.0		2.6	
98	4.6		4.3		3.4		2.8		2.5	
99	2.0		3.4		3.0		2.6		3.1	
100	2.4	0	3.6	50	3.4	0	3.5	25	2.7	25
Minimum	**1.8**		**1.9**		**1.3**		**1.9**		**1.7**	
Maximum	**11.7**		**10.5**		**12.3**		**9.5**		**10.2**	
Mean	**4.5**		**4.1**		**4.6**		**4.0**		**3.8**	
Geometric mean	**4.0**		**3.8**		**4.1**		**3.7**		**3.5**	
Median	**3.9**	**25**	**3.7**	**25**	**3.8**	**0**	**3.6**	**13**	**3.3**	**13**

Note: intermediate axis length is the second longest axis on a rock. Embeddedness refers to how deeply the rock is surrounded or buried by other substrate

Table E.7: Intermediate axis length and embeddedness of 100 rocks washed during Hess sampling at benthic invertebrate stations, Minto Mine WUL, 2016.

Rock Number	Lower Minto Creek									
	LMC-1		LMC-2		LMC-3		LMC-4		LMC-5	
	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)	Intermediate Axis Length (cm)	Embeddedness (%)
1	5.6		6.0		3.9		10.3		4.2	
2	5.7		7.5		5.2		3.6		7.2	
3	7.2		6.0		7.4		3.7		4.3	
4	9.0		7.3		7.5		3.3		4.7	
5	6.8		4.3		7.3		6.4		3.4	
6	6.1		4.8		4.2		2.7		3.3	
7	7.9		4.0		3.1		10.2		5.4	
8	4.1		5.5		4.3		5.0		4.7	
9	3.0		6.3		5.0		9.0		4.2	
10	5.5	0	6.4	0	3.2	0	6.6	0	2.7	0
11	3.0		6.3		5.5		4.3		5.1	
12	3.4		2.5		8.1		3.0		4.5	
13	2.6		4.4		6.9		7.6		3.8	
14	2.9		4.8		5.7		4.9		4.7	
15	3.5		7.1		5.0		4.9		4.5	
16	5.5		4.2		3.1		7.3		4.8	
17	4.0		5.6		3.5		4.6		4.4	
18	2.7		4.5		5.1		5.7		3.2	
19	4.8		5.1		5.8		4.6		3.8	
20	2.7	0	9.5	25	5.4	25	7.7	0	3.2	0
21	3.0		7.6		6.2		4.2		2.3	
22	4.6		3.9		6.2		2.3		4.3	
23	4.9		4.6		3.6		1.9		3.6	
24	3.6		4.6		2.4		7.2		2.7	
25	2.5		8.2		4.6		3.6		3.5	
26	7.1		5.9		10.2		4.5		3.6	
27	6.6		3.2		5.5		3.6		3.7	
28	5.2		3.4		5.4		2.2		3.8	
29	4.3		2.3		7.4		5.0		2.8	
30	3.0	25	3.6	50	5.7	25	6.8	50	2.3	0
31	7.9		2.9		3.6		4.6		2.8	
32	7.7		4.2		2.8		6.2		1.9	
33	5.0		4.0		4.4		4.2		2.3	
34	11.5		9.1		3.1		4.2		2.1	
35	3.5		10.5		3.2		5.8		2.3	
36	3.1		2.2		4.1		4.7		2.1	
37	3.2		2.8		3.7		3.0		3.5	
38	4.9		4.3		4.1		9.2		3.8	
39	5.2		2.7		4.5		4.6		2.5	
40	3.4	50	5.5	0	3.4	0	2.6	25	2.0	25
41	2.7		7.2		3.5		5.2		3.3	
42	4.7		4.2		3.2		7.0		2.8	
43	3.6		2.2		5.5		3.2		1.8	
44	3.5		2.3		5.8		7.1		2.9	
45	3.5		6.6		4.1		8.5		2.4	
46	3.5		2.9		2.7		3.2		2.5	
47	3.0		3.7		3.2		3.3		2.1	
48	3.3		3.8		2.3		4.3		1.6	
49	4.6		5.0		5.7		5.5		2.2	
50	5.7	0	2.1	0	3.7	0	4.6	25	3.0	0
51	2.5		5.4		3.5		3.7		7.6	
52	4.8		7.0		3.6		4.7		6.6	
53	2.7		5.0		4.6		4.4		6.3	
54	4.5		3.6		3.7		4.0		7.7	
55	4.9		1.8		2.5		3.1		4.7	
56	5.8		3.4		5.2		2.2		4.5	
57	6.2		3.4		2.7		3.9		5.0	
58	5.6		4.0		4.5		4.3		4.8	
59	2.5		3.0		3.3		3.6		3.8	
60	3.7	25	4.1	25	3.2	0	3.2	50	3.4	25
61	2.7		1.9		2.7		4.7		4.4	
62	2.8		4.3		3.5		6.7		4.1	
63	3.5		3.2		2.7		3.3		3.1	
64	3.4		3.7		3.6		3.0		3.7	
65	5.3		3.2		2.1		1.9		8.0	
66	3.6		4.5		3.5		4.0		3.6	
67	2.3		3.1		1.8		3.9		2.8	
68	1.9		2.8		2.9		6.4		3.3	
69	2.0		7.4		2.8		5.6		3.4	
70	3.5	25	3.0	50	2.7	75	4.0	75	4.8	0
71	4.6		3.6		2.7		2.1		4.4	
72	3.7		2.6		3.1		2.8		5.3	
73	1.9		5.0		2.4		2.4		2.0	
74	3.1		3.9		2.6		2.0		1.8	
75	2.5		11.7		2.8		3.3		2.7	
76	2.5		2.4		4.5		3.0		3.5	
77	5.9		4.0		7.0		3.2		5.5	
78	7.2		3.2		7.7		1.9		6.6	
79	7.4		4.2		2.8		2.4		3.6	
80	3.8	0	2.1	25	6.1	75	1.8	75	4.7	25
81	3.8		2.1		3.6		5.2		4.4	
82	3.8		2.7		3.0		5.7		5.7	
83	2.1		4.5		4.6		4.1		2.6	
84	2.1		4.5		2.9		2.7		4.7	
85	3.4		2.7		3.7		4.7		2.6	
86	2.8		2.2		2.7		4.1		4.3	
87	2.0		3.0		2.8		2.8		6.3	
88	2.5		3.0		2.4		5.0		2.4	
89	2.8		2.2		2.3		5.2		3.1	
90	2.0	0	2.0	25	4.4	25	3.2	0	5.0	25
91	5.0		3.0		4.8		3.5		4.6	
92	4.7		2.8		3.2		3.5		5.5	
93	5.8		1.6		3.3		1.8		3.3	
94	3.7		2.1		2.7		4.4		2.7	
95	7.5		2.4		3.6		4.7		2.8	
96	5.6		2.1		3.1		4.9		4.4	
97	5.7		3.0		1.5		1.5		5.0	
98	4.8		2.1		2.5		1.8		3.4	
99	6.0		2.4		2.0		2.4		2.1	
100	4.2	0	2.0	25	3.6	0	3.1	0	2.4	50
Minimum	**1.9**		**1.6**		**1.5**		**1.5**		**1.6**	
Maximum	**11.5**		**11.7**		**10.2**		**10.3**		**8.0**	
Mean	**4.3**		**4.2**		**4.1**		**4.4**		**3.8**	
Geometric mean	**4.0**		**3.8**		**3.8**		**4.0**		**3.6**	
Median	**3.8**	**0**	**3.9**	**25**	**3.6**	**13**	**4.2**	**25**	**3.6**	**13**

Note: intermediate axis length is the second longest axis on a rock. Embeddedness refers to how deeply the rock is surrounded or buried by other substrate

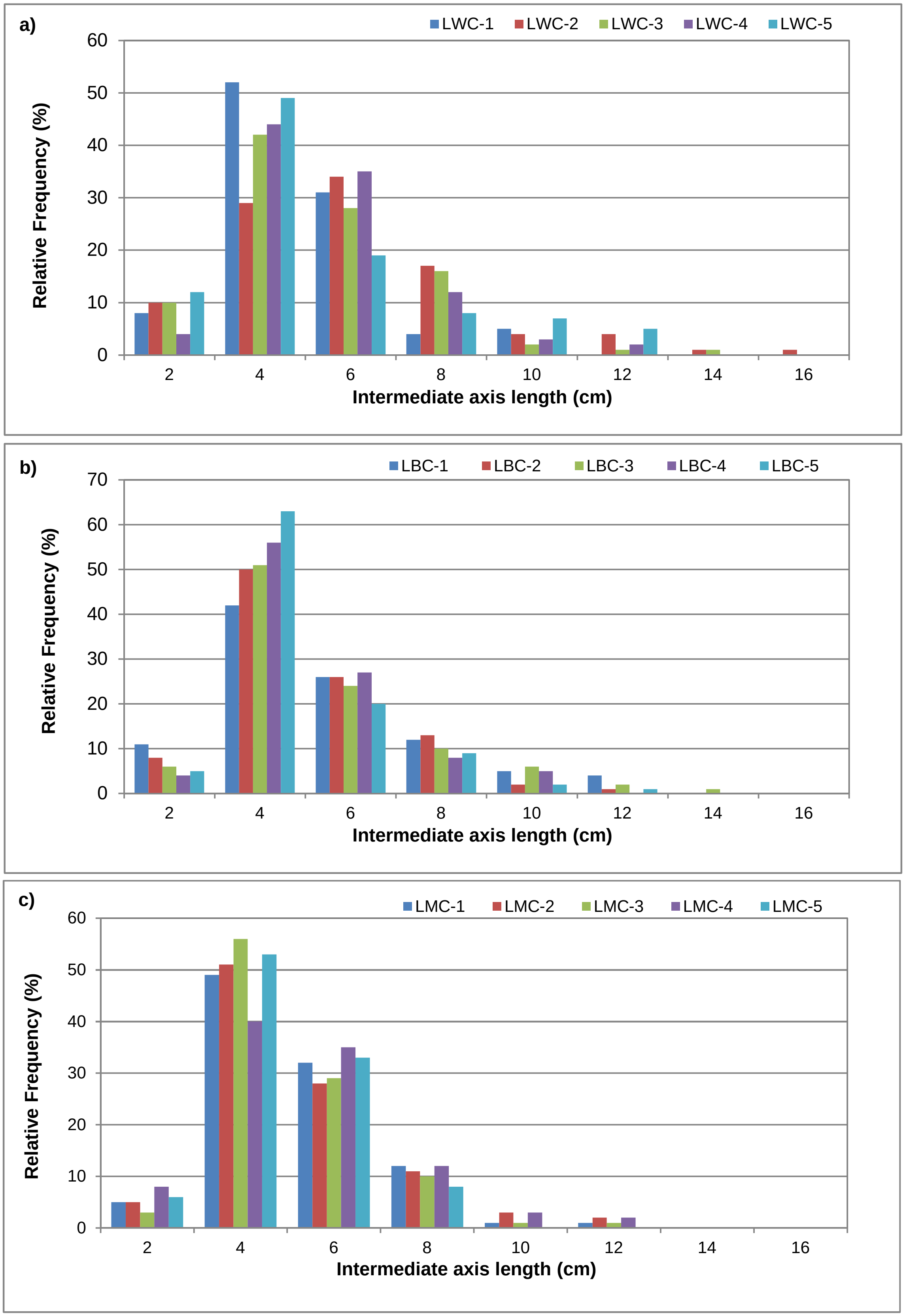

Figure E.1: Intermediate axis length of 100 rocks measured at five benthic stations in a) lower Wolverine Creek, b) lower Big Creek and c) lower Minto Creek.

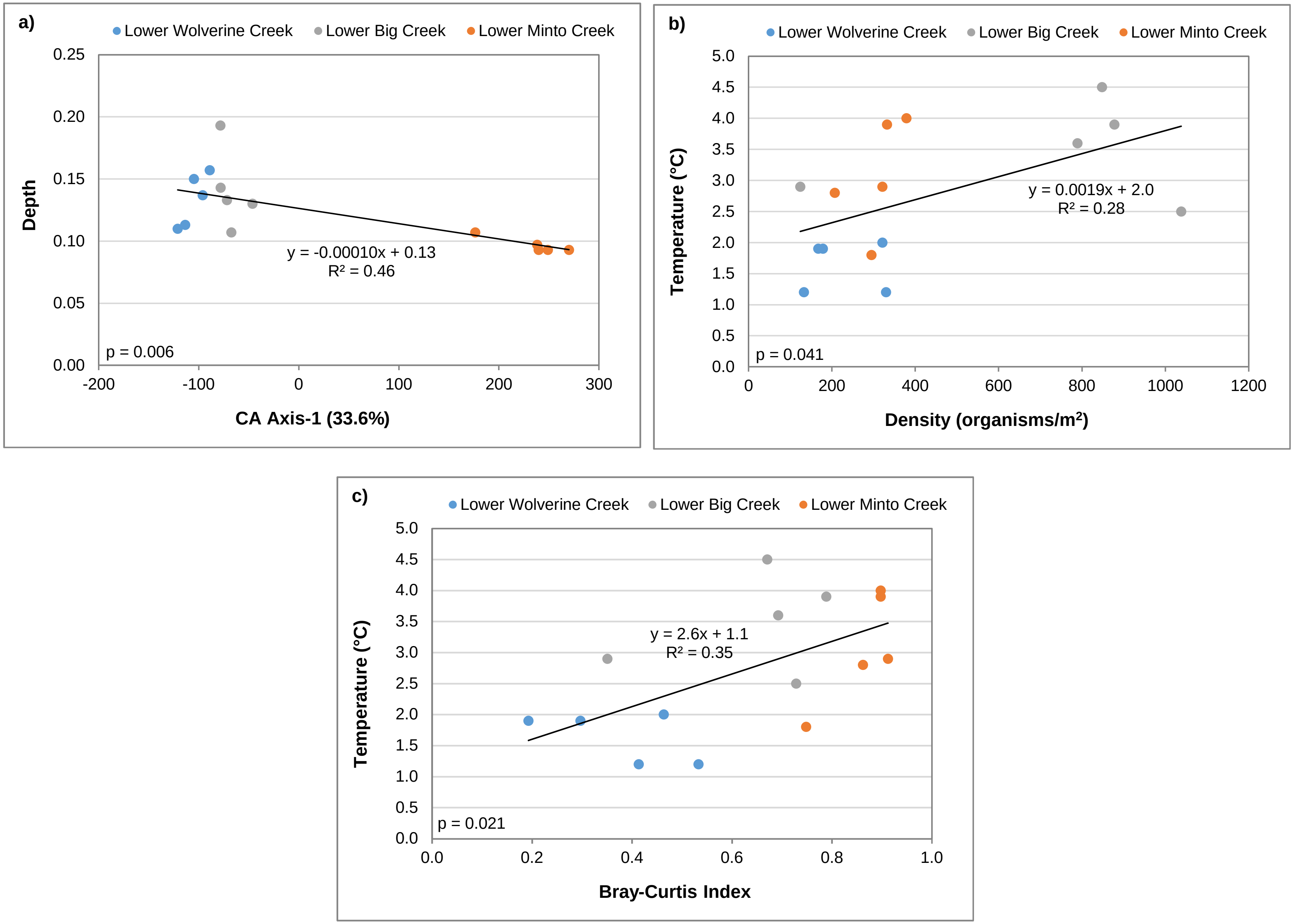

Figure E.2: Scatterplots of relationships ($p < 0.050$) between selected benthic invertebrate environmental measurements and a) CA Axis-1, b) density and c) Bray-Curtis Index, Minto Mine WUL, 2016.

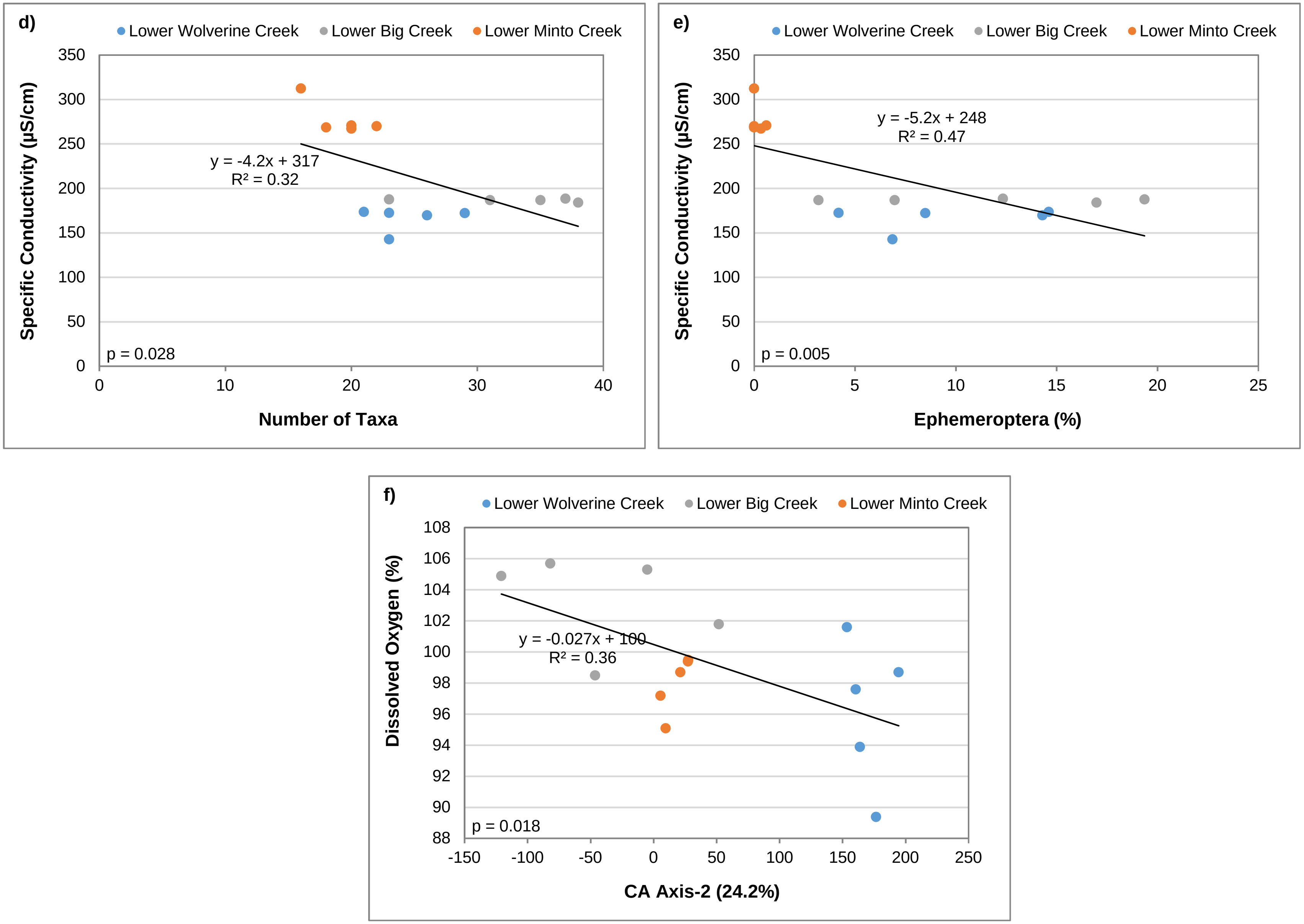

Figure E.2: Scatterplots of relationships ($p < 0.050$) between selected benthic invertebrate environmental measurements and a) number of taxa, b) ephemeroptera and c) CA Axis-2, Minto Mine WUL, 2016.

BENTHIC INVERTEBRATE COMMUNITY ANALYSIS

PROVIDED BY:

CORDILLERA CONSULTING

(SUMMERLAND, BC)

Cordillera Consulting

Project: Minto WUL Monitoring 2016 (16-80)
Minnow (Victoria), Lisa Bowron
Taxonomist: Sue Salter
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250-494-7553

Site:	LWC	LWC	LWC	LWC	LWC	LBC	LBC	LBC	LBC	LBC	LMC	LMC	LMC	LMC	LMC
Sample:	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Sample Collection Date:	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16
CC#:	CC171123	CC171124	CC171125	CC171126	CC171127	CC171128	CC171129	CC171130	CC171131	CC171132	CC171133	CC171134	CC171135	CC171136	CC171137
Phylum: Arthropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Order: Collembola	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0
| Family: Onychiuridae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Subphylum: Hexapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Class: Insecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Order: Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Family: Baetidae	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Acentrella	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Baetis	2	0	0	2	2	0	5	0	0	16	0	0	0	0	0
Baetis tricaudatus group	4	1	2	5	2	2	2	48	12	36	0	1	0	0	0
Baetis bicaudatus	10	1	6	5	2	6	35	10	8	36	0	0	0	1	0
| Family: Ephemerellidae	0	0	2	0	3	0	2	4	1	0	0	0	0	0	0
Drunella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drunella grandis group	0	0	1	0	0	8	9	2	1	2	0	0	0	0	0
Drunella doddsii	2	2	7	0	1	2	0	0	0	0	0	0	0	0	0
Ephemerella	0	0	0	1	0	0	0	6	0	12	0	0	0	0	0
| Family: Heptageniidae	8	3	3	6	17	10	2	72	2	26	0	0	0	1	0
| Order: Plecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Family: Capniidae	3	4	4	7	17	66	37	224	20	62	1	1	2	5	1
Isocapnia	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
| Family: Chloroperlidae	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Alloperla	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Haploperla	3	0	2	4	5	0	1	0	0	4	0	0	0	0	0
Sweltsa	0	1	1	3	1	0	1	0	0	4	0	0	0	0	0
| Family: Nemouridae	0	0	0	0	0	0	0	0	0	0	7	11	42	61	38
Nemoura	0	0	0	0	0	0	0	2	0	0	18	27	75	48	51
Ostrocerca	0	0	0	0	0	0	0	2	0	0	1	1	4	4	8
Zapada	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0
Zapada oregonensis group	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Zapada cinctipes	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0
| Family: Perlodidae	6	8	4	14	17	0	2	0	1	0	0	0	0	0	0

Site:	LWC	LWC	LWC	LWC	LWC	LBC	LBC	LBC	LBC	LBC	LMC	LMC	LMC	LMC	LMC
Sample:	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Sample Collection Date:	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16
CC#:	CC171123	CC171124	CC171125	CC171126	CC171127	CC171128	CC171129	CC171130	CC171131	CC171132	CC171133	CC171134	CC171135	CC171136	CC171137
Isoperla	7	3	11	12	23	0	0	2	0	0	0	0	0	0	0
Skwala	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
| Family: Taeniopterygidae	0	0	1	2	0	0	0	0	1	2	0	0	0	0	0
| Order: Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Family: Glossosomatidae	1	1	6	4	0	0	0	2	0	4	0	0	0	0	0
Glossosoma	1	2	21	7	1	0	1	2	1	0	0	0	0	0	0
| Family: Limnephilidae	1	0	1	1	0	2	0	0	0	2	0	0	15	8	7
Dicosmoecus	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1
Ecclisomyia	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
| Family: Rhyacophilidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhyacophila	2	5	1	1	4	0	0	0	0	0	0	0	1	0	0
Rhyacophila brunnea/vemna grou	3	0	5	1	2	2	2	0	0	0	0	0	0	0	0
| Order: Diptera	0	2	0	2	0	0	0	0	0	0	0	0	1	0	0
| Family: Ceratopogonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Culicoides	0	0	0	0	0	0	0	0	0	0	0	5	2	0	3
| Family: Chironomidae	3	14	13	2	6	12	10	14	0	0	1	2	3	2	2
| Subfamily: Chironominae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Tribe: Chironomini	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomus	0	0	1	0	0	0	0	6	0	0	0	0	0	0	0
Polypedilum	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Tribelos	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Tribe: Tanytarsini	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micropsectra	0	0	0	0	1	4	3	0	0	6	1	5	11	8	10
Neozavrelia	0	0	0	0	0	6	0	4	0	14	0	0	0	0	0
Rheotanytarsus	0	0	0	0	3	230	181	104	0	102	0	0	0	0	0
Stempellina	0	2	0	0	2	0	0	10	3	2	0	0	0	0	2
| Subfamily: Diamesinae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Tribe: Diamesini	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diamesa	4	0	2	1	1	10	105	52	1	140	0	0	0	0	0
Pagastia	6	6	7	8	3	34	18	8	1	38	0	0	0	0	0
Potthastia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potthastia longimana group	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Pseudodiamesa	0	2	0	0	0	14	4	2	0	12	0	2	1	0	0
| Subfamily: Orthocladiinae	0	0	0	0	0	0	1	0	0	0	2	1	0	3	0
Brillia	0	0	1	0	0	0	3	0	0	0	6	1	0	0	0
Chaetocladius	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Corynoneura	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Diplocladius cultriger	0	0	0	0	0	0	0	0	0	0	1	1	7	2	0
Eukiefferiella	1	1	1	0	1	4	8	12	0	30	58	52	42	0	30
Hydrobaenus	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Limnophyes	0	0	0	0	0	0	0	0	0	0	4	0	1	2	0

Site:	LWC	LWC	LWC	LWC	LWC	LBC	LBC	LBC	LBC	LBC	LMC	LMC	LMC	LMC	LMC
Sample:	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Sample Collection Date:	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16
CC#:	CC171123	CC171124	CC171125	CC171126	CC171127	CC171128	CC171129	CC171130	CC171131	CC171132	CC171133	CC171134	CC171135	CC171136	CC171137
Lopescladius	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Metriocnemus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Orthocladius complex	7	17	0	1	3	54	80	50	8	118	48	120	84	150	116
Parakiefferiella	0	0	0	0	0	0	0	4	0	6	5	4	46	2	6
Paraphaenocladius	0	0	0	0	0	0	0	2	0	0	36	0	5	7	7
Pseudosmittia	0	0	0	0	0	8	11	10	0	2	0	0	0	0	0
Rheocricotopus	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
Synorthocladius	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Tvetenia	0	0	0	0	0	0	4	6	0	6	0	0	0	0	0
Zalutschia	0	0	0	0	0	0	1	0	0	6	0	0	0	3	1
| Subfamily: Tanypodinae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Tribe: Pentaneurini	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thienemannimyia group	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
| Tribe: Procladiini	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Procladius	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
| Family: Empididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chelifera/ Metachela	0	0	0	0	1	18	4	0	1	12	0	0	0	0	0
Clinocera	0	0	0	0	0	0	0	0	0	0	1	8	6	3	0
Clinocerinae Unknown Genus A	1	1	1	2	3	2	0	0	0	0	0	1	0	0	0
Neoplasta	0	1	0	0	0	0	2	0	0	0	0	0	1	0	0
Roederiodes	0	0	0	0	0	0	4	4	0	6	0	0	0	0	0
| Family: Muscidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limnophora	0	0	0	0	0	0	0	0	0	0	0	0	10	1	0
| Family: Psychodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pericoma/Telmatoscopus	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
| Family: Simuliidae	0	0	0	1	0	0	2	0	0	4	1	0	0	0	0
Prosimulium	0	0	0	0	0	0	0	8	5	14	0	0	0	0	0
Simulium	1	0	0	1	0	0	0	0	1	0	1	0	0	8	7
| Family: Tipulidae	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Antocha	0	1	0	0	0	20	20	2	1	12	0	0	0	0	0
Dicranota	0	0	1	9	3	12	1	12	3	4	0	5	10	6	19
Erioptera	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
Hesperoconopa	4	20	8	14	5	6	0	2	0	0	0	0	0	0	0
Hexatoma	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Tipula	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
| Order: Thysanoptera	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Subphylum: Chelicerata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Class: Arachnida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Order: Trombidiformes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
| Family: Hygrobatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygrobates	0	0	0	0	0	4	2	0	0	16	0	0	0	0	0

Site:	LWC	LWC	LWC	LWC	LWC	LBC	LBC	LBC	LBC	LBC	LMC	LMC	LMC	LMC	LMC
Sample:	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Sample Collection Date:	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16
CC#:	CC171123	CC171124	CC171125	CC171126	CC171127	CC171128	CC171129	CC171130	CC171131	CC171132	CC171133	CC171134	CC171135	CC171136	CC171137
| Family: Lebertiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lebertia	0	4	0	2	1	38	51	8	3	100	0	0	0	0	0
| Family: Sperchontidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sperchon	0	0	1	0	0	30	9	4	0	30	0	7	3	6	6
| Order: Sarcoptiformes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Order: Oribatida	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
| Class: Malacostraca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Order: Isopoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Family: Sphaeromatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gnorimosphaeroma	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Phylum: Mollusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Class: Gastropoda	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Phylum: Annelida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subphylum: Clitellata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Class: Oligochaeta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Order: Lumbriculida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Family: Lumbriculidae	92	62	204	9	194	32	70	130	36	100	10	38	5	0	0
Rhynchelmis	0	0	2	0	0	0	0	2	4	4	0	0	1	0	0
| Order: Tubificida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Family: Enchytraeidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeus	0	0	0	1	0	0	5	0	4	0	0	0	0	0	0
| Family: Naididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nais	0	0	0	0	0	232	90	0	4	40	0	0	0	0	0
Tubifex	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Subfamily: Tubificinae without	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals:	**178**	**167**	**321**	**133**	**330**	**878**	**789**	**848**	**124**	**1038**	**207**	**295**	**379**	**332**	**321**

Site:	LWC	LWC	LWC	LWC	LWC	LBC	LBC	LBC	LBC	LBC	LMC	LMC	LMC	LMC	LMC
Sample:	LWC-1	LWC-2	LWC-3	LWC-4	LWC-5	LBC-1	LBC-2	LBC-3	LBC-4	LBC-5	LMC-1	LMC-2	LMC-3	LMC-4	LMC-5
Sample Collection Date:	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	25-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	27-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16	23-Sep-16
CC#:	CC171123	CC171124	CC171125	CC171126	CC171127	CC171128	CC171129	CC171130	CC171131	CC171132	CC171133	CC171134	CC171135	CC171136	CC171137
Taxa present but not included:															
Terrestrials	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Phylum: Arthropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subphylum: Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Class: Ostracoda	0	0	0	0	0	0	0	2	0	2	0	1	1	1	1
| Class: Branchiopoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Order: Cladocera	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
| Class: Maxillipoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Class: Copepoda	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Phylum: Annelida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subphylum: Clitellata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Class: Oligochaeta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Order: Tubificida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
| Family: Lumbricidae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Phylum: Nemata	0	1	1	0	0	2	1	2	0	0	1	1	1	1	0
Totals:	**0**	**1**	**1**	**0**	**1**	**2**	**1**	**4**	**0**	**2**	**2**	**3**	**2**	**3**	**1**

Cordillera Consulting

Project: Minto WUL Monitoring 2016 (16-80)
Minnow (Victoria), Lisa Bowron
Taxonomist: Sue Salter
suesalter@cordilleraconsulting.ca
250-494-7553

		Total Recovered	Total from Sample	Percent Efficiency
Site - QC, Sample - QC 1, CC# - CC171125, Percent sampled = 100%, Sieve size = 500				
Chironomidae		4		
Trichoptera		2		
	Total:	**6**	**322**	**98%**
Site - QC, Sample - QC 2, CC# - CC171131, Percent sampled = 100%, Sieve size = 500				
Ephemeroptera		1		
Trombidiformes		1		
	Total:	**2**	**124**	**98%**

Cordillera Consulting

Project: Minto WUL Monitoring 2016 (16-80)
Minnow (Victoria), Lisa Bowron
Taxonomist: Sue Salter
suesalter@cordilleraconsulting.ca
250-494-7553

Station ID		Organisms in Subsample																				Actual Total	Precision Error		Accuracy Error	
CC#	Sample Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		Min (%)	Max (%)	Min (%)	Max (%)
171130	LBC,3	421	483																			904	12.84	12.84	6.86	6.86

Appendix M – Fisheries Monitoring Program, Minto Creek, 2016 Summary Report

Minto Mine
Fisheries Monitoring Program
2016 Summary Report

March 2017

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1 Introduction

Minto Explorations Ltd. (MEL), a wholly owned subsidiary of Capstone Mining Corp., owns and operates the Minto Mine, a high-grade copper mine, located approximately 240 km northwest of Whitehorse, Yukon Territory (Figure 1). The project is located within Selkirk First Nation (SFN) Category A Settlement Land Parcel R6A, and is centered at approximately 62°37'N latitude and 137°15'W longitude. The Minto Mine commenced commercial operation in October 2007 and is permitted to conduct mining and milling operations at a rate of 4,200 tonnes of ore per day (tpd). Some of the Minto ore deposits (copper/gold/silver) currently being mined are located in the upper reaches of the Minto Creek watershed approximately 12 km to the west of the Minto Creek confluence with the Yukon River (Figure 2). MEL is required, under the terms of its water use license #QZ14-031 (Amendment 1), to conduct an aquatic environmental monitoring program, of which, this fisheries monitoring program in Minto Creek is a component. This current report provides details of the monitoring conducted during the open water season in 2016 and the results of the work undertaken. This program was carried out under DFO Scientific Collection Licence number XR 182 2016.

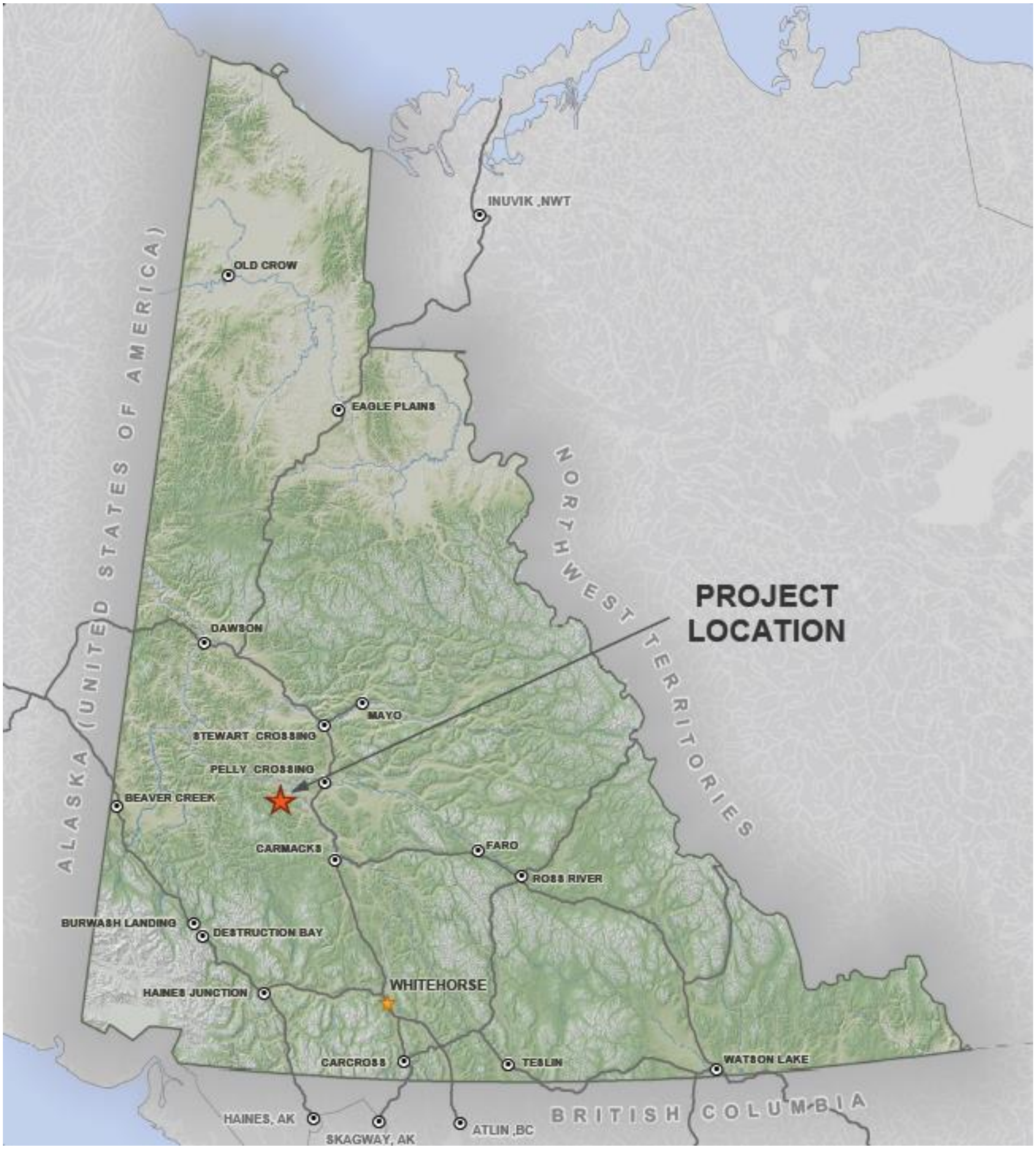


Figure 1: Project Location

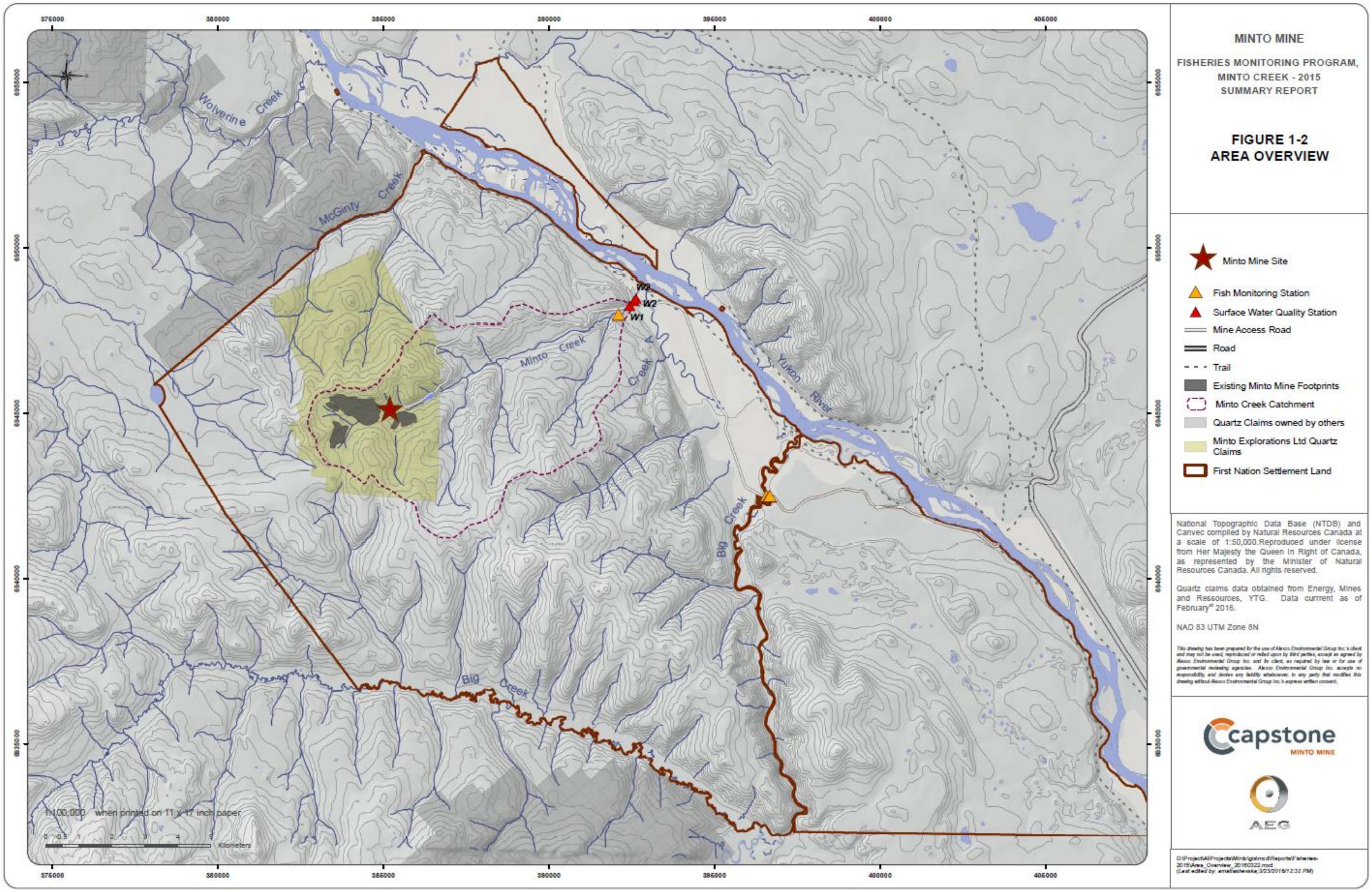


Figure 2: Project Overview

2 Previous Studies

Numerous studies on fisheries and fish habitat have been conducted over the recent history of the Minto Mine. These studies are summarized chronologically in Table 1, below.

Table 1: Minto Creek Fish Investigations

Year	Months	Purpose of Study	Conducted by
1994	June, August, September	Baseline Collection	Hallam Knight Piesold (HKP)
2006	September	Baseline Collection	Access Consulting Group (ACG)
2007	May, June, August, September	Environmental Effects Monitoring Study Design Development	ACG / Minnow Environmental (Minnow)
2008	June, September	Environmental Effects Monitoring, Cycle I	ACG / Minnow
2009	June, July	Monitoring	ACG
2009	September, October	Fish Re-location	ACG
2010	June - October	Juvenile Chinook Salmon Mark-recapture program, compliance Monitoring	ACG
2011	July - October	Environmental Effects Monitoring Cycle II, Compliance Monitoring	ACG, Minnow
2011	July, August	EEM Cycle II – Growth Trials	ACG, Minnow
2012	May - September	Compliance Monitoring Se in tissue study	ACG, MEL (Minto Exploration Ltd.)
2013-2015	May - October	Compliance Monitoring	ACG/AEG, MEL
2016	June - September	Compliance Monitoring	MEL, AEG

Attempts to collect fish in lower Minto Creek while conducting the Phase 1 Metal Mining Effluent Regulation, Environmental Effects Monitoring (EEM) study in 2008 resulted in the capture of no fish during the month of June and very few fish during the month of September. This is consistent with the findings of previous fish investigations conducted in the creek (HKP 1994; R&D 2006, 2007). Fish use of Minto Creek is transient and likely short-lived, as has been found in other non-natal chinook rearing creeks (Walker 1976; Scrivener et al. 1994).

The majority of fish using the system are juvenile chinook salmon (*Onchoryhnchus tshawytscha*), as determined by the above investigations. Other species that have been found in the creek in low numbers include round whitefish (*Prosopium cylindraceum*), Arctic grayling (*Thymallus arcticus*), Slimy sculpin (*Cottus cognatus*) and Burbot (*Lota lota*). Of these, only slimy sculpin have been captured on a regular basis.

Juvenile chinook salmon (JCS) have never been encountered in the creek before July and their numbers tend to peak in late August or early September. Moreover, the mark-recapture investigation conducted in 2010 on JCS indicates that use of the creek is transient. The majority of JCS using the system stay in the creek for about two to three weeks or less.

A summary of past fish sampling results in Minto Creek is presented in Table 2.

Table 2: Summary of Fish captures in Minto Creek between 2008 and 2015

Year	Method	Effort	Summary Statistics	Units	Juvenile Chinook Salmon	All Other Species
2008	Backpack Electrofishing	796 secs	Catch	#	1	0
			CPUE	Fish/min	0.075	0
	Baited Gee Minnow Trapping	28.6 days	Catch	#	18	0
			CPUE	Fish/day	0.63	0
2009*	Baited Gee Minnow Trapping	28.6 days	Catch	#	136	142
			CPUE	Fish/day	4.76	4.97
2010	Baited Gee Minnow Trapping	145.9 days	Catch	#	2293	2307
			CPUE	Fish/day	15.72	15.81
2011	Baited Gee Minnow Trapping	71 days	Catch	#	12	29
			CPUE	Fish/day	0.17	0.41
2012	Backpack Electrofishing	1051 secs	Catch	#	0	4
			CPUE	Fish/min	0	0.23
	Baited Gee Minnow Trapping	43 days	Catch	#	3	6
			CPUE	Fish/day	0.07	0.14
2013	Backpack Electrofishing	3402 secs	Catch	#	0	4
			CPUE	Fish/min	0	0.07
	Baited Gee Minnow Trapping	62.5 days	Catch	#	121	7
			CPUE	Fish/day	1.94	0.11
2014	Baited Gee Minnow Trapping	70.2 days	Catch	#	151	3
			CPUE	Fish/day	2.15	0.04
2015	Baited Gee Minnow Trapping	67.3 days	Catch	#	6	0
			CPUE	Fish/day	0.089	0

JCS presence in Minto creek was observed to be influenced by mine water discharge. During non-discharge periods, and prior to operations (baseline), numbers of JCS and other species of fish in the system were found to be very low. In contrast, during the two major discharge events (2009 and 2010), numbers of JCS were 20 to 30 times higher in the system (see Table 3 below), indicating that they may have been attracted into the system as a likely result of a more consistent temperature and flow regime associated with mine water discharge. Numbers of other species of fish during discharge events did not increase. It is important to note however, that numbers of other species using the system has been consistently very low, prior to mine development and during operations.

Table 3: Maximum Catch per Unit Effort (CPUE) of Juvenile Chinook Salmon in Minto Creek using baited Minnow traps 1994-2016

Year	Month	JCS – CPUE (#fish/trap-day)*	Minto Creek Conditions
1994	September	0	Pre-development – no discharge
2008	September	0.9	Operational – no discharge
2009	September/October	20.0	Discharge
2010	August	30.0	Discharge
2011	September	0.43	No discharge – high TSS contribution from tributary
2012	September	0.19	No discharge – high TSS contribution from tributary
2013	October	5.01	Operational – no discharge
2014	September	5.05	Operational – no discharge
2015	July	0.30	Operational – no discharge
2016	July	0.30	Operational – no discharge

**CPUE calculated for actual 24-hr period (rather than nominal 24-hr period)*

Minto Creek does not provide preferred spawning habitat for fish because it completely freezes during winter months with no flow in lower Minto Creek. Accordingly, there is no evidence of spawning in Minto Creek (HKP 1994; R&D 2006, 2007), nor is there traditional knowledge indicating spawning occurring in the system (HKP 1994). Lower Minto Creek is also subject to low or zero flow conditions during periods in the summer when a portion (or all) of the flow sometimes infiltrates the ground, preventing the establishment of resident fish populations in this section of the stream. A natural barrier to fish passage exists at approximately km 1.2 upstream in Minto Creek from the Yukon River, therefore limiting fish use upstream of the barrier. This barrier is largely comprised of organic debris and can be considered to be temporary as it will likely degrade over time, although it has been consistently observed since it was first characterized in 2010. Sampling effort has been applied upstream of the barrier during every sampling event since 2010 and resulted in no fish capture. New temporary barriers may also be established in any given year and could occur both upstream and further downstream of the current barrier location. The canyon located upstream of the current barrier however, is a permanent barrier to fish passage due to its high gradient, thus limiting fish habitat to the lower 2.0 km of the system.

Water temperatures tend to remain cooler in Minto Creek than in the Yukon River. This likely deters fish, in particular JCS, from entering the system until creek temperatures approach or equilibrate with the Yukon River. Minto Creek is subject to large diurnal fluctuations in temperature (up to 5°C or more) throughout the open water season. This daily variation is not ideal for fish and may limit their interest in using the creek for rearing.

Creek bottom substrate is comprised mostly of fines (silt/sand) with limited cobble/gravel sections which are more desirable for fish. In addition, significant input of suspended solids from a tributary in 2011 and 2012 may have further limited the use of the system by JCS during those years.

Bottom substrate at the mouth of Minto Creek and at the Yukon River confluence consists primarily of silt and mud which is not considered suitable substrate for salmonid spawning (grayling, salmon etc.). Aerial surveys for spawning fish were conducted in 2011, 2012, 2013 and 2014, and no adult fish were observed spawning in the vicinity of the Minto Creek/Yukon River confluence. No signs were present during the surveys that this area is used for spawning (such as redds or carcasses).

Starting in 2012, the compliance monitoring program included sampling efforts in Big Creek, which serves as a reference site. The same fish species as in Minto Creek were generally observed in Big Creek, and the CPUE has normally been slightly higher in Big Creek. Table 4 summarizes fish captures in Big Creek from 2012 to 2015.

Table 4: Summary of Fish captures in Big Creek in 2012 to 2015

Year	Method	Effort	Summary Statistics	Units	Juvenile Chinook Salmon	All Other Species
2012	Backpack Electrofishing	273 secs	Catch	#	1	23
			CPUE	Fish/min	0.22	5.05
	Baited Gee Minnow Trapping	11.8 days	Catch	#	7	2
			CPUE	Fish/day	0.59	0.17
2013	Backpack Electrofishing	911 secs	Catch	#	0	27
			CPUE	Fish/min	0	1.78
	Baited Gee Minnow Trapping	14.8 days	Catch	#	19	2
			CPUE	Fish/day	1.28	0.14
2014	Baited Gee Minnow Trapping	16.4 days	Catch	#	96	3
			CPUE	Fish/day	5.86	0.18
2015	Baited Gee Minnow Trapping	17.1 days	Catch	#	58	5
			CPUE	Fish/day	3.39	0.15

3 Objectives

The objectives of the 2016 Fisheries Monitoring Program were to monitor, assess and characterize fish usage in Minto Creek during the open water season, and to provide data for the interpretation of the potential role and influence of the Minto Mine on the fish community. The 2016 fisheries program was a continuation of the previous year's components and targeted all species that have previously been encountered, as well as any new species. As part of the monitoring program since 2012, assessments at Big Creek were made concurrently with sampling in Minto Creek, to compare fish use in a neighboring system relative to Minto Creek. Fish monitoring studies were conducted in support of the requirements of Water Use License QZ14-031 and EEM Cycle 4.

4 Methodology

4.1 Fish Monitoring

Fish monitoring of Minto Creek and Big Creek was conducted monthly during open water season, from June to September 2016, at trapping sites consistent with the 2010 mark-recapture study and the 2011 to 2015 fish monitoring programs (Figure 3). Capture effort included the use of Gee-type Minnow traps with 0.635 cm wire mesh size, baited with Yukon River origin chinook salmon roe. A total of 17 to 20 minnow traps were set during each sampling event in Minto Creek, depending on water levels and availability of pools and backwater areas. Four traps were set during each event in Big Creek, in the vicinity of the Minto access road bridge.

All fish captured were identified, enumerated and measured for fork length or total length (± 1 mm), inspected for abnormalities, and released in the vicinity of their trapping location. JCS were also weighed (± 0.01g) prior to being released.

Additional supporting information collected included:

- photo-documentation of the creek,
- water level readings at station W1 staff gauge,
- in situ water parameters in Minto Creek, Big Creek and the Yukon River - temperature, dissolved oxygen, conductivity, pH, ORP,
- flow discharge measured at W1, and
- weather conditions at time of sampling.

Continuous temperature loggers (TidbiT) were deployed in the Yukon River and Big Creek for the duration of the project, while a Levelogger recorded continuous temperature and stage in Minto Creek. Supporting variables also included monitoring of the previously identified fish barrier (1.2 km upstream of the Yukon River confluence) and/or any new barriers that may have developed.

Selected photographs documenting field activities and site conditions are presented in Appendix A.

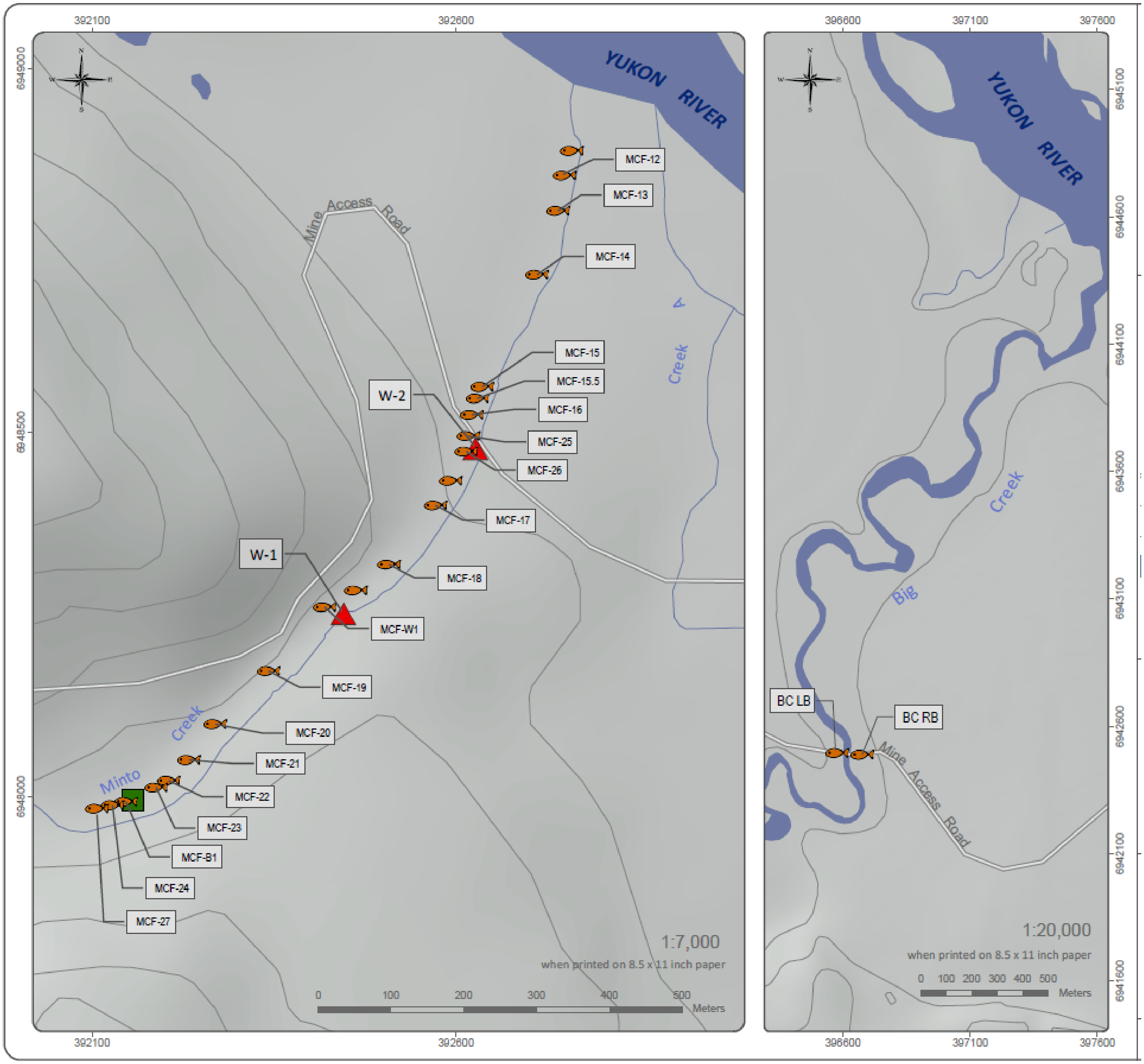


Figure 3: Minto Creek and Big Creek Fisheries Monitoring stations

5 Results

The following sections present the fisheries statistics and effort in Minto Creek and Big Creek between June and September 2016.

5.1 Fish Usage and Distribution

5.1.1 Minto Creek

Minto Creek was assessed monthly between June and September 2016. A total of 6 fish were captured in Minto Creek, all of which were juvenile chinook salmon (JCS). All 6 JCS were captured in September, and all fish were found in the trap located the most downstream site (MCF-12). The average catch per unit effort (CPUE) for JCS was 0.085 fish/trap-day throughout the open water season in Minto Creek, but was the highest in September at 0.339 fish/trap-day. In comparison, the average JCS CPUE (June to October) in 2015 was 0.089 JCS/trap-day and a maximum of 0.301 JCS/trap-day was reached in July. Of note is that a portion of Minto Creek was found to be dry during the fish monitoring event in July 2016 and in 2015, which could have played an important role in preventing fish movement up and down Minto Creek. The following table (Table 5) presents the effort applied and the summary of fish capture in Minto Creek in 2016.

Table 5: Summary Statistics of Minnow Trapping in Minto Creek

Month	Effort (trap-hours)	Effort(trap-days)	Juvenile Chinook Salmon (*Onchoryhnchus tshawytscha*)	
			Results	CPUE*
June	424.2	17.7	0	0
July	390.9	16.3	0	0
August	424	17.7	0	0
September	424	17.7	6	0.339
Total	1663.1	69.4	6	0.085

** CPUE = fish/trap-day (for actual 24-hr period)*

5.1.2 Big Creek

Fisheries sampling effort in Big Creek was initiated in June, and conducted monthly until September, concurrent with sampling in Minto Creek, resulting in the capture of 60 fish, 51 of which were JCS. JCS were captured during every monthly sampling event in 2016, with highest numbers (21) captured in July. In addition, nine slimy sculpin were captured during the 2016 sampling season.

The average catch per unit effort for JCS in Big Creek was much higher than in Minto Creek at 0.751 JCS/trap-day and was highest in July (1.288 JCS/trap-day). In comparison, the average JCS CPUE (June to October) in 2015 was higher at 3.393 JCS/trap-day and was as high as 10.448 JCS/trap-day in September 2015. In 2012, 2014, 2015, and 2016, the average JCS CPUE was much higher in Big Creek than in Minto

Creek but it was the opposite situation in 2013 due to a discharging event. The following table (Table 6) presents the effort undertaken and the resulting fish capture in Big Creek in 2016.

Due to a heavy rain event during the evening of the July 7th sampling session, 18 of the 21 JCS caught in Big Creek were dead upon retrieval (see Appendix A). There were also 2 JCS dead upon retrieval on August 6th, 2016 due to strong currents.

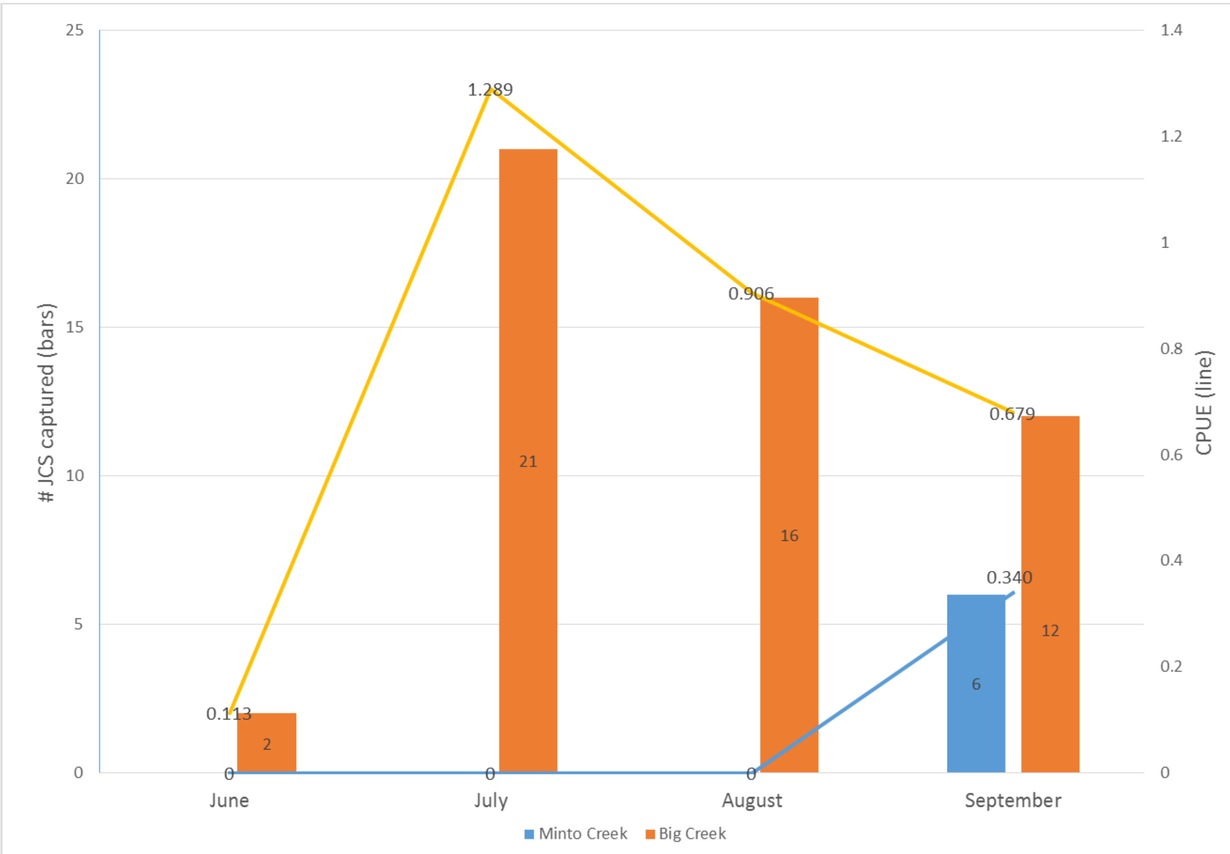
Table 6: Summary Statistics of Minnow Trapping in Big Creek in 2016

Month	**Effort (trap-hours)**	**Effort(trap-days)**	**Juvenile Chinook Salmon (*Onchoryhnchus tshawytscha*)**		**Slimy Sculpin (*Cottus cognatus*)**	
			Results	**CPUE***	**Results**	**CPUE***
June**	424.2	17.7	2	0.113	7	0.395
July	390.9	16.3	21	1.288	2	0.123
August	424	17.7	16	0.904	0	0
September	424	17.7	12	0.678	0	0
Total	1663.1	69.4	51	0.751	9	0.130

**CPUE = fish/trap-day (for actual 24-hr period)*
*** Several small fish (10-25 mm in length) were observed near one of the minnow traps but not captured*

Figure 4 presents a comparison between monthly JCS capture and CPUE in Minto Creek and Big Creek for 2016.

Figure 4: Monthly JCS capture in Minto Creek and Big Creek, 2016

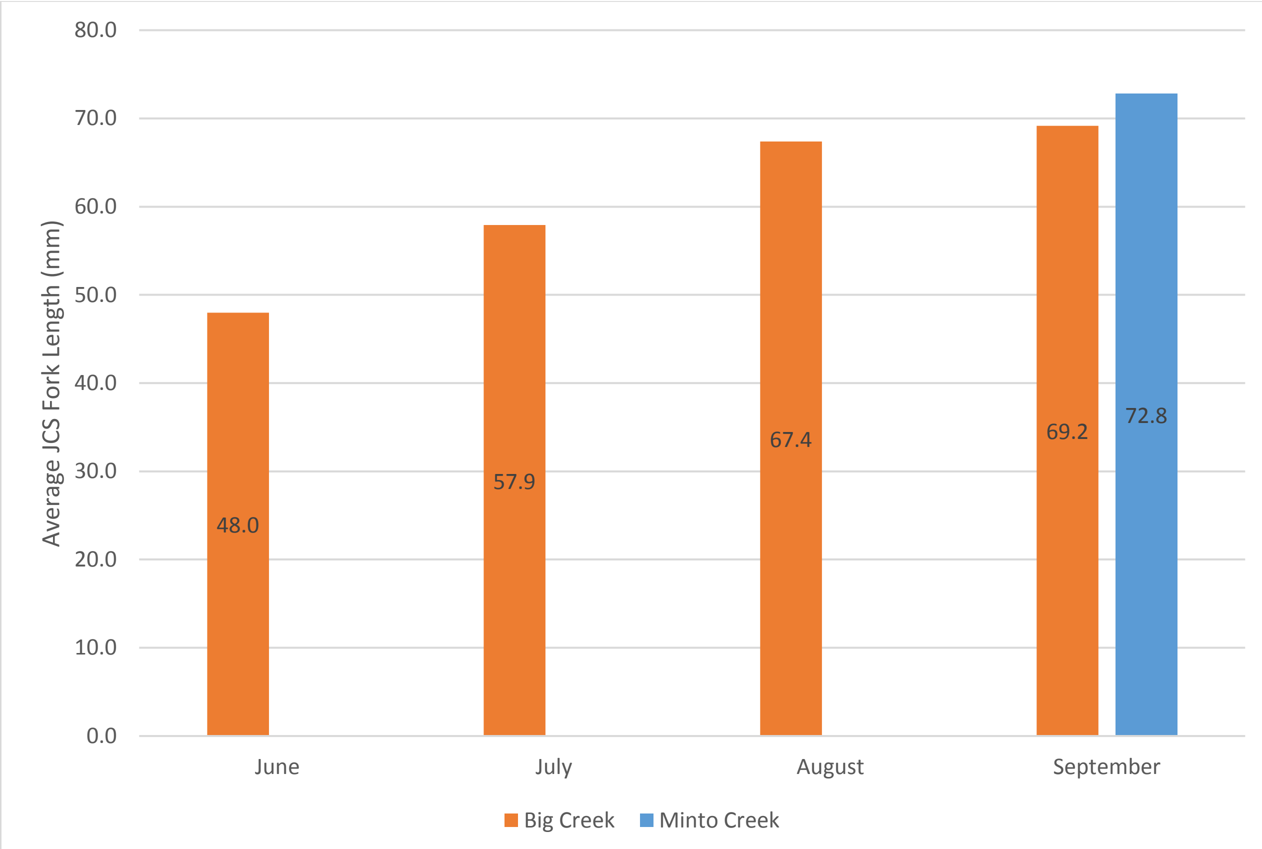


5.2 Fish Metrics

Fork lengths of JCS captured in Minto Creek ranged from 62 to 87 mm and their weights ranged from 3.03 to 7.20 g, while in Big Creek, JCS fork lengths ranged from 48 to 81 mm and their weights ranged from 1.10 to 6.37 g. There was a notable difference between the JCS lengths and widths during each sampling event. The JCS observed in June were smaller than the JCS captured in September. The lengths and weights observed throughout the season were consistent with 0+ aged fish (young of year).

Figure 5 presents the monthly averages for both creeks. Individual results for all fish captured are presented in Appendix B.

Figure 5: Average JCS length (fork) in Minto Creek and Big Creek, 2016



5.3 Water Quality Parameters

In situ data was collected in Minto Creek at station W2, and Big Creek (bridge) during each site visit and results are summarized in Table 7. In situ data was also collected at the Yukon River (W4) during the June and August sampling events. In situ parameters were collected with a YSI Professional Plus multimeter, which was calibrated prior to each trip.

Table 7: In situ data from Minto Creek, Big Creek, and Yukon River, 2016

Site	Date	Time	Temperature (˚C)	Dissolved Oxygen (%)	Dissolved Oxygen (m/L)	Specific Conductance (µS/cm)	pH
Minto Creek	9-Jun-16	16:16	6.4	97.5	11.99	305.8	7.96
	7-Jul-16	14:20	8.2	93	10.95	354.6	7.95
	2-Aug-16	10:55	7.7	97.7	11.69	356.8	7.94
	20-Sept-16	15:25	4.4	95.4	12.35	309.1	8.15
Big Creek	9-Jun-16	16:33	13.4	101.4	10.51	185.5	8.13
	7-Jul-16	14:10	12.6	97.5	10.36	187.8	8.33
	2-Aug-16	9:25	10.3	93	10.4	184.2	7.96
	23-Sep-16	14:45	3.9	107.0	14.08	214.9	7.60
Yukon River	9-Jun-16	16:57	13.1	98.5	10.34	164.5	8.04
	2-Aug-16	10:10	15	92.5	9.33	159.7	7.92

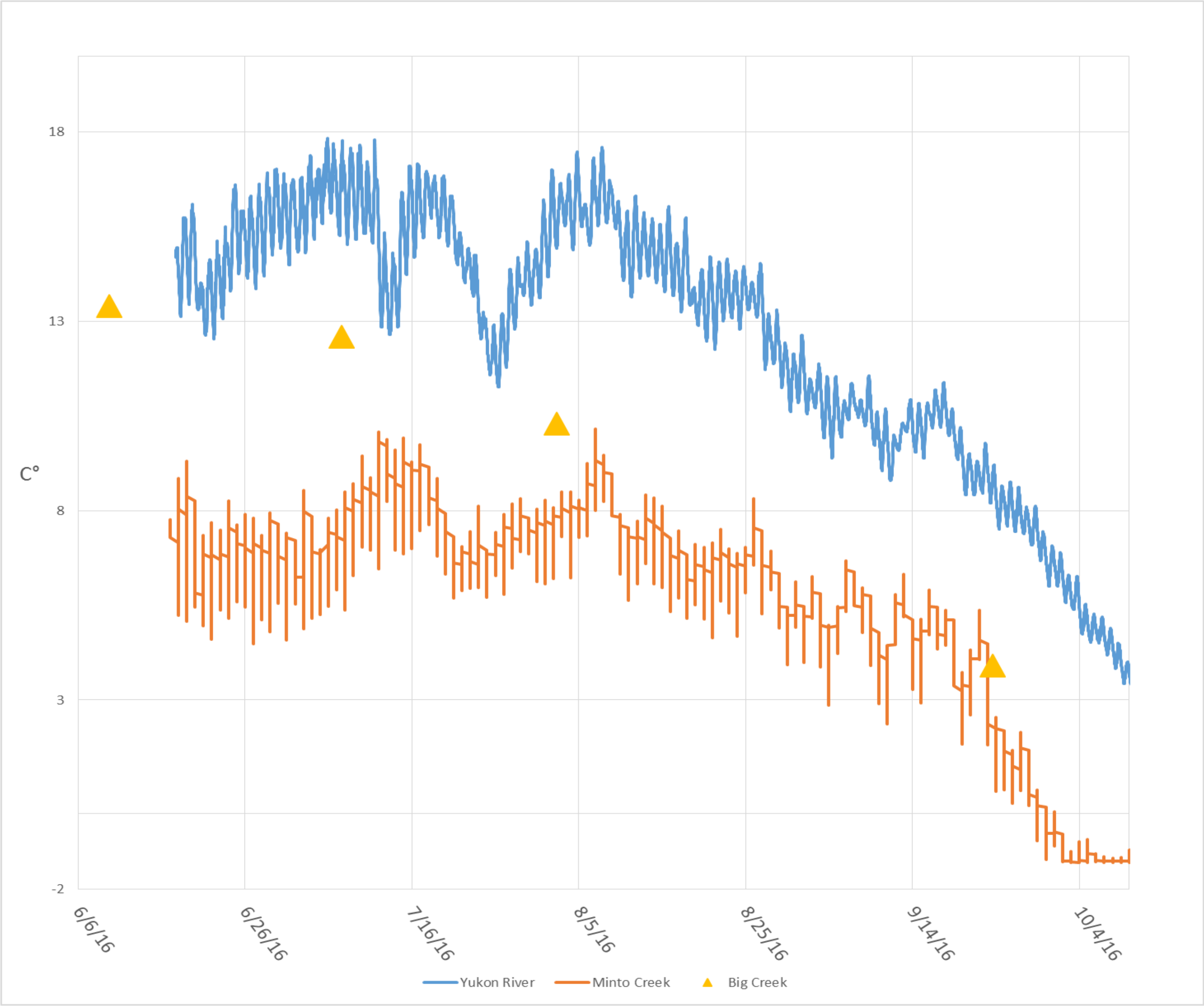
TidbiT water temperature loggers were deployed in the Yukon River at station W4 (between the barge landing and the mouth of Minto Creek) and in Big Creek (near the bridge) during the open water season, while a continuous logger located at W1 records the water temperature and stage of lower Minto Creek.

Due to ice formation in early October 2016, the Tidbit logger at Big Creek was unable to be retrieved. The water temperature data for Big Creek was collected with a YSI Professional Plus multimeter during each of the sampling events.

Figure 6 presents the two temperature curves. This figure indicates that the temperatures of Minto Creek is generally colder than that of the Yukon River. The average difference in water temperature over this period between the Yukon River and Big Creek was 3.5°C, while the difference between Big Creek and Minto Creek was 4.8°C.

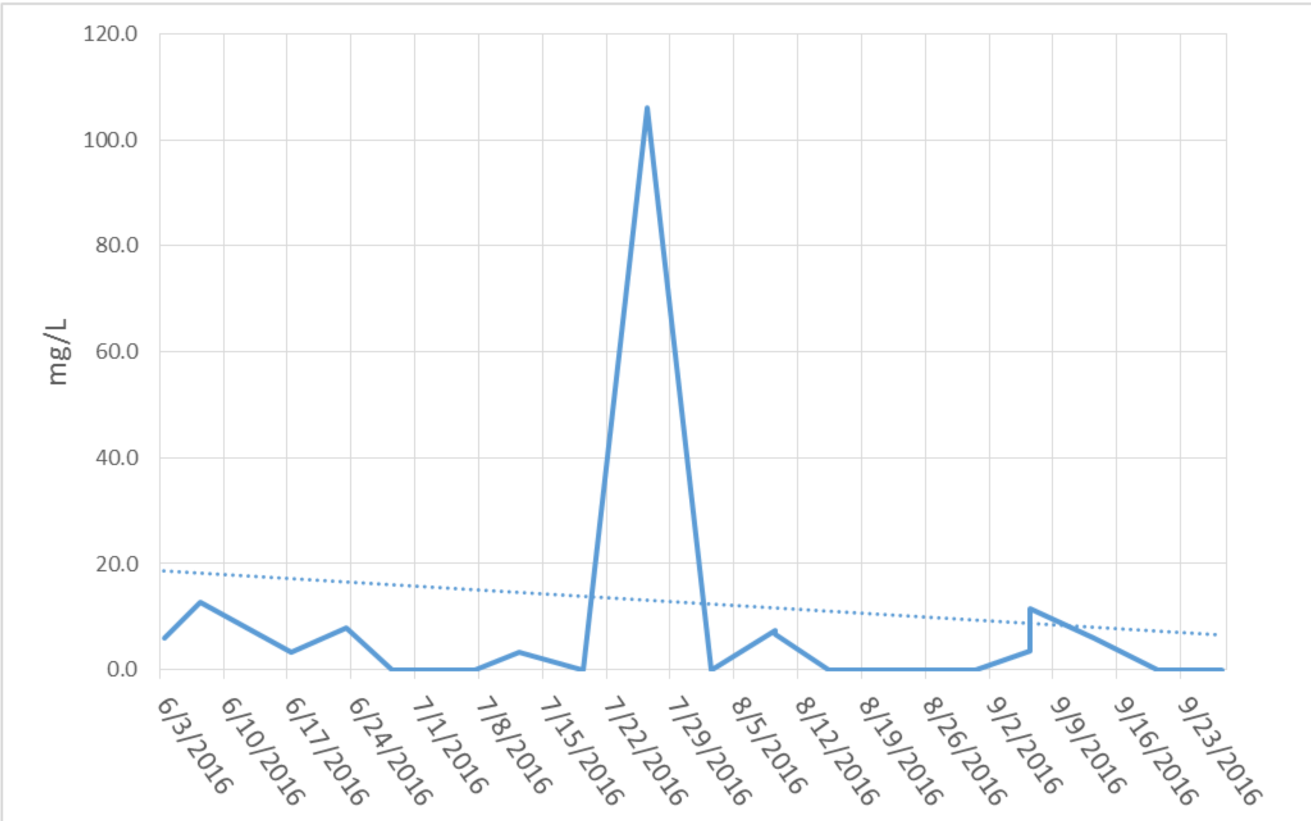
The 2016 data record does not indicate that the water temperature of Minto Creek equilibrated with that of the Yukon River during the 2016 open water season, although this has occasionally been observed to happen for a short period in June in the past. In 2013 for example, the maximum water temperature observed in Minto Creek was 15.7°C in late June, at which time the temperature of the Yukon River was very similar. In 2014 and 2015 however, the water temperature in Minto Creek did not exceed 10.6°C and 9.7°C respectively, and did not reach equilibrium with the Yukon River. In 2016 the maximum water temperature observed in Minto Creek was 10.2°C.

Figure 6: Water Temperature, Minto Creek and Yukon River, 2016



Turbidity in Minto Creek was noted to be higher in July due to a significant rain event. Figure 7 presents Total Suspended Solids (TSS) values measured at W2 from June 3rd to September 23rd, 2016; the dotted line indicates the trend. W2 TSS records for the open water season from 2011 to 2016 are presented in Appendix C for comparison.

Figure 7: Total Suspended Solids (mg/L) measured at W2 in 2016



5.4 Stage and Discharge

The staff gauge located at W1 in Minto Creek was read during each trip, and discharge was measured at W1 with a Marsh McBirney Flo-Mate electromagnetic flow meter or a with a Hach FH950 electromagnetic flow meter. A continuously logging water level recorder is also located at W1.

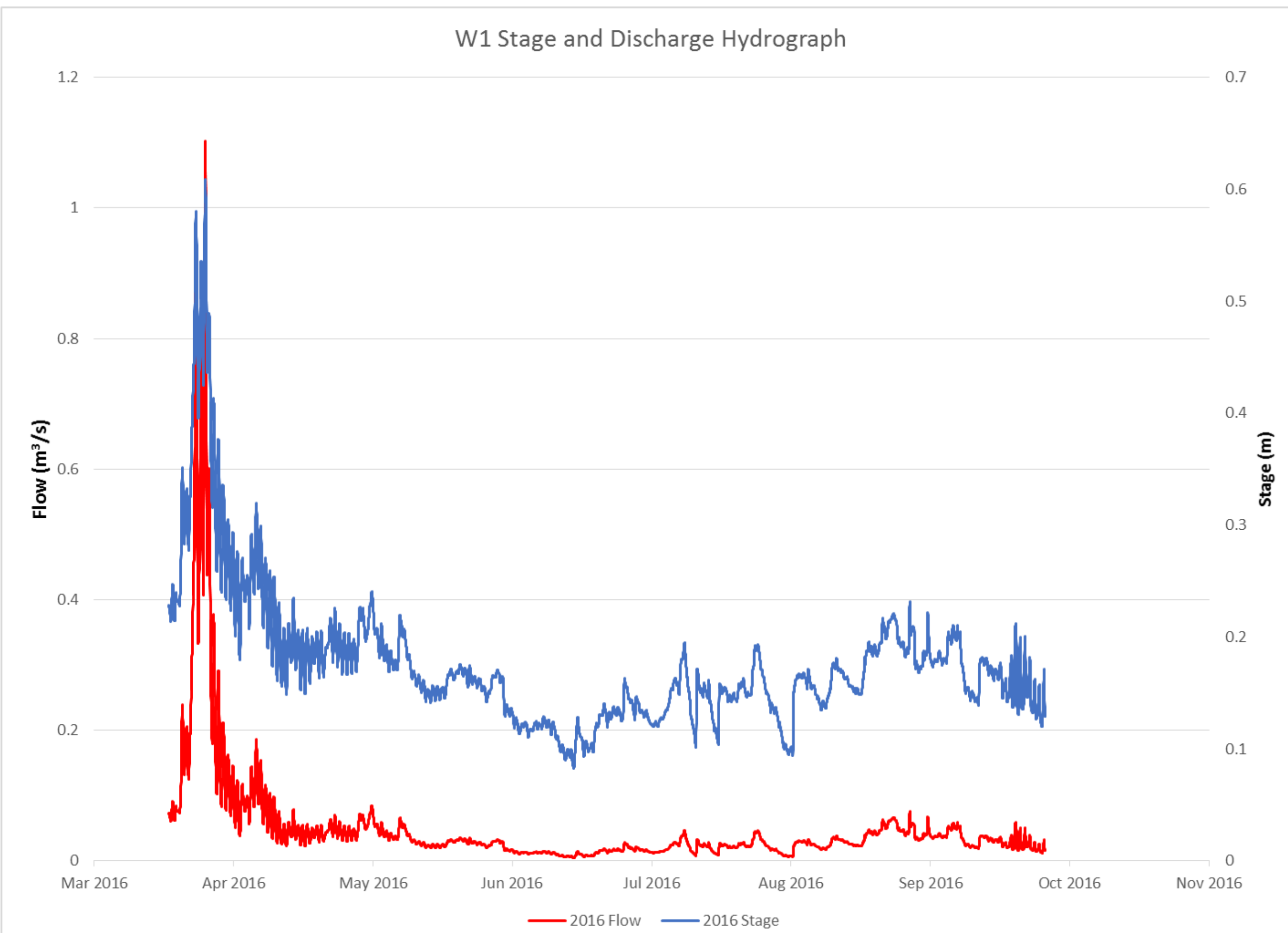
Water levels and discharge for Minto Creek and Big Creek are presented in Table 8 below, for dates when fisheries surveys occurred. Big Creek values were obtained through the Water Survey of Canada on-line database (Water Survey Canada, 2016) and are subject to change as they have not yet been validated by Water Survey Canada.

Table 8: Stage and Discharge in Minto Creek and Big Creek, 2016

Date	Time (PDT)	Minto Creek		Big Creek	
		Stage (m)	Discharge (m^3/s)	Stage (m)	Discharge (m^3/s)
6/7/2016	11:35	0.170	0.047	6.15	6.847
6/9/2016	16:00	0.168	0.026	6.206	9.016
7/7/2016	15:55	0.128	0.007	6.309	13.736
8/2/2016	10:40	0.149	0.020	6.312	13.888
8/5/2016	17:15	0.142	0.020	6.294	12.99
9/23/2016	11:05	0.183	0.056	6.23	10.031

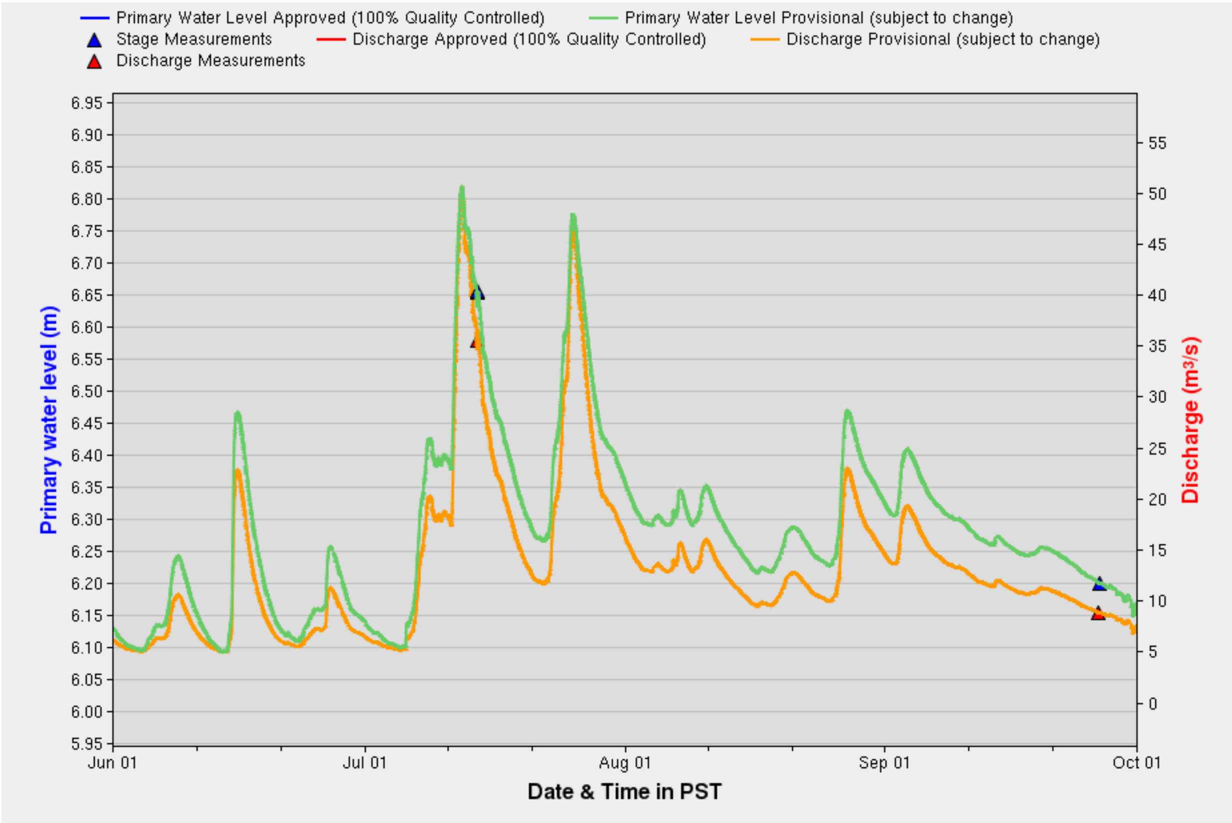
Figure 8 displays the continuous record available from April to early October in Minto Creek.

Figure 8 Stage and discharge in Minto Creek at monitoring station W1, 2016



The Big Creek hydrometric station (Water Survey of Canada station ID # 09AH003) is located downstream of the Minto access road bridge, near its confluence with the Yukon River, at the following coordinates: 62° 34' 07'' N; 137° 00' 58'' W. It records continuous water level and discharge. Figure 9 presents data from June to October 2016.

Figure 9: Water Level Discharge in Big Creek 2016 (Source: Water Survey of Canada, 2016)



5.5 Fish Barrier

The fish barrier located approximately 1.2 km upstream of the Yukon River (MCF-B1 on Figure 3), which was documented in previous years, was re-confirmed in 2016. Fish use upstream of the barrier, which consists of a log jam (Figure 10), was assessed by setting traps upstream of it during each sampling event. No fish were captured upstream of the barrier during 2016.

Figure 10: Fish Barrier and Minnow Trap at MCF-B1 (June 2016)

6 Discussion

A section of lower Minto Creek (downstream of MCF-14) was dry during the July 2016 sampling event, preventing fish movement up the system. The period of time during which this section of the creek was going dry is unknown, however this could have occurred on other occasions throughout the summer.

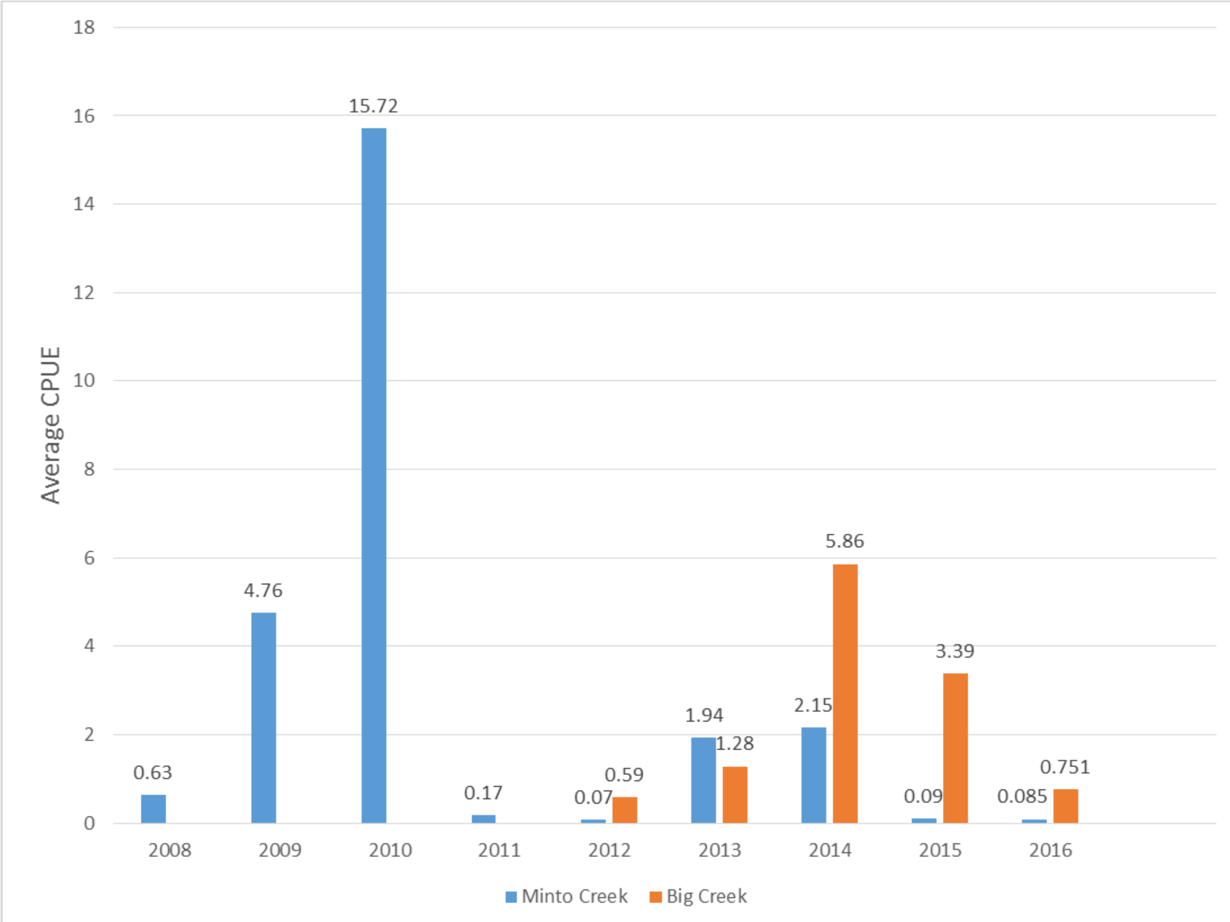
In 2016, no JCS were captured in Minto Creek during June, July, and August sampling events and only 6 JCS were captured in September's event. This may be related in part to the higher water temperatures observed in Big Creek and the lower temperatures observed in Minto Creek during this season. More generally this supports previous findings that JCS do not tend to enter Minto Creek (or Big Creek) until the water temperature has equilibrated with that of the Yukon River or reached a minimum threshold temperature, which was not observed in 2016.

The highest JCS catch per unit effort (CPUE) was observed in July in Big Creek. Figure 11 shows the CPUE trends since 2008 for JCS (Minnow trapping only) in Minto Creek and since 2012 in Big Creek. The average CPUE in Minto Creek has shown some variability since 2008 but has generally been relatively low. One exception is the year 2010 where the average CPUE in Minto Creek was 15.7 JCS/trap-day and some trapping events returned over 400 JCS. Those high numbers are thought to be associated with mine water discharge occurring throughout the open water season in Minto Creek that year (ACG, 2010), the more consistent temperature and flow regimes possibly acting as attractants to fish.

The average CPUE for JCS in Minto Creek in 2016 was the lowest since 2008. This could be explained by a section of the lower creek going dry in July, preventing fish movement up or down the creek, combined with a relatively low temperature profile in 2016. In some years, water temperature of Minto Creek and Yukon River reach equilibrium for a short period in June, however this did not happen in 2014, 2015, or 2016. In 2016, Minto Creek's maximum water temperature stayed below 10°C, whereas the Yukon River minimum temperature largely stayed above 10°C throughout the summer. The colder temperature profile of Minto Creek in 2016 may have deterred the movement of JCS into the system.

In Big Creek, the average CPUE for 2016 was the second lowest recording since 2012. The CPUE was generally higher in Big Creek than in Minto Creek, except in 2013 where it was the opposite. A higher CPUE in Big Creek than in Minto Creek could be explained by the fact that Big Creek is a larger system, with a higher water temperature, generally providing better rearing conditions for JCS. The CPUE has also been noted as following the same trend within both Minto Creek and Big Creek since 2008.

Figure 11: JCS Average CPUE, Minnow Trapping, in Minto Creek (2008-2016), and Big Creek (2012-2016)



In 2009 and 2010, the mine was discharging water throughout the open water season into Minto Creek, causing higher and more consistent flow and temperature regimes in lower Minto Creek, conditions which may have been more attractive to JCS. Mine water discharge only occurred during spring freshet from 2012 to 2015 and no discharge occurred in 2011. In 2016 the permitted discharge rate (Q_{EFF}), as per the WUL QZ14-031, was calculated as follows:

a) Initial discharge rate: 1/3 $(Q_{MC}+Q_{RO}) \geq Q_{EFF\text{-}c}$
b) Rate after discharge has commenced: 1/3 $(Q_{MC}+Q_{RO} - Q_{EFF\text{-}M}) \geq Q_{EFF\text{-}c}$

Where:

Q_{MC} = daily flow rate in Lower Minto Creek (represented by either W1 or MC1),
Q_{RO} = daily flow rate of discharged from the RO
$Q_{EFF\text{-}M}$ = measured daily rate of discharge from mine site
$Q_{EFF\text{-}C}$ = calculated rate of water discharge from mine site

In 2016 Minto mine was discharging throughout the open water season. However, this year's discharge was at much lower rates than in 2009 and 2010 because of the new discharge formula.

Following a forest fire in 2010, more sediment entered Minto Creek through runoff in 2011 and 2012, thereby increasing turbidity. A small landslide was also documented by Minto personnel in an upstream tributary in May 2012, likely contributing to high TSS levels observed downstream. The elevated turbidity may have deterred fish from entering Minto Creek. Average TSS values at W2 in 2016 were the lowest since 2011, with the highest being observed in 2012 (see Appendix C for details). Turbidity and TSS did not likely influence fish presence or absence in Minto Creek in 2016 as values remained low throughout the season.

The natural fish barrier identified in Minto Creek in previous years was again confirmed in 2016. Therefore, the area of usable fish habitat in Minto Creek is limited to the lower 1.2 km of the creek.

Aerial surveys for spawning fish were carried out in the vicinity of the Minto Creek/Yukon River confluence from 2010 to 2014 and no spawning activity was ever observed or suspected. Bottom substrate in the confluence area consists primarily of silt and mud which is not suitable substrate for salmon spawning.

7 References

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http://wateroffice.ec.gc.ca/report/report_e.html?type=realTime&stn=09AH003

Appendix A

2016 Photo Log

Photo 1: Big Creek looking downstream (June)

Photo 2: Minto Creek downstream of W2 (June)

Photo 3: JCS captured in Big Creek (June)

Photo 4: Slimy Sculpin captured in Big Creek (June)

Photo 5: Big Creek Bridge (July)

Photo 6: High flow after rain event at Big Creek (July)
Red circle indicates location of minnow baited gee trap

Photo 7: JCS killed upon retrieval at Big Creek (July)

Photo 8: Slimy Sculpin captured in Big Creek (July)

Photo 9: Site MCF-12 dry (July)

Photo 10: Site MCF-13 dry (July)

Photo 11: Trap set at site MCF-19 (July)

Photo 12: Mouse discovered in Minto Creek Trap (July)

Photo 13: JCS captured in Big Creek (August)

Photo 14: JCS caught in Big Creek (August)

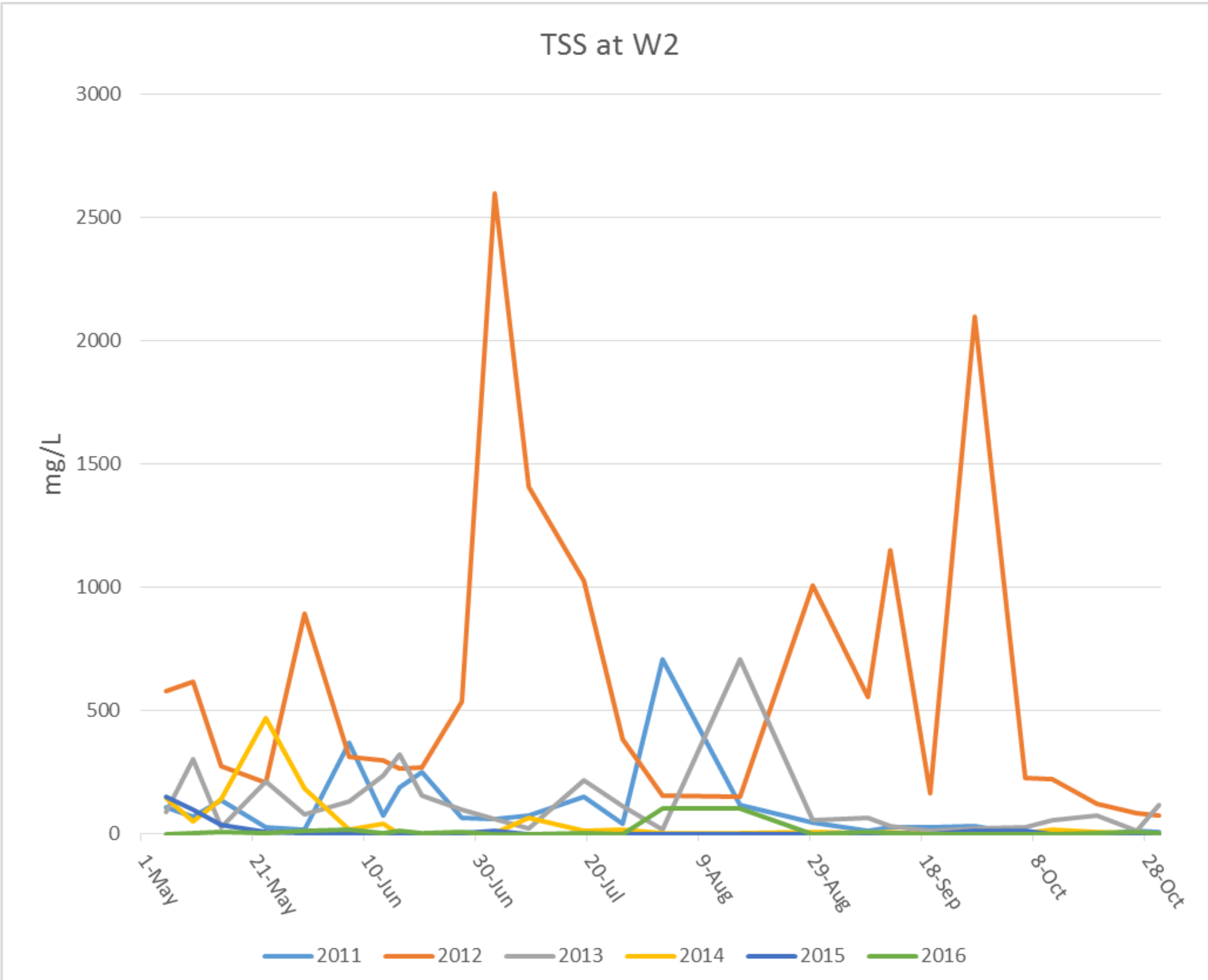
Photo 15: Big Creek upstream (September)

Photo 16: Big Creek downstream (September)

Appendix B

Fish Data, Minto Creek and Big Creek, 2016

Appendix C
TSS Results at W2, 2011-2016



Appendix N – Report on the Copper Toxicity for a Clear Flow Stream

March 29, 2017

Mr. Ryan Herbert
Environmental Manager
Capstone Mining Corporation - Minto Mine
13 - 151 Industrial Road
Whitehorse, Yukon, Y1A 2V3

Dear Mr. Herbert,

Re: Update on Minto Mine Water Use Licence QZ14-031 Clause 105 - Toxicity Testing to Verify the Water Quality Objective for Copper in Minto Creek

This letter provides an update on toxicity testing to verify the Minto Mine's water quality objective (WQO) for copper in lower Minto Creek, as required under Clause 105 of the Minto Mine's Water Use Licence (WUL QZ14-031). As required, clear flow testing was completed in late September 2015. However, due to an absence of appropriate conditions to support turbid water testing in 2016, the latter condition has not yet been evaluated. This letter provides background, outlines why testing was not completed in 2016, and outlines the Mine's intent and plan for testing in 2017.

Background

In August 2015, the Yukon Water Board (YWB) issued an amended WUL (QZ14-031) to the Minto Mine that indicated a WQO of 20 µg/L dissolved copper applicable when dissolved organic carbon (DOC) concentrations exceed 10 mg/L and 13 µg/L dissolved copper applicable when DOC concentrations are 10 mg/L or lower[1] (YWB 2015). The amended WUL included a clause (Clause 105) stipulating that "the licensee shall complete the study generally described in the document entitled Study Plan for Evaluating the Toxicity of Copper to Selected Aquatic Organisms in Minto Creek Water Version 3 and shall submit the results to the Board by March 31, 2017 for Review and Approval." The Study Plan was designed by MacDonald Environmental Sciences Limited (MESL) and reviewed by Minnow Environmental Inc. (Minnow) prior to a YWB public hearing in March 2015 (MESL 2015).

Briefly, the Study Plan (Appendix A) was designed to determine if the WQO is protective of sensitive organisms and endpoints (survival, growth and reproduction) under a range of water

[1] WQOs are applicable at Station W2 in lower Minto Creek when water is flowing at the mine site (at Stations W15 and W35) and are applicable to water leaving the site at Station W16 when there is no flow at Stations W15 and W35 (see Figure 1 for station locations). The former condition is the focus of this document, as WQOs are intended to be protective of lower Minto Creek.

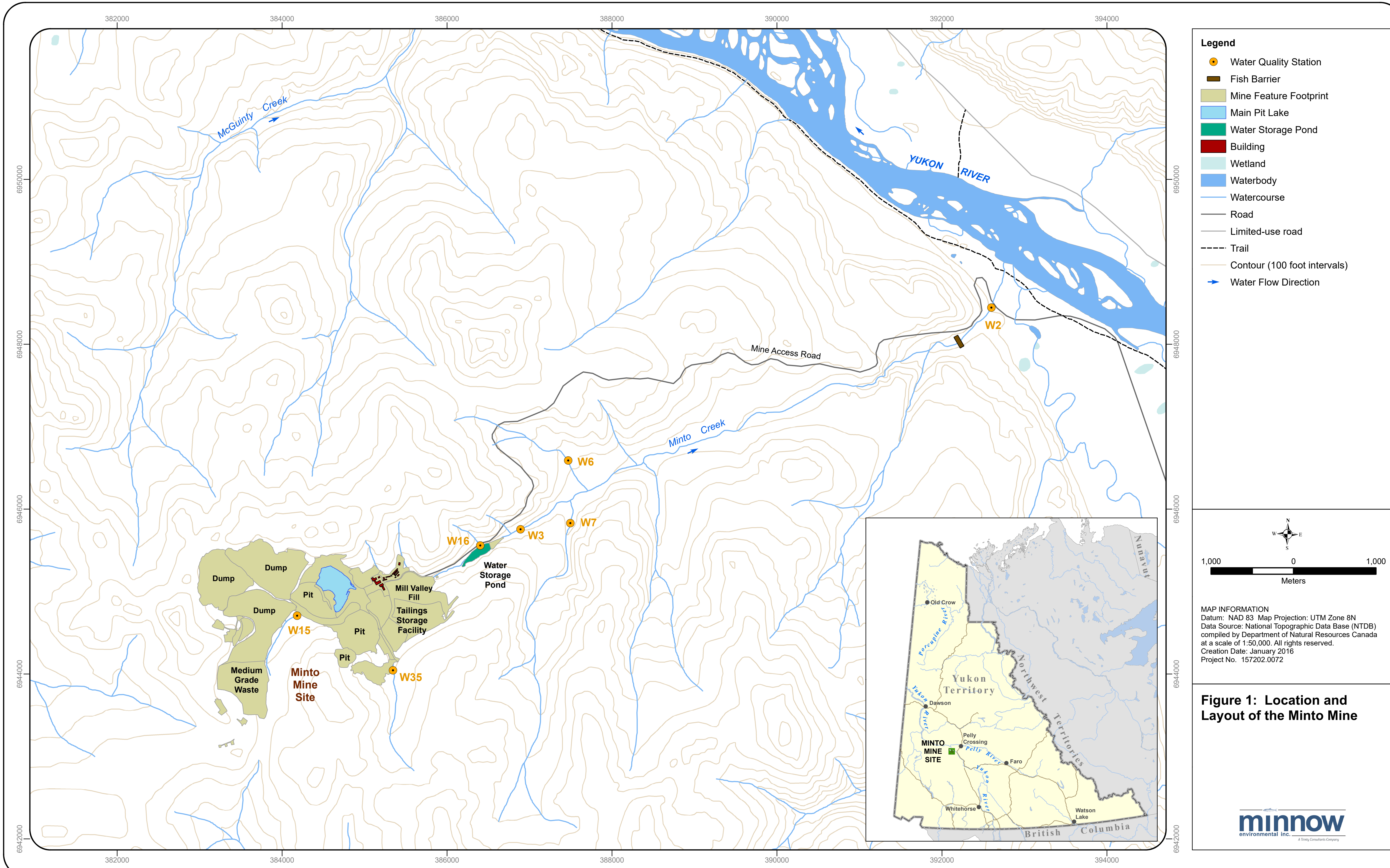


Figure 1: Location and Layout of the Minto Mine

quality conditions. The Study Plan included laboratory testing with site water collected during both clear and turbid flow conditions. Clear flow was defined as flowing water with less than 25 mg/L total suspended solids (TSS) and turbid flow was defined as flowing water with greater than 25 mg/L TSS.

Minto's WQO for copper was based on a number of evaluations that identified high background copper concentrations, as well as site-specific water quality conditions known and demonstrated to limit the bioavailability and toxicity of copper, the dominant of which is the relatively high concentration of DOC in Minto Creek (approximately 12 mg/L, on average). Briefly, Minto's proposed WQO for copper was based on a combination of background concentration characterization (e.g., Minnow 2009), toxicity testing in site water (e.g., Minnow 2009), application of scientific literature-based quantitative relationships between copper toxicity and DOC, biotic ligand modelling (e.g., Minnow 2009, 2013, 2014) and testing of potential effects to fish olfaction (Kennedy et al. 2012).

Clear Flow Findings

Four long-term (i.e., chronic) static-renewal toxicity tests were completed in accordance with standard protocols for clear flow conditions (Minnow 2016). These tests included a 48-h toxicity test with the rotifer *Brachionus calyciflorus* (intrinsic rate of population increase); a 21-d toxicity test with the cladoceran *Daphnia magna* (survival and reproduction); a 32-d toxicity test with the fathead minnow *Pimephales promelas* (hatching success, total post-hatch survival, overall survival, and dry weight); and a 42-d toxicity test with the amphipod *Hyalella azteca* (survival, growth, and reproduction; MESL 2015; Appendix A).

As reported in the clear flow water toxicity testing report only two endpoints (*D. magna* survival and *H. azteca* reproduction) had 20th percentile effect concentrations lower than 20 µg/L (Minnow 2016). However, the 20 µg/L exposure results for both of these test endpoints did not differ significantly from the control (Minnow 2016). As set out in the Study Plan, "if one or more of the 20th percentile effect concentrations is less than or equal to the proposed WQO and the WQO test concentration of 20 µg/L differs significantly from the control, the WQO would be revised downward to establish a level that is protective of aquatic organisms in site water" (Appendix A). Based on this evaluation criterion and the results of the toxicity testing under clear flow conditions, no downward revision of the WQO (from 20 µg/L) is warranted as there were no endpoints with 20th percentile effect concentrations lower than 20 µg/L and for which the 20 µg/L exposure resulted in a statistically significant reduction relative to the control (Minnow 2016).

Turbid Flow Attempts in 2016

Identification of appropriate timing for collection of test waters for turbid flow evaluation was based on a decision path developed as implementation guidance (Figure 2; Minnow 2015). Turbidity greater than approximately 15 NTU was determined to represent turbid flow (Figure 2). The Minto Mine sampled total suspended solids and conducted visual observations weekly throughout the spring and summer of 2016 with a view to identifying if/when turbidity conditions at lower Minto Creek were suitable for turbid flow sampling. If high total suspended solids or turbid flows were observed, turbidity samples were collected for verification. Due to cool spring temperatures and low snow pack in 2016, the spring freshet produced limited runoff (i.e., runoff was insufficient to sustain the required turbidity levels). Thus, during the 2016 spring freshet, turbid flow conditions were not sufficiently sustained at lower Minto Creek to allow Minto Mine to collect the large water sample required for turbid flow toxicity testing. Minto Mine continued to monitor turbidity throughout 2016 in an effort to identify potentially appropriate sustained turbid flow conditions (e.g., in association with extended rainfall events). One heavy rainfall event in late July resulted in appropriate turbidity levels (on July 25th and 26th). However, by the time Minto Mine could deploy the sampling equipment required to collect the samples for toxicity testing, turbidity had decreased to below 15 NTU. No additional periods of turbid flow conditions developed in 2016, and therefore sampling of turbid flow conditions for toxicity testing was not completed in 2016.

Turbid Flow Plan for 2017

Turbid flow evaluation will be attempted again in 2017 using the same decision path (i.e., Figure 2). Collection of site water will be completed in the same manner as for the clear flow samples and will be shipped to the same toxicity test laboratory for completion of toxicity testing using the same tests and endpoints (Minnow 2016). Results from turbid flow testing will be reported in a letter report, which will include comparison to the clear flow testing and provide the overall conclusions derived from the results of the two test periods.

Sincerely,
Minnow Environmental Inc.

Pierre Stecko, M.Sc., EP, RPBio
Senior Aquatic Scientist

Lisa Bowron, M.Sc.
Aquatic Toxicologist

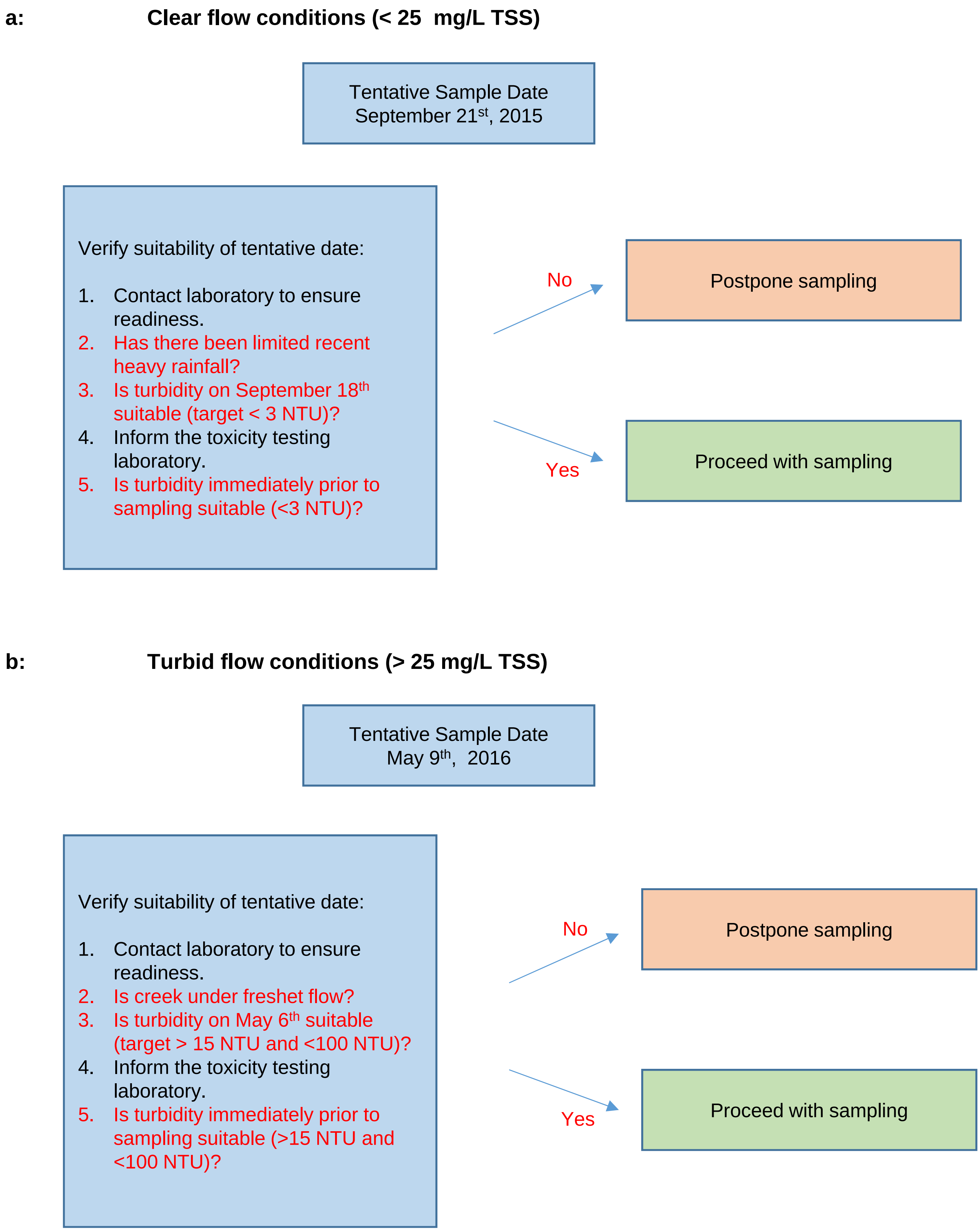


Figure 2: Decision Path for when to sample under a) clear flow (< 25 mg/L Total Suspended Solids [TSS]); and b) turbid flow (> 25 mg/L TSS)

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May 13, 2016

Mr. Ryan Herbert
Environmental Manager
Capstone Mining Corporation - Minto Mine
13 - 151 Industrial Road
Whitehorse, Yukon, Y1A 2V3

Dear Mr. Herbert,

Re: Clear Flow Water Toxicity Testing to Verify the Minto Mine Water Quality Objective for Copper in Minto Creek

This brief letter report provides the results of toxicity testing undertaken to verify the Minto Mine's water quality objective (WQO) for copper in lower Minto Creek. The testing was completed as required under the Minto Mine's Water Use Licence (WUL) under clear flow conditions in late September 2015 and will be repeated in 2016 under turbid flow conditions to verify the WQO at the extremes that occur in Minto Creek.

Background

In August 2015, the Yukon Water Board (YWB) issued an amended WUL (QZ14-031) to the Minto Mine that indicated a WQO of 20 µg/L dissolved copper applicable when dissolved organic carbon (DOC) concentrations exceed 10 mg/L and 13 µg/L dissolved copper applicable when DOC concentrations are 10 mg/L or lower[1] (YWB 2015). The amended WUL included a clause (Clause 105) stipulating that "the licensee shall complete the study generally described in the document entitled Study Plan for Evaluating the Toxicity of Copper to Selected Aquatic Organisms in Minto Creek Water Version 3 and shall submit the results to the Board by March 31, 2017 for Review and Approval." The Study Plan was designed by MacDonald Environmental Sciences Limited (MESL) and reviewed by Minnow Environmental Inc. (Minnow) prior to a YWB public hearing in March 2015 (MESL 2015).

Briefly, the Study Plan (Appendix A) was designed to determine if the WQO is protective of sensitive organisms and endpoints (survival, growth and reproduction) under a range of water quality conditions. The Study Plan includes laboratory testing with site water collected during both clear and turbid flow conditions. Clear flow is defined as flowing water with less than 25

[1] WQOs are applicable at Station W2 in lower Minto Creek when water is flowing at the mine site (at Stations W15 and W35) and are applicable to water leaving the site at Station W16 when there is no flow at Stations W15 and W35 (see Figure 1 for station locations). The former condition is the focus of this document, as WQOs are intended to be protective of lower Minto Creek.

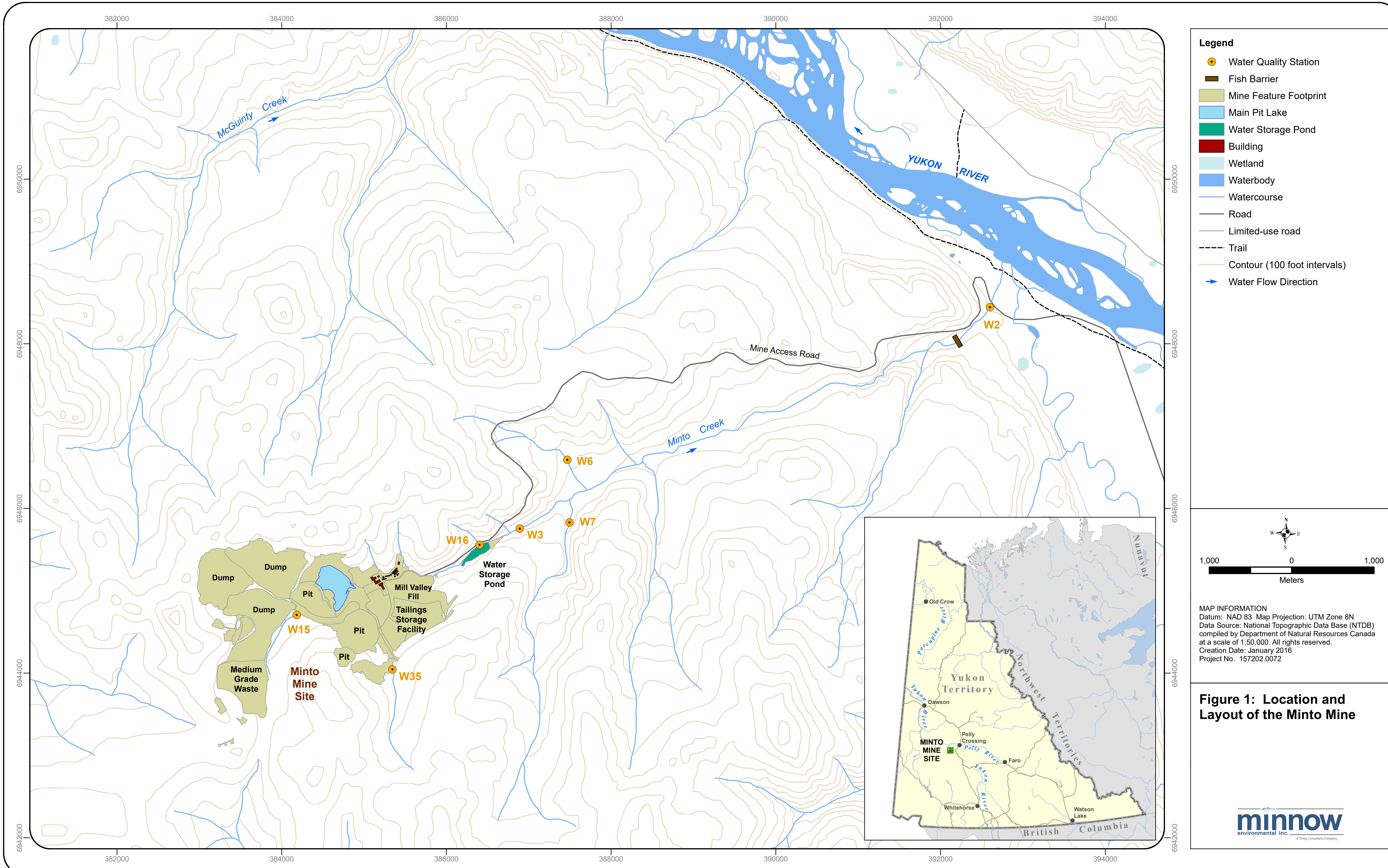

Figure 1: Location and Layout of the Minto Mine

mg/L total suspended solids (TSS) and turbid flow is defined as flowing water with greater than 25 mg/L TSS.

Minto's WQO for copper was based on a number of evaluations that identified high background copper concentrations, as well as site-specific water quality conditions known and demonstrated to limit the bioavailability and toxicity of copper, the dominant of which is the relatively high concentration of DOC in Minto Creek (approximately 12 mg/L, on average). Briefly, Minto's proposed WQO for copper was based on a combination of background concentration characterization (e.g., Minnow 2009), toxicity testing in site water (e.g., Minnow 2009), application of scientific literature-based quantitative relationships between copper toxicity and DOC, biotic ligand modelling (e.g., Minnow 2009, 2013, 2014) and testing of potential effects to fish olfaction (Kennedy et al. 2012). The WQO was supported through the Yukon Environmental and Socio-economic Assessment Board assessment, when independent evaluation suggested that 40 µg/L could be used as the WQO for copper in lower Minto Creek (Ecometrix 2014).

Methods

Site water from lower Minto Creek (W2) and the water storage pond (WSP; W16; Figure 1) was collected on September 28th, 2015 for clear flow testing. The timing of collection was based on a decision path developed for Study Plan implementation (Figure 2; Minnow 2015). Collected water arrived at the Nautilus Environmental (Nautilus) toxicity testing laboratory (Calgary, AB) on October 2nd, 2015. At the laboratory, site water from W2 and W16 were mixed at a 3:1 ratio of W2:W16. This ratio was used as it mimics the ratio expected at maximum effluent discharge. Four long-term (i.e., chronic) static-renewal toxicity tests were completed in accordance with standard protocols (described in Appendix B – Nautilus 2015) and included a 48-h toxicity test with the rotifer *Brachionus calyciflorus* with the test endpoint of intrinsic rate of population increase; a 21-d toxicity test with the cladoceran *Daphnia magna* with test endpoints of survival and reproduction; a 32-d toxicity test with the fathead minnow *Pimephales promelas* with test endpoints of hatching success, total post-hatch survival, overall survival, and dry weight; and a 42-d toxicity test with the amphipod *Hyalella azteca* with test endpoints of survival, growth, and reproduction (MESL 2015; Appendix B – Nautilus 2015).

The mixed site water was spiked with copper to achieve six nominal copper concentrations (5, 10, 20, 40, 80 and 160 µg/L; Appendix B - Nautilus 2015) which were evaluated in each test. An un-spiked site water control and a laboratory control were also evaluated in each test. Total and dissolved copper concentrations were measured in each of the test vessels on a weekly basis. In addition, major ions (calcium, magnesium, potassium, sodium, sulphate and chloride)

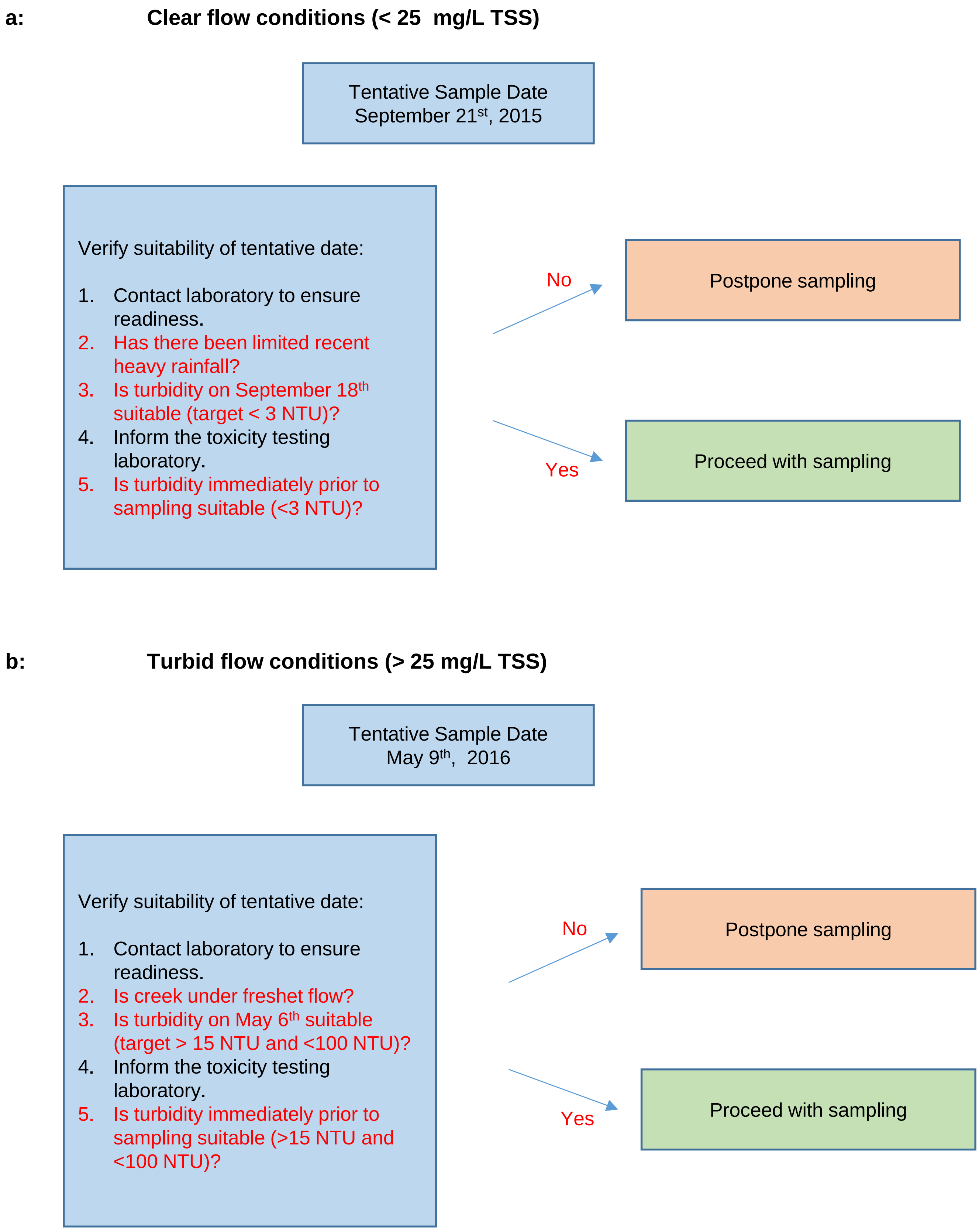

Figure 2: Decision Path for when to sample under a) clear flow (< 25 mg/L Total Suspended Solids [TSS]); and b) turbid flow (> 25 mg/L TSS)

and alkalinity were measured in the site and laboratory control waters, and DOC was measured in mixed site water (Appendix B – Nautilus 2015).

Lethal concentrations (LC) and/or inhibitory concentrations (IC) were determined for all endpoints in all four toxicity tests. All LC and IC values were calculated at the 10th percentile, 20th percentile and median (Appendix B – Nautilus 2015). In addition, survival, growth, and reproduction results at each exposure concentration were statistically contrasted with the results of the laboratory control to determine concentrations resulting in significant difference from control. The interpretation of all test endpoints for the evaluation of the suitability of the WQO is based on conditions defined a-priori (MESL 2015). Specifically, the WQO for copper will be considered to be protective if the reported 20th percentile effect concentrations (LC20 and IC20) are greater than 20 µg/L and the WQO test concentration of 20 µg/L does not differ significantly from the control ($p = 0.05$; Appendix A). Conversely, if one or more of the 20th percentile effect concentrations is less than or equal to the proposed WQO and the WQO test concentration of 20 µg/L differs significantly from the control ($p = 0.05$), the WQO would be revised downward to establish a level that is protective of aquatic organisms in site water (Appendix A). Further consideration was given to the results relative to the DOC-dependent WQO for copper specified in the Minto Mine WUL.

Results

Mean concentration of DOC in test waters (9.2 ± 0.5 mg/L) was slightly lower than 10 mg/L, and therefore the objective of 13 µg/L would apply under the current WUL. Nonetheless, as outlined above, this evaluation focusses on whether the WQO of 20 µg/L (currently applicable when DOC is greater than 10 mg/L) is protective.

Of a total of thirteen endpoints evaluated, only two endpoints (*D. magna* survival and *H. azteca* reproduction in the 42-day test) had 20th percentile effect concentrations lower than 20 µg/L (Table 1; Figure 3). The reported LC20 for *D. magna* was 18.3 µg/L dissolved copper (21.0 µg/L total copper; Table 1). However, the 20 µg/L exposure did not differ significantly from the control (Appendix B), and a no-observed effect concentration (NOEC) associated with a nominal exposure to 40 µg/L copper was identified as 37 µg/L dissolved copper (43 µg/L total copper; Table 1; Figure 3). These results indicate that the WQO of 20 µg/L is protective of the sensitive endpoint of *D. magna* survival (i.e., even copper concentrations of approximately 40 µg/L did not result in significant mortality relative to controls). It is also noted that the toxicity test report indicates that LC10 and LC20 estimates may not be appropriate estimates of effect levels (Appendix B – Nautilus 2015). The reported IC20 for *H. azteca* reproduction in 42-day tests was 17.6 µg/L dissolved copper (18.0 µg/L total copper; Table 1; Figure 3). As noted above for *D.*

Table 1: Results of Clear Flow Toxicity Testing of Dissolved and Total Copper (µg/L) [1]

Organism	Endpoint	Dissolved Copper (µg/L)						Total Copper (µg/L)					
		LC20	LC50	IC20	IC50	NOEC	LOEC	LC20	LC50	IC20	IC50	NOEC	LOEC
Brachionus calyciflorus - 48 hour	Population Growth Rate	-	-	45.1 (38.2 - 52.1)	62.1 (55.2 - 70.7)	32	65	-	-	63.4 (54.2 - 72.4)	85.2 (76.4 - 96.1)	46	89
Daphnia magna - 21 day	Survival	18.3 (16.1 - 71.9)	52.0 (38.2 - 70.7)	-	-	37	71	21.0 (18.4 - 58.2)	58.7 (43.4 - 79.2)	-	-	43	80
	Reproduction	-	-	53.5 (NC - 68.9)	66.7 (56.8 - 80.8)	71	136	-	-	71.0 (NC)	77.8 (NC)	80	149
Pimephales promelas - 32 day	Hatching Success	> 144	> 144	-	-	144	> 144	> 148	> 148	-	-	148	> 148
	Post-hatch Survival	> 139	> 139	-	-	139	> 139	> 155	> 155	-	-	155	> 155
	Overall Survival	> 139	> 139	-	-	139	> 139	> 155	> 155	-	-	155	> 155
	Length	-	-	> 139	> 139	139	> 139	-	-	> 155	> 155	155	> 155
	Biomass	-	-	> 139	> 139	139	> 139	-	-	> 155	> 155	155	> 155
Hyalella azteca - 28 day	Survival	86.1 (63.0 - 100)	120 (104 - 141)	-	-	72	138	95.5 (69.9 - 111)	133 (115 - 156)	-	-	80	153
	Biomass	-	-	49.0 (43.4 - 55.3)	74.4 (65.3 - 86.1)	38	72	-	-	53.8 (47.5 - 60.8)	82.1 (72.0 - 95.1)	42	80
Hyalella azteca - 42 day	Survival	77.8 (62.1 - 88.8)	114 (102 - 129)	-	-	38	74	87.4 (70.1 - 99.6)	127 (114 - 144)	-	-	44	83
	Biomass	-	-	44.2 (34.3 - 52.8)	77.2 (68.1 - 86.7)	38	74	-	-	50.4 (39.4 - 60.2)	86.9 (76.9 - 97.4)	44	83
	Reproduction	-	-	17.6 (NC - 30.9)	38.9 (23.5 - 64.3)	38	74	-	-	18.0 (NC - 31.7)	39.4 (23.2 - 66.8)	44	83

[1] Water sample collected on September 28th, 2015

Endpoint value is lower than 13 µg/L (the water quality objective [WQO] applicable at dissolved organic carbon [DOC]≤ 10 mg/L)

Endpoint value is lower than 20 µg/L (the water quality objective [WQO] applicable at dissolved organic carbon [DOC] > 10 mg/L)

NC = Not calculable

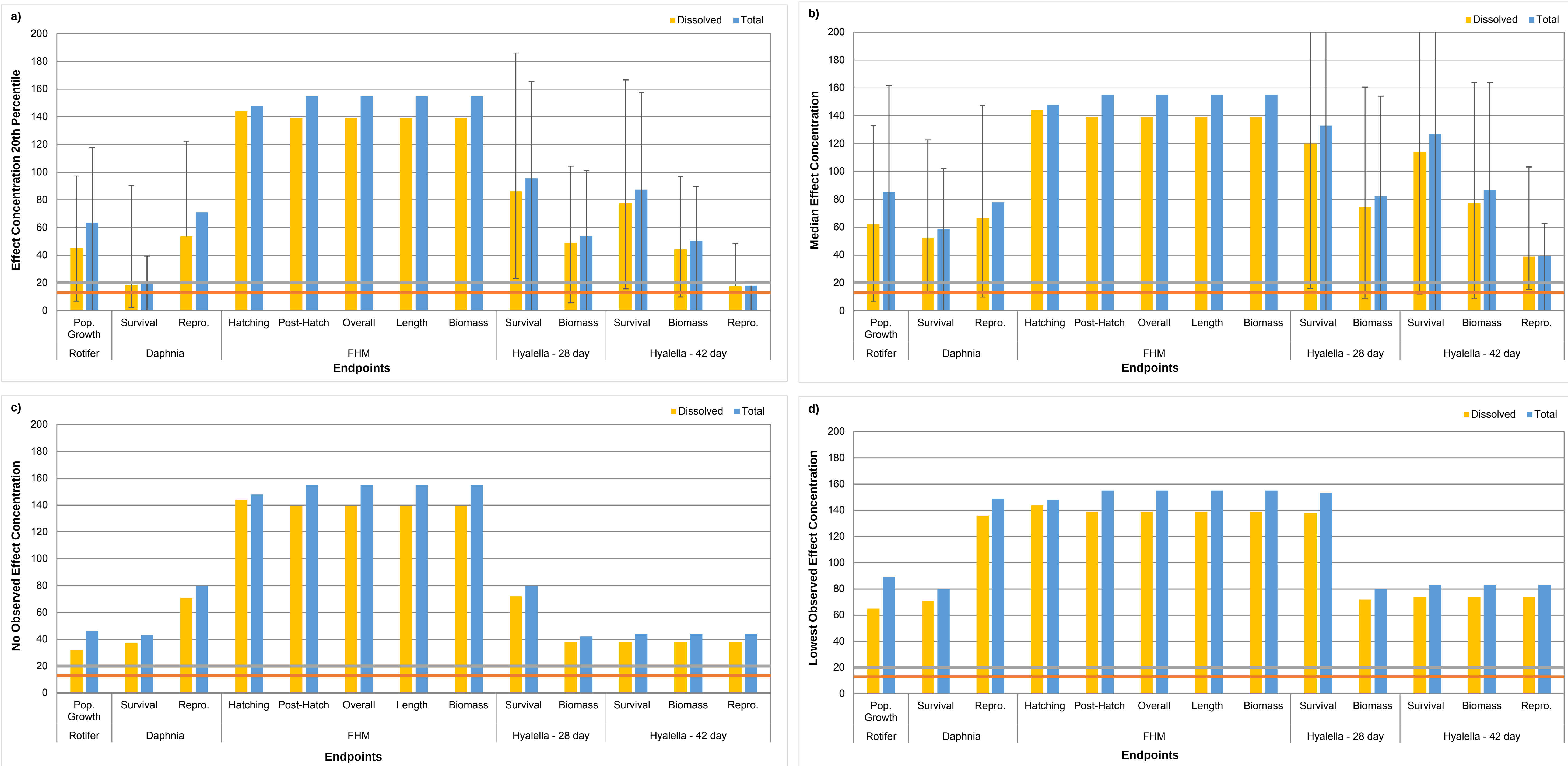

Figure 3: Results of testing of the toxicity of copper in Minto Creek water (dissolved and total): a) 20th percentile effect concentrations; b) median effect concentrations; c) No Observed Effect Concentrations; and d) Lowest Observed Effect Concentrations.

* NOTE: Pop. Growth = Population Growth; Repro. = Reproduction; Hatching = Hatching Success; Post-Hatch = Post-Hatch Survival; Overall = Overall Survival; Rotifer = *Brachionus calyciflorus*; Daphnia = *Daphnia magna*; FHM = *Pimephales promelas*; Hyalella = *Hyalella azteca*

Orange lines represent Water Quality Objective of 13 µg/L when dissolved organic carbon (DOC) ≤ 10 mg/L

Grey lines represent Water Quality Objective of 20 µg/L when dissolved organic carbon (DOC) > 10 mg/L *magna* survival, *H. azteca* reproduction in the 20 µg/L exposure did not differ significantly from the control (Appendix B). Furthermore, the NOEC was identified as 38 µg/L dissolved copper (44 µg/L total copper; Table 1; Figure 3). These results indicate that the WQO of 20 µg/L is protective of the sensitive endpoint of *H. azteca* reproduction (i.e., even copper concentrations of approximately 40 µg/L did not result in significant reproductive impairment relative to controls).

Eleven of the thirteen organism-endpoint combinations evaluated resulted in 20th percentile effect concentrations (LC20s or IC20s) greater than 20 µg/L as well as 20 µg/L copper treatment results that did not differ significantly from control (Table 1). Testing of *B. calyciflorus* resulted in an IC20 for "intrinsic rate of population increase" of 45.1 µg/L dissolved copper (63.4 µg/L total copper; Table 1). A nominal copper concentration of 40 µg/L (32 µg/L dissolved; 46 µg/L total) resulted in no effect and the next nominal test concentration of 80 µg/L (65 µg/L dissolved and 89 µg/L total) caused an effect (Table 1). Testing of *D. magna* resulted in a LC20 of 18.3 dissolved copper (21.0 µg/L total copper) and an IC20 for reproduction of 53.5 µg/L dissolved copper (71.0 µg/L total copper; Table 1). A nominal copper concentration of 80 µg/L (71 µg/L dissolved and 80 µg/L total) resulted in no effect and the next nominal test concentration of 160 µg/L (136 µg/L dissolved; 149 µg/L total) caused an effect (Table 1). *P. promelas* was the least copper sensitive species tested, with all five endpoints yielding LC20 or IC20 values greater than highest concentration tested (nominally 160 µg/L, but measured as either 139 µg/L or 144 µg/L dissolved copper and 148 µg/L or 155 µg/L total copper; Table 1). Testing of *H. azteca* over a 42-day period resulted in a LC20 for survival of 77.8 µg/L dissolved copper (87.4 µg/L total copper), an IC20 for growth of 44.2 µg/L dissolved copper (50.4 µg/L total copper), and an IC20 for reproduction of 17.6 µg/L dissolved copper (18.0 µg/L total copper; Table 1). As indicated previously, despite the IC20 for *H. azteca* reproduction being slightly lower than 20 µg/L, *H. azteca* reproduction at the WQO concentration did not differ significantly from the laboratory control. A nominal copper concentration of 40 µg/L (38 µg/L dissolved; 44 µg/L total) resulted in no effect on *H. azteca* reproduction and the next nominal test concentration of 80 µg/L (74 µg/L dissolved; 83 µg/L total) caused an effect (Table 1).

Conclusion and Closure

As set out in the Study Plan, "if one or more of the 20th percentile effect concentrations is less than or equal to the proposed WQO and the WQO test concentration of 20 µg/L differs significantly from the control, the WQO would be revised downward to establish a level that is protective of aquatic organisms in site water" (Appendix A). Based on this evaluation criterion and the results of the toxicity testing under clear flow conditions, no downward revision of the WQO (from 20 µg/L) is warranted as there were no endpoints with 20th percentile effect concentrations lower than 20 μg/L and for which the 20 μg/L exposure resulted in a statistically significant reduction relative to the control (Table 2). The most sensitive endpoints were *D. magna* survival and *H. azteca* reproduction, for which a LC20 of 18.3 μg/L dissolved copper (21.0 μg/L total copper), and an IC20 of 17.6 μg/L dissolved copper (18.0 μg/L total copper) were reported, respectively. However, neither the 20 μg/L treatment nor the next higher test concentration (the 40 μg/L treatment) resulted in significantly reduced *D. magna* survival or *H. azteca* reproduction relative to the laboratory control (nor did these concentrations result in statistically significant effects to any of the thirteen combinations of species and endpoint tested; Table 2). The lowest no-effect concentration reported in all testing was associated with the 40 μg/L copper exposures and the lowest effect concentration in all testing was associated with the 80 μg/L copper exposures.

These tests will be repeated to test turbid flow conditions in 2016. Collection of site water will be completed the same way and shipped to the same toxicity test laboratory. The same organisms will be tested with the same endpoints. However, some consideration should be given to whether or not testing of fathead minnow is justified given the lack of sensitivity documented herein. Results from turbid flow testing will reported in a second letter report and will include comparison to the clear flow testing as well as the overall conclusions derived from the results of the two test periods.

Sincerely,
Minnow Environmental Inc.

Pierre Stecko, M.Sc., EP, RPBio
Senior Aquatic Scientist/Principal

Table 2: Evaluation of Clear Flow Toxicity Testing of Dissolved and Total Copper (µg/L) Relative to Pre-Defined Criteria [1]

Organism	Endpoint	Criterion 1 [a] LC20 or IC20 Dissolved Copper (µg/L) Mean	Criterion 1 [a] Dissolved Copper EC20 < 20 µg/L?	Criterion 1 [a] Total Copper (µg/L) Mean	Criterion 1 [a] Total Copper EC20 < 20 µg/L?	Criterion 2 [b] Copper Treatment (Nominal Concentrations) 20 µg/L Mean ± SD	20 µg/L p value	20 µg/L Significant Difference?	40 µg/L Mean ± SD	40 µg/L p value	40 µg/L Significant Difference?	80 µg/L Mean ± SD	80 µg/L p value	80 µg/L Significant Difference?
Brachionus calyciflorus - 48 hour	Population Growth Rate	45.1	NO	63.4	NO	0.85 ± 0.06	0.993	NO	0.79 ± 0.09	0.917	NO	0.35 ± 0.12	< 0.001	YES
Daphnia magna - 21 day	Survival	18.3	YES	21.0	NO	60 ± 52	0.111	NO	80 ± 42	0.612	NO	50 ± 53	0.027	YES
	Reproduction	53.5	NO	71.0	NO	74 ± 46	0.952	NO	98 ± 28	1.000	NO	37 ± 21	0.048	YES
Pimephales promelas - 32 day	Hatching Success	> 144	NO	> 148	NO	93 ± 7.7	0.888	NO	93 ± 5.4	0.875	NO	92 ± 8.4	0.803	NO
	Post-hatch Survival	> 139	NO	> 155	NO	86 ± 5.1	0.350	NO	97 ± 4.0	0.979	NO	95 ± 3.5	0.939	NO
	Overall Survival	> 139	NO	> 155	NO	80 ± 5.4	0.580	NO	90 ± 3.8	0.952	NO	87 ± 5.4	0.875	NO
	Length [2]	> 139	NO	> 155	NO	10 ± 0.40	-	-	10 ± 0.50	-	-	10 ± 0.20	-	-
	Biomass	> 139	NO	> 155	NO	1.7 ± 0.20	0.811	NO	2.1 ± 0.22	1.000	NO	2.1 ± 0.21	1.000	NO
Hyalella azteca - 28 day	Survival	86.1	NO	95.5	NO	98 ± 5.0	0.875	NO	98 ± 5.0	0.875	NO	88 ± 9.6	0.100	NO
	Biomass	49.0	NO	53.8	NO	0.66 ± 0.06	1.000	NO	0.57 ± 0.05	0.985	NO	0.34 ± 0.09	< 0.001	YES
Hyalella azteca - 42 day	Survival	77.8	NO	87.4	NO	94 ± 7.4	0.782	NO	96 ± 5.2	0.919	NO	76 ± 17	0.005	YES
	Biomass	44.2	NO	50.4	NO	0.78 ± 0.09	0.476	NO	0.73 ± 0.16	0.161	NO	0.45 ± 0.12	< 0.001	YES
	Reproduction	17.6	YES	18.0	YES	2.8 ± 1.4	0.211	NO	3.3 ± 2.0	0.351	NO	1.3 ± 1.9	0.023	YES

[1] Water sample collected on September 28th, 2015
[2] Since the highest concentration performed the same as the control, data examined on basis of data inspection rather than statistics (Nautilus 2015)
[a] 20th percentile effect concentration relative to 20 µg/L
[b] Concentrations not significantly different from control

Endpoint value is lower than 13 µg/L (the water quality objective [WQO] applicable at dissolved organic carbon [DOC] ≤ 10 mg/L)
Endpoint value is lower than 20 µg/L (the water quality objective [WQO] applicable at dissolved organic carbon [DOC] > 10 mg/L)
p value < 0.050

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APPENDIX A

STUDY PLAN FOR EVALUATING THE TOXICITY OF COPPER TO SELECTED AQUATIC ORGANISMS IN MINTO CREEK WATER – VERSION 3 (MESL 2015)

Attachment 1:

Study Plan for Evaluating the Toxicity of Copper to Selected Aquatic Organisms in Minto Creek Water Version 3

Prepared by: MESL/PERC, with comments by Minnow Environmental
Version 3 Prepared: January 14, 2015

Purpose: The purpose of this study is to determine if the proposed water quality objective (WQO) for copper in Minto Creek (20 µg/L) would be protective of aquatic organisms.

Approach: The protectiveness of the proposed WQO for copper would be evaluated by conducting a series of laboratory toxicity tests with selected species of fish and invertebrates. A resident species approach could be applied to evaluate the protectiveness of the proposed WQO (which could involve toxicity testing with chinook salmon, slimy sculpin, Yukon floaters, and various crustaceans and/or insect larvae). However, it is more practical to utilize an indicator species approach that involves conducting toxicity tests with a number of commonly-tested fish and invertebrate species that are likely to be representative of sensitive species that utilize aquatic habitats within Minto Creek. Application of this approach would involve:

- Collecting site water (i.e., Minto Creek at W2) during two periods of the hydrological regime (i.e., clear flow; TSS < 25 mg/L; and, turbid flow: TSS $\geq$ 25 mg/L);
- Transporting sufficient quantities of site water to the toxicity testing laboratory to support toxicity testing;
- Spiking site water with copper chloride to achieve five exposure concentrations, as well as a negative control (Lab water), site control (i.e., unspiked site water);
- Conducting a total of four long-term (i.e., chronic) static-renewal toxicity tests to evaluate the effects of copper on aquatic organisms in site water, including:
    1. 42-d toxicity test with the amphipod, *Hyalella azteca* (Endpoints: Survival, growth, and reproduction);

2. 21-d toxicity test with the cladoceran, *Daphnia magna* (Endpoints: Survival and reproduction);
3. 48-h toxicity test with the rotifer, *Brachionus calyciflorus* (Endpoint: Intrinsic rate of population increase); and,
4. 32-d toxicity test with fathead minnows, *Pimephales promelas* (Endpoints: Hatching success, total post-hatch survival, overall survival, and dry weight);

- Conducting a reference toxicity test with each species to confirm that sensitivity is within the expected range;
- Measuring the concentrations of total and dissolved copper in each treatment for each toxicity test at the beginning of the test, the end of the test, and periodically during the test (i.e., depending on when new batches of site water are used and/or when dilution water is prepared. Note our preference would be to have all of the tests conducted with a single batch of homogenized site water);
- Characterizing water quality in each treatment at the beginning of the test, the end of the test, and periodically during the test (i.e., depending on when new batches of site water are used);
- Calculating EC_{10} and EC_{20} values; and,
- Compiling and reporting the results of the toxicity testing program.

Interpretation: The WQO for copper will be considered to be protective if the reported EC_{20} values are greater than 20 µg/L for all tested species and the 20 µg/L treatment does not differ significantly from the control ($p = 0.05$). If one or more of the EC_{20} values is less than or equal to the proposed WQO and the 20 µg/L treatment is significantly impaired relative to control ($p = 0.05$), the WQO would be revised downward to establish a level that is protective of aquatic organisms in site water.

Note: This general approach can be modified to evaluate the protectiveness of the WQOs that have been proposed for all of the COPCs. In this case, site water would be spiked with all of the identified COPCs at levels equivalent to the WQOs (i.e., in site water collected during clear-flow and turbid flow periods).

Note: Add Table of Test Conditions for Each Toxicity Test to complete Study Plan.

APPENDIX B

COPPER TOXICITY TESTING
FOR MINTO CREEK
(NAUTILUS 2015)

Copper Toxicity Testing for Minto Creek

Final Report

Report date:
May 10, 2016

Submitted to:

Minnow Environmental Inc.
Victoria, BC

#4, 6125 12 St SE
Calgary, Alberta
T2H 2K1

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This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

1.0 INTRODUCTION

Nautilus Environmental Company Inc. conducted sub-lethal toxicity tests for Minnow Environmental Inc. (Minnow) to investigate the effects of copper in site water collected from lower Minto Creek by the Minto Mine. The purpose of this study was to determine if the proposed water quality objective (WQO) for copper in Minto Creek would be protective of aquatic organisms.

The following sub-lethal toxicity tests were performed:

- 48-hour *Brachionus calyciflorus* population growth test
- 21-day *Daphnia magna* survival and reproduction test
- 32-day *Pimephales promelas* survival and growth test
- 42-day *Hyalella azteca* survival, reproduction and growth test

This report describes the results of these toxicity tests.

2.0 METHODS

Two water samples (W2, collected from Lower Minto Creek, and W16, which is a mine water sample) were collected on September 28, 2015 and submitted by Minto Mine to Nautilus Environmental, Calgary (formerly HydroQual) for testing. The water was delivered in 200-L plastic barrels in a refrigerated truck.

Test water was prepared in the laboratory by mixing the two waters in a 3:1 ratio of W2:W16, which reflects the dilution rate that is expected at maximum discharge. This site water was then spiked with copper using a stock solution of $CuCl_2 \cdot 2H_2O$ to achieve six nominal copper concentrations (5, 10, 20, 40, 80 and 160 µg/L). In addition to the copper concentrations, an unspiked site water control and laboratory control were also evaluated in each test.

Total and dissolved copper concentrations were measured in each of the test concentrations on a weekly basis. In addition, Ca, Mg, K, Na, SO_4, Cl and alkalinity were measured in the site and laboratory control waters and Dissolved Organic Carbon (DOC) was measured in the site water control.

Testing was conducted following standard protocols that are currently employed in Canada and the USA for these test species, and are described below. Statistical analyses were performed on the basis of average measured total concentrations of copper using CETIS (Tidepool Scientific Software, 2015). Where possible, linear or non-linear regression models were used to calculate point estimates. In instances where a linear or non-linear regression model did not fit the data, Spearman-Karber or linear interpolation were used, as appropriate.

2.1 *Brachionus calyciflorus*

The *B. calyciflorus* tests followed procedures outlined in Snell and Moffat (1992) and APHA (2012) and are summarized in Table 1. The test was a 48-hour growth test that measured the intrinsic rate of population increase. The test was conducted at 25 ± 1°C and *B. calciflorus* were fed green algae (*Pseudokirchneriella subcapitata*) at test initiation.

Table 1. Summary of test conditions: *Brachionus calyciflorus* growth test.

Test organism	*Brachionus calyciflorus*
Test organism age	< 2 h-post hatch
Test type	Static
Test duration	48 h
Test chamber	Test tube
Test solution volume	12 mL
Test concentrations	Six concentrations, plus site water and laboratory controls
Number of replicates	5
Control water	Moderately-hard reconstituted water (hardness 80-100 mg/L)
Test solution renewal	None
Test temperature	25 ± 1°C
Number of organisms/chamber	6
Feeding	*Pseudokirchneriella subcapitata* at test initiation
Photoperiod	Continuous darkness
Aeration	None
Test protocol	Snell and Moffat (1992); APHA (2012)
Test endpoints	Growth rate (intrinsic rate of population increase; r)
Test acceptability criterion for controls	r ≥ 0.7

2.2 *Daphnia magna*

The *D. magna* test followed methods described in ASTM (2012), which are summarized in Table 2. The test involved a 21-day exposure under static-renewal conditions, with solutions being renewed three times per week and survival and reproduction being monitored. The test was conducted at 20 ± 1°C and daphnids were fed a mixture of green algae (*P. subcapitata*) and digested yeast, alfalfa and trout chow (YAT).

Table 2. Summary of test conditions: 21 day *Daphnia magna* survival and reproduction test.

Test organism	*Daphnia magna*
Test organism source	In-house culture
Test organism age	<24-h old neonates
Test type	Static-renewal
Test duration	21 days
Test chamber	120-mL plastic cup
Test solution volume	100 mL
Test concentrations	Six concentrations, plus site water and laboratory controls
Number of replicates	10
Control/dilution water	Moderately hard water (hardness 80-100 mg/L $CaCO_3$)
Test solution renewal	Three times weekly
Test temperature	20 ± 2°C
Number of organisms/chamber	1
Feeding	Daily, with *Pseudokirchneriella subcapitata* and digested yeast, alfalfa and trout chow
Light intensity	400 to 800 lux
Photoperiod	16 hours light/8 hours dark
Aeration	None
Test protocol	ASTM E1193 – 97
Test endpoints	Survival and reproduction
Test acceptability criterion for controls	≥70% survival; average of ≥60 young per surviving control female
Reference Toxicant	Sodium chloride

2.3 *Pimephales promelas*

The *P. promelas* test followed methods described in USEPA (1996) and ASTM (2013), which are summarized in Table 3. The test evaluated a hatch, survival and growth test during a 32-day static-renewal exposure, with solutions being renewed daily. The test was conducted at 25 ± 1°C and minnows were fed daily with *Artemia* nauplii.

The test used four replicates for each test concentration with 15 eggs in each test container. After 48 hours of exposure, undeveloped eggs in each replicate (i.e., unfertilized eggs) were replaced with eggs contained in two additional sacrificial test containers that were initiated for each test concentration for this purpose.

Table 3. Summary of test conditions: fathead minnow early life stage test.

Test organism	*Pimephales promelas*
Test organism age	< 24-h old fertilized eggs
Test type	Static-renewal
Test duration	~32 days
Test chamber	1-L plastic beakers
Test solution volume	1 L
Test concentrations	Six concentrations, plus site water and laboratory controls
Number of replicates	4
Control water	Moderately-hard reconstituted water (hardness 80-100 mg/L)
Test solution renewal	Daily
Test temperature	25 ± 1°C
Number of organisms/chamber	15
Feeding	Twice daily, with *Artemia* nauplii
Light intensity	100 to 600 lux
Photoperiod	16 hours light/8 hours dark
Aeration	None unless required to maintain DO >50% saturation
Test protocol	USEPA (1996); ASTM (2013)
Test endpoints	Survival, hatch, growth
Test acceptability criterion for controls	>66% hatch; ≥70% post-hatch survival

2.4 *Hyalella azteca*

The *H. azteca* tests followed methods described by USEPA (2000), with modifications described recently by the *Hyalella* Advisory Group, headed by Dr. Chris Ingersoll of USGS. A description of test conditions is provided in Table 4. The test involved a 42 day exposure of 7- to 8-day old organisms using twelve replicates of ten amphipods. Four replicates were terminated at Day 28 to assess biomass and survival, and the remaining eight were continued to Day 42 and were used to evaluate survival, biomass and reproduction. The test organisms were fed a ramped diet of Tetramin and YAT, with increased feeding rates as the test progressed. The test was conducted under static renewal conditions, with one water renewal per day. The control and test waters for the *H. azteca* tests contained at least 0.02 mg/L Br and 15 mg/L Cl. Reproduction was assessed on days 35 and 42. Debris was removed from the test vessels on days 7 and 14. Additionally, on day 21, the Nitex screens were replaced in each test vessel. On day 42, the number of adult females was evaluated in each replicate so that reproduction could be reported on the basis of the number of female amphipods.

Table 4. Summary of test conditions: *Hyalella azteca* survival, growth and reproduction test.

Test organism	*Hyalella azteca*
Test organism age	7-8 days old
Test type	Static-renewal
Test duration	42 days
Test vessel	375 mL glass container with a 5 cm disc of Nitex for substrate
Test volume	200 mL of water
Test concentrations	Six concentrations, plus site water and laboratory controls
Test replicates	12 test replicates per treatment; 4 terminated at day 28
Number of organisms	10 per replicate
Control water	Moderately-hard water (hardness 80-100 mg/L $CaCO_3$) containing >25 mg/L Cl and supplemented with 0.02 mg/L Br.
Test solution renewal	Twice daily
Test temperature	23 ± 1°C
Feeding	1 mL of YAT daily to each container. Tetramin daily, with amounts in each test container increasing weekly: Week 1, 0.25 mg; Week 2, 0.5 mg; Week 3, 1 mg; Week 4, 1 mg; Week 5, 1.5 mg; Week 6, 2.0 mg.
Light intensity	500 to 1000 lux at water surface
Photoperiod	16 hours light/8 hours dark
Aeration	None
Test protocol	Modified from US EPA (2000)
Test endpoint	Survival, dry weight, reproduction
Test acceptability criteria for controls	Mean control survival of ≥80% survival, >6 young/female
Reference toxicant	Copper

2.5 QA/QC

Nautilus Environmental follows a comprehensive QA/QC program to ensure that data generated are of high quality and are scientifically defensible. To meet these objectives, the following quality control procedures are implemented:

- Negative controls to ensure that appropriate testing performance criteria are met;
- Use of appropriate species, life stage, and test methods to meet the study objectives;
- Appropriate number of replicates to allow the proper statistical analyses;
- Calibration and proper maintenance of instruments to ensure accurate measurements;
- Proper documentation and recordkeeping to allow traceability of performance;
- Adequate supervision and training of staff to ensure that methods are followed;
- Proper handling and storage of samples to ensure sample integrity;
- Procedures in place to address issues that may arise during testing and ensure the implementation of appropriate corrective actions; and,
- Rigorous review of data by a Registered Professional Biologist to ensure that the data are of good quality and are scientifically defensible prior to release to the client.

3.0 RESULTS

The nominal and mean measured concentrations of copper for each species tested are presented in Table 5. The site control was included in the statistical analysis as an additional treatment level due to the copper concentration that was present in the site water (approximately 5 µg/L). The measured concentrations were in good agreement with the nominal concentrations, after accounting for the copper that was already present in the site water.

Table 5. Measured copper concentrations for each test species.

Nominal concentration (µg/L Cu)	Mean measured concentration (total, dissolved µg/L Cu)				
	Brachionus calyciflorus	*Daphnia magna*	*Pimephales promelas*	*Hyalella azteca* – day 28	*Hyalella azteca* – day 42
Site Control	7.3, 5.0	4.9, 5.5	5.1, 5.4	5.2, 5.4	5.1, 5.3
5	14, 8.8	10, 9.6	10, 8.9	10, 9.0	10, 8.6
10	17, 13	15, 13	15, 13	15, 13	15, 13
20	26, 18	24, 21	24, 21	24, 21	24, 22
40	46, 32	43, 37	43, 38	42, 38	44, 38
80	89, 65	80, 71	82, 73	80, 72	83, 74
160	168, 126	149, 139	155, 141	153, 140	156, 141

The results of the test using *B. calyciflorus* are provided in Table 6. The IC20 for *B. calyciflorus* was 63.4 µg/L total copper.

The results of the test using *D. magna* are provided in Table 7. Effects on *D. magna* were observed on both the survival and reproduction endpoints. The LC20 for survival was 21.0 µg/L copper and the IC20 for reproduction was 71.0 µg/L total copper. It should be noted that this test only involves exposure of ten organisms and, consequently, the estimates for the LC10 and LC20 should be interpreted with caution. The NOEC and LOEC for survival were 43 and 80 µg/L total copper, which is considerably higher than the estimates calculated for the LC10 and LC20, indicating that the 10 and 20% effect levels would not be statistically distinguishable from the control performance. Thus, these may not be appropriate estimates of effect levels from the test (de Bruyn and Elphick, 2013). Moreover, these point estimates could only be derived using linear interpolation, since the data did not meet the assumptions for analyzing the dose-response using linear regression. Linear interpolation is not generally appropriate for survival data, but was the only tool available to provide estimates of these values. The LC50 was calculated using Trimmed Spearman Karber.

The results of the test using *P. promelas* are provided in Tables 8 and 9. *P. promelas* was the least sensitive species to copper, with the majority of the endpoints occurring above the highest concentration tested. The un-spiked site water (5.1 µg/L total copper) and the two lowest spiked concentrations (10 and 15 µg/L total copper) each exhibited mortalities of *P. promelas* in a manner that was inconsistent with that observed in the laboratory water control and the higher concentrations of copper, each of which had a relatively low degree of mortality. This pattern of effect is consistent with effects from bacterial or fungal constituents that were present in the site water.

The pattern of adverse effects in the site water, combined with a lack of effects associated with higher copper concentrations suggests that the copper that was amended into the site water was effective at mitigating the growth of microbes and associated adverse effect that were observed in the site water and low doses of copper. Adverse effects on survival are not unusual in testing this species with ambient samples; fathead minnows are known to be susceptible to adverse effects caused by fungi and microbes (Grothe and Johnson, 1996; Ksoz et al., 2997; Downey et al. 2000). These effects have been termed "sporadic mortality phenomenon", and are associated with mortalities that generally occur beginning on day 4 of a 7-day test with this species (Downey et al. 2000). This age is equivalent to day 6 of the 32-day test, which starts with an earlier life-stage. Indeed, the effects that were observed in the present case occurred between days 6 and 9 of exposure, and the pattern of response is consistent with sporadic mortality phenomenon. Fortunately, the higher copper concentrations were not subject to adverse effects associated with this phenomenon, and the data were analyzed after excluding the results for the site water control and the two lowest doses of copper. No adverse effects associated with copper exposure were observed in this test.

The results of the testing using *H. azteca* are provided in Tables 10 and 11. The IC20 values for biomass were 53.8 and 50.4 µg/L total copper at day 28 and 42 of exposure, respectively. The IC20 for offspring per female was 18.0 µg/L total copper; however, there was considerable variability in this endpoint, and this may not reflect a real response level. The NOEC and LOEC were 44 and 83 µg/L total copper, indicating that the effect concentration associated with the IC20 would not be statistically distinguishable from the control performance The minimum difference from the control performance that would be statistically distinguishable from the control (i.e., the %MSD) was 65.7% (i.e., a 65.7% difference in reproduction would be required to detect this as being statistically significant).

Table 6. Results: *B. calyciflorus* toxicity test using copper.

Measured copper (µg/L)		**Growth rate (r)**
Total	**Dissolved**	**(mean ± SD)**
Lab Control	Lab Control	0.77 ± 0.13
7.3	5.4	0.87 ± 0.10
14	8.7	0.81 ± 0.12
17	13	0.86 ± 0.09
26	18	0.85 ± 0.06
46	32	0.79 ± 0.09
89	65	0.35 ± 0.12 *
168	126	0.00 ± 0.00 *
Test endpoint (µg/L Total Cu)		
IC10 (± CL)		56.6 (NC – 65.7)
IC20 (± CL)		63.4 (54.2 - 72.4)
IC50 (± CL)		85.2 (76.4 – 96.1)
Test endpoint (µg/L Dissolved Cu)		
IC10 (± CL)		40.0 (NC – 46.9)
IC20 (± CL)		45.1 (38.2 -52.1)
IC50 (± CL)		62.1 (55.2 – 70.7)

CL = Confidence limits, IC = Inhibition concentration, NC = Not calculable
* statistically significantly adversely affected relative to the control

Table 7. Results: *D. magna* toxicity test using copper.

Measured copper (µg/L)		% Survival	Reproduction
Total	**Dissolved**	**(mean ± SD)**	**(mean ± SD)**
Lab Control	Lab Control	90.0 ± 31.0	68 ± 37
4.9	5.5	100.0 ± 0.0	97 ± 17
10	9.6	100.0 ± 0.0	110 ± 9
15	13	100.0 ± 0.0	111 ± 15
24	21	60.0 ± 52.0	74 ± 46
43	37	80.0 ± 42.0	98 ± 28
80	71	50.0 ± 53.0 *	37 ± 21
149	136	0.0 ± 0.0 *	0 ± 0 *
Test endpoint (µg/L Total Cu)			
LC10 (± CL)		17.7 (16.6 – 35.6)	
LC20 (± CL)		21.0 (18.4 – 58.2)	
LC50 (± CL)		58.7 (43.4 – 79.2)	
IC10 (± CL)			68.2 (NC)
IC20 (± CL)			71.0 (NC)
IC50 (± CL)			77.8 (NC)
Test endpoint (µg/L Dissolved Cu)			
LC10 (± CL)		15.4 (14.5-37)	
LC20 (± CL)		18.3 (16.1-71.9)	
LC50 (± CL)		52 (38.2-70.7)	
IC10 (± CL)			49.2 (NC-64.1)
IC20 (± CL)			53.5 (NC-68.9)
IC50 (± CL)			66.7 (56.8-80.8)

SD = Standard Deviation, CL = Confidence limits, IC = Inhibition concentration, LC = Lethal Concentration, NC = Not calculable

* statistically significantly adversely affected relative to the control

Table 8. Hatch and survival results: *P. promelas* toxicity test using copper.

Measured copper (µg/L) Total	Dissolved	Hatch (%)** (mean ± SD)	Post Hatch Survival (%) (mean ± SD)	Overall Survival (mean ± SD)
Lab Control	Lab Control	93.3 ± 5.4	93.0 ± 5.8	86.7 ± 5.4
5.1	5.4	78.3 ± 11.4	46.3 ± 13.4 *	48.3 ± 30.5 *
10	8.9	91.7 ± 3.3	31.5 ± 23.2 *	28.3 ± 19.9 *
15	13	95.0 ± 10.0	40.8 ± 8.8 *	38.3 ± 6.4 *
24	21	93.3 ± 7.7	85.9 ± 5.1	80.0 ± 5.4
43	38	93.3 ± 5.4	96.6 ± 4.0	90.0 ± 3.8
82	73	91.7 ± 8.4	94.8 ± 3.5	86.7 ± 5.4
155	139	93.3 ± 7.7	89.2 ± 4.2	83.3 ± 4.3
Test endpoint (µg/L Total Cu)				
EC10		>148	>155	>155
EC20		>148	>155	>155
EC50		>148	>155	>155
Test endpoint (µg/L Dissolved Cu)				
EC10		>144	>139	>139
EC20		>144	>139	>139
EC50		>144	>139	>139

SD = Standard Deviation, EC = Effect concentration

* statistically significantly adversely affected relative to the control

** the measured concentrations of dissolved copper for Hatch % are as follows: lab control, 5.0, 9.9, 13, 23, 38, 75 and 144 µg/L copper.

** the measured concentrations of total copper for Hatch % are as follows: lab control, 5.2, 10, 15, 24, 43, 81 and 148 µg/L copper.

Table 9. Growth results: *P. promelas* toxicity test using copper.

Measured copper (µg/L)		Length (mm)	Biomass (mg)
Total	**Dissolved**	**(mean ± SD)**	**(mean ± SD)**
Lab Control	Lab Control	10.0 ± 0.5	1.75 ± 0.08
5.1	5.4	11.5 ± 1.4	1.59 ± 0.10
10	8.9	13.3 ± 1.8	1.46 ± 0.27
15	13	12.2 ± 0.4	1.74 ± 0.29
24	21	10.2 ± 0.4	1.72 ± 0.20
43	38	10.2 ± 0.5	2.09 ± 0.22
82	73	10.3 ± 0.2	2.08 ± 0.21
155	139	10.0 ± 0.5	1.99 ± 0.12
Test endpoint (µg/L Total Cu)			
IC10 (± CL)		>155	>155
IC20 (± CL)		>155	>155
IC50 (± CL)		>155	>155
Test endpoint (µg/L Dissolved Cu)			
IC10 (± CL)		>139	>139
IC20 (± CL)		>139	>139
IC50 (± CL)		>139	>139

SD = Standard Deviation, CL = Confidence limits, IC = Inhibition concentration, na = not applicable
* statistically significantly adversely affected relative to the control

Table 10. 28-d results: *Hyalella azteca* toxicity test using copper.

Measured copper (µg/L)		Survival (%)	Biomass (mg)
Total	**Dissolved**	**(mean ± SD)**	**(mean ± SD)**
Lab Control	Lab Control	97.5 ± 5.0	0.533 ± 0.069
5.2	5.4	95.0 ± 5.7	0.664 ± 0.021
10	9.0	100.0 ± 0.0	0.732 ± 0.036
15	13	100.0 ± 0.0	0.684 ± 0.036
24	21	97.5 ± 5.0	0.662 ± 0.060
42	38	97.5 ± 5.0	0.566 ± 0.046
80	72	87.5 ± 9.6	0.336 ± 0.092 *
153	138	35.0 ± 17.3 *	0.062 ± 0.047 *
Test endpoint (µg/L Total Cu)			
LC10 (± CL)		78.8 (49.9 – 95.6)	
LC20 (± CL)		95.5 (69.9 – 111.2)	
LC50 (± CL)		132.9 (114.9 – 156)	
IC10 (± CL)			47.0 (40.9 – 53.5)
IC20 (± CL)			53.8 (47.5 – 60.8)
IC50 (± CL)			82.1 (72.0 – 95.1)
Test endpoint (µg/L Dissolved Cu)			
LC10 (± CL)		70.9 (44.9 - 86.1)	
LC20 (± CL)		86.1 (63.0 - 100)	
LC50 (± CL)		120 (104 - 141)	
IC10 (± CL)			42.9 (37.4 - 48.8)
IC20 (± CL)			49 (43.4 – 55.3)
IC50 (± CL)			74.4 (65.3 – 86.1)

SD = Standard Deviation, CL = Confidence limits, IC = Inhibition concentration, LC = Lethal Concentration
* statistically significantly adversely affected relative to the control

Table 11. 42-day results: *Hyalella azteca* toxicity test using copper.

Measured copper (µg/L) Total	Dissolved	Survival (%) (mean ± SD)	Biomass (mg) (mean ± SD)	Reproduction (mean ± SD)
Lab Control	Lab Control	95.0 ± 9.3	0.837 ± 0.139	5.00 ± 1.60
5.1	5.3	86.2 ± 14.1	0.799 ± 0.162	6.25 ± 3.73
10	8.6	95.0 ± 5.3	0.859 ± 0.095	5.25 ± 5.04
15	13	96.2 ± 7.4	0.923 ± 0.129	5.50 ± 2.93
24	22	93.8 ± 7.4	0.775 ± 0.087	2.75 ± 1.39
44	38	96.2 ± 5.2	0.726 ± 0.156	3.25 ± 1.98
83	74	76.2 ± 16.8 *	0.447 ± 0.121 *	1.25 ± 1.91 *
156	140	31.2 ± 17.3 *	0.089 ± 0.046 *	0.12 ± 0.35 *
Test endpoint (µg/L Total Cu)				
LC10 (± CL)		71.8 (52.8 – 84.8)		
LC20 (± CL)		87.4 (70.1 – 99.6)		
LC50 (± CL)		127.4 (114.0 – 143.5)		
IC10 (± CL)			35.2 (23.1 – 44.4)	11.4 (NC – 22.4)
IC20 (± CL)			50.4 (39.4 – 60.2)	18.0 (NC – 31.7)
IC50 (± CL)			86.9 (76.9 – 97.4)	39.4 (23.2 – 66.8)
Test endpoint (µg/L Dissolved Cu)				
LC10 (± CL)		63.7 (46.4 – 75.5)		
LC20 (± CL)		77.8 (62.1 – 88.8)		
LC50 (± CL)		114 (102 – 129)		
IC10 (± CL)			30.5 (20.0 – 38.6)	11.6 (NC – 22.1)
IC20 (± CL)			44.2 (34.3 – 52.8)	17.6 (NC – 30.9)
IC50 (± CL)			77.2 (68.1 – 86.7)	38.9 (23.5 – 64.3)

SD = Standard Deviation, CL = Confidence limits, IC = Inhibition concentration, LC = Lethal Concentration, NC = Not calculable
* statistically significantly adversely affected relative to the control

4.0 QA/QC

The *B. calyciflorus* and *D. magna* tests met the requirements for control performance in both the site water and laboratory control water. The *P. promelas* test met the requirements for control performance in the laboratory water control, but exhibited significant mortalities in the site water control, as described in Section 3.0. The *H. azteca* test met the control acceptability criteria specified in the test protocol, although control produced 5.0 offspring per female, which is marginaly lower than the target level of six offspring per female recommended by the *Hyalella* Advisory Group. This was a relatively small departure from the target level, and the reproductive rate exceeded six offspring per female in the site water control, which produced 6.25 per female. Uncertainty associated with these tests is best described by the confidence limits around the point estimates.

Results of the reference toxicant tests conducted during the testing program are summarized in Table 12. The results for the tests fell within the range for organism performance of mean and two standard deviations (where available) based on previous results obtained by the laboratory with these tests. There was not enough historical data to produce a historical mean or CV for the *B. calyciflorus* test; however, the result presented for this species is within a factor of two of three prior tests performed with this species. Thus, the sensitivities of the organisms used in the tests were considered to be appropriate. It should be noted that the *Pimephales promelas* reference toxicant test was conducted using eggs that were hatched in the laboratory from the same batch of eggs used to initiate the test.

Table 12. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
Brachionus calyciflorus	Survival LC50 = 3.6 mg/L NaCl	-	-	Oct 13, 2015
Daphnia magna	Survival LC50 = 6.3 g/L NaCl	5.8 (4.9 - 6.8)	5.4	Oct 5, 2015
Pimephales promelas	Survival LC50 = 912 mg/L NaCl	912 (562 - -1479)	16.1	Oct 12, 2015
	Growth IC25 = 490 mg/L NaCl	501 (331 -759)	13.8	Oct 12, 2015
Hyalella azteca	Survival LC50 = 708 µg/L Cu	631 (251 - 1585)	27.8	Oct 8, 2015

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibitory Concentration, CV = Coefficient of Variation

5.0 REFERENCES

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APPENDIX A –*Brachionus calyciflorus* Toxicity Test Data

Brachionus calyciflorus Summary Sheet

Client: Minnow Environmental
Work Order No.: 15789

Start Date/Time: Oct 13/15 @ 1600h
Test Species: Brachionus calyciflorus
Set up by: BPL/FMM

Sample Information:

Sample ID: W2/W16 W2:W16 (3:1)
Sample Date: Oct 12/15
Date Received: Oct 13/15
Sample Volume: W2: 3x1L; W16: 1x1L

Test Organism Information:

Age of young (Day 0): < 2 hours

NaCl Reference Toxicant Results:

Reference Toxicant ID: ~~BC05~~ BC03
Stock Solution ID: 15Na02
Date Initiated: Oct 13/15
48-h LC50 (95% CL): 3.6 (3.2-4.0) mg/L NaCl

Reference Toxicant Mean ± 2 SD: n/a
Reference Toxicant CV (%): n/a

Test Results: Adverse effects were observed on growth of B. calyciflorus. The resulting IC25 and IC50 values were 66.7 and 85.2 µg/L Cu, (58.1-75.6) (76.4-96.1) respectively (when compared to negative control)

Reviewed by: JCL
Date reviewed: Nov. 16/15

Freshwater Acute
48 Hour Toxicity Test Data Sheet

Client: Hydroqual (minnow)
Start Date/Time: Oct 13/15 @ 1600
Sample ID: W2: WIL mixture spiked w/ Cu (3:1)
Test Organism: *Brachionus calyciflorus*
Work Order No.: 15789
Set up by: BKL, EMM

DO meter: DO-1
pH meter: pH-1
Conductivity meter: C-1

Concentration (µg/L) Cu	Temperature (°C)		Dissolved oxygen (mg/L)		pH		Conductivity (µS/cm)	
	0	48	0	48	0	48	0	48
Lab MHW control	24.0	25.0	7.9	7.6	7.7	7.8	355	361
site mix control (unspiked)	24.0	25.0	7.8	7.8	7.8	7.9	354	362
5	24.0	25.0	7.8	7.7	7.8	7.9	352	364
10	24.0	25.0	7.8	7.7	7.8	7.9	352	364
20	24.0	25.0	7.9	7.8	7.8	7.9	353	361
40	24.0	25.0	7.9	7.8	7.8	7.9	352	364
Technician Initials	EMM	EMM	EMM	EMM	EMM	EMM	EMM	EMM

	Hardness	Alkalinity
Control	100	72
Highest concentration	N/A	N/A

	Adjustment	Adjusted WQ
Temp (°C)	N/A	N/A
DO (mg/L)	N/A	N/A
pH	N/A	N/A
Cond (µS/cm)	N/A	N/A

Comments: initiated test w/ 6 organisms per replicate

Reviewed by: JOL
Nov. 12/15

Freshwater Acute
48 Hour Toxicity Test Data Sheet

Client: Hydroqual (Minnow)
Sample ID: W2 W16 mixture spiked w/ Cu (3:1)
Work Order No.: 15789

Start Date/Time: Oct 13/15 @ 1600
Test Organism: *Brachionus calyciflorus*
Set up by: BPL/FMM

DO meter: DO-1
pH meter: pH-1
Conductivity meter: C-1

Concentration (µg/L) Cu	Temperature (°C)		Dissolved oxygen (mg/L)		pH		Conductivity (µS/cm)	
	0	48	0	48	0	48	0	48
80	24.0	25.0	7.9	7.8	7.8	7.9	353	366
160	24.0	25.0	7.9	7.8	7.8	7.9	353	362
Technician Initials	FMM	FMM	FMM	FMM	FMM	FMM	FMM	FMM

	Hardness	Alkalinity
Control	100	72
Highest concentration	N/A	N/A

	Adjustment	Adjusted WQ
Temp (°C)	N/A	N/A
DO (mg/L)	N/A	N/A
pH	N/A	N/A
Cond (µS/cm)	N/A	N/A

Comments: initiated test w/ 6 organisms per replicate

Reviewed by: JCh
Nov. 12/15

Freshwater Acute Toxicity Test
B. calyciflorus Survival

Client: Hydroqual (minnow)
Sample ID: W2:W16 (3:1)
Work Order: 15787

Start Date & Time: OCT 13/15 @ 1600h
Stop Date & Time: OCT 15/15 @ 1600h
Set up by: EMM / BDL

(~~mg/L total~~) emm (µg/L Cu)

Hrs	Concentration: control MHW								Concentration: site control (unspiked)							
	A	B	C	D	E	F	G	Init	A	B	C	D	E	F	G	Init
24	6	6	6	6	6			EMM	6	6	6	6	6			EMM
48	30	28	34	18	32			EMM	38	27	34	40	33			EMM

Hrs	Concentration: 5								Concentration: 10							
	A	B	C	D	E	F	G	Init	A	B	C	D	E	F	G	Init
24	6	6	6	6	6			EMM	6	6	6	6	6			EMM
48	34	30	20	36	35			EM	26	40	34	39	32			EMM

Hrs	Concentration: 20								Concentration: 40							
	A	B	C	D	E	F	G	Init	A	B	C	D	E	F	G	Init
24	6	6	6	6	6			EMM	6	6	6	6	6			EMM
48	32	28	38	31	36			EMM	24	28	32	26	37			EMM

Sample Description: slightly yellow: W2, W16
Comments:

Reviewed by: JCh
Date reviewed: Nov-12/15

Freshwater Acute Toxicity Test
B. calyciflorus Survival

Client: Hydroqual (Cminnan)
Sample ID: W2: W16 (3:1)
Work Order: 15789

Start Date & Time: Oct 13/15 @1600h
Stop Date & Time: Oct 15/15 @1600h
Set up by: BH/EMM

(µg/L Cu)

Hrs	Concentration: 80								Concentration: 100							
	A	B	C	D	E	F	G	Init	A	B	C	D	E	F	G	Init
24	6	6	6	6	6			EMM	6	6	6	6	6			EMM
48	13	10	~~15~~ 16 EMM	14	9			EMM	0	0	0	0	0			EMM

Hrs	Concentration:								Concentration:							
	A	B	C	D	E	F	G	Init	A	B	C	D	E	F	G	Init
24																
48																

Hrs	Concentration:								Concentration:							
	A	B	C	D	E	F	G	Init	A	B	C	D	E	F	G	Init
24																
48																

Sample Description: slightly yellow ; W2, W16
Comments:

Reviewed by: JGU

Date reviewed: Nov. 12/15

Rotifer 48-h Life Cycle Test — **Nautilus Environmental**

Analysis ID:	07-1908-2018	**Endpoint:**	Growth Rate-r	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Oct-15 16:23	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes
Batch ID:	11-4341-8233	**Test Type:**	Rotifer Growth	**Analyst:**	Bonnie Lo
Start Date:	13 Oct-15	**Protocol:**	SNELL/ET&C 11 (1992)	**Diluent:**	
Ending Date:	15 Oct-15	**Species:**	Brachionus calyciflorus	**Brine:**	
Duration:	48h	**Source:**	Brine Shrimp Direct	**Age:**	
Sample ID:	14-7194-6422	**Code:**	15789	**Client:**	Minnow Environmental
Sample Date:	12 Oct-15 16:02	**Material:**	Copper (total)	**Project:**	
Receive Date:	13 Oct-15 16:02	**Source:**	Minnow Environmental		
Sample Age:	8h	**Station:**	W2/W16		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
6	56.25	-102.9	-98.89	0.7556	Yes	0.2443	3.403	0.7852	Non-Significant Lack of Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC5	52.9	N/A	62.08
IC10	56.56	N/A	65.74
IC15	60.02	50.07	69.15
IC20	63.38	54.16	72.41
IC25	66.73	58.06	75.65
IC40	77.23	69.2	86.37
IC50	85.21	76.35	96.06

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	0.7656	0.04293	0.6815	0.8497	17.84	<0.0001	Significant Parameter
C	3.455	0.7847	1.918	4.993	4.404	0.0002	Significant Parameter
D	85.21	5.38	74.66	95.75	15.84	<0.0001	Significant Parameter
E	0.00612	0.004585	-0.00287	0.01511	1.335	0.1935	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	0.925474	0.925474	1	92.68	<0.0001	Significant
Lack of Fit	0.00518	0.00259	2	0.2443	0.7852	Non-Significant
Pure Error	0.254446	0.010602	24			
Residual	0.259626	0.009986	26			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance	2.622	11.07	0.7580	Equal Variances
	Mod Levene Equality of Variance	0.2688	2.773	0.9243	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9347	0.9303	0.0655	Normal Distribution
	Anderson-Darling A2 Normality	0.7016	2.492	0.0669	Normal Distribution

Growth Rate-r Summary

			Calculated Variate						
C-ug/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	5	0.7657	0.5493	0.8673	0.05647	0.1263	16.49%	0.0%
14		5	0.8103	0.602	0.8959	0.05436	0.1216	15.0%	-5.83%
17.1		5	0.8644	0.7332	0.9486	0.03884	0.08686	10.05%	-12.89%
26.2		5	0.8494	0.7702	0.9229	0.02719	0.0608	7.16%	-10.93%
46.3		5	0.7886	0.6931	0.9096	0.03841	0.08588	10.89%	-2.99%
88.8		5	0.3518	0.2027	0.4904	0.05343	0.1195	33.97%	54.06%

Rotifer 48-h Life Cycle Test — **Nautilus Environmental**

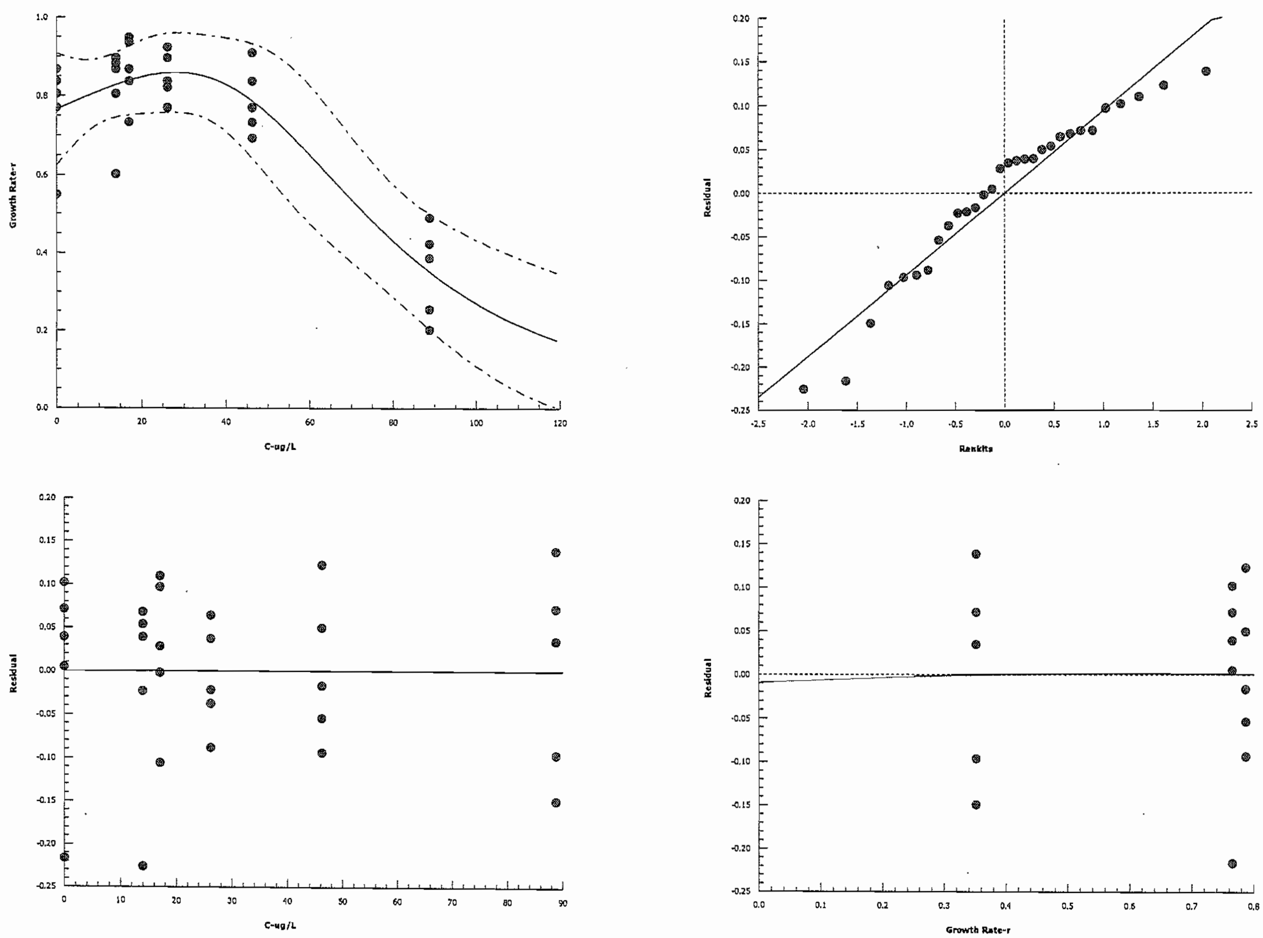
Analysis ID:	07-1908-2018	**Endpoint:**	Growth Rate-r	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Oct-15 16:23	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Growth Rate-r Detail

C-ug/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	Negative Control	0.8047	0.7702	0.8673	0.5493	0.837
14		0.8673	0.8047	0.602	0.8959	0.8818
17.1		0.7332	0.9486	0.8673	0.9359	0.837
26.2		0.837	0.7702	0.9229	0.8211	0.8959
46.3		0.6931	0.7702	0.837	0.7332	0.9096
88.8		0.3866	0.2554	0.4904	0.4236	0.2027

Graphics

4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]



CETIS Analytical Report

Report Date:	16 Nov-15 11:45 (p 1 of 1)		
Test Code:	15789 | 15-8083-7570		

Rotifer 48-h Life Cycle Test — **Nautilus Environmental**

Analysis ID:	03-5747-2073	**Endpoint:**	Growth Rate-r	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Nov-15 11:45	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes
Batch ID:	11-4341-8233	**Test Type:**	Rotifer Growth	**Analyst:**	Bonnie Lo
Start Date:	13 Oct-15	**Protocol:**	SNELL/ET&C 11 (1992)	**Diluent:**	
Ending Date:	15 Oct-15	**Species:**	Brachionus calyciflorus	**Brine:**	
Duration:	48h	**Source:**	Brine Shrimp Direct	**Age:**	
Sample ID:	14-7194-6422	**Code:**	15789	**Client:**	Minnow Environmental
Sample Date:	12 Oct-15 16:02	**Material:**	Copper (total)	**Project:**	
Receive Date:	13 Oct-15 16:02	**Source:**	Minnow Environmental		
Sample Age:	8h	**Station:**	W2/W16		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C > T	NA	NA	16.0%	Passes growth rate-r

Equal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		7.3	-1.561	1.86	0.123	8	0.9214	CDF	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.02648649	0.02648649	1	2.436	0.1572	Non-Significant Effect
Error	0.08696895	0.01087112	8			
Total	0.1134554		9			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	2.749	23.2	0.3509	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.8637	0.741	0.0843	Normal Distribution

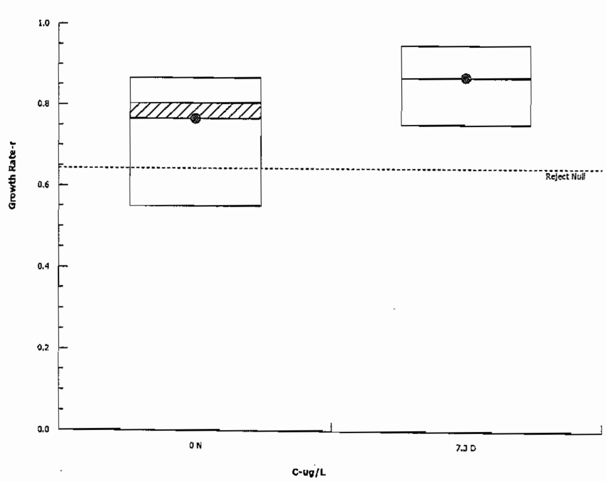
Growth Rate-r Summary

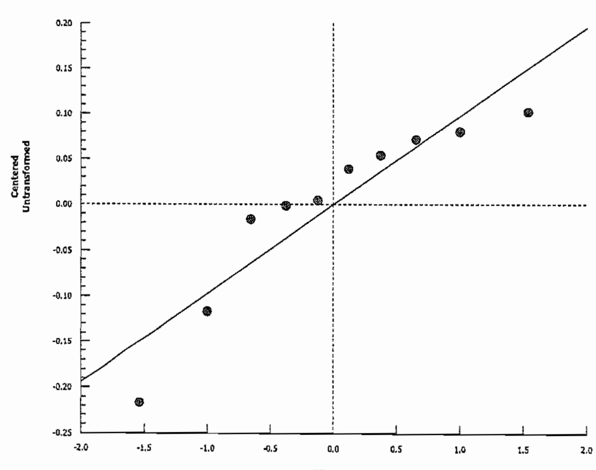
C-ug/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	5	0.7657	0.6089	0.9225	0.8047	0.5493	0.8673	0.05647	16.5%	0.0%
7.3	Dilution Water	5	0.8686	0.7741	0.9632	0.8673	0.752	0.9486	0.03406	8.77%	-13.4%

Growth Rate-r Detail

C-ug/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	Negative Control	0.8047	0.7702	0.8673	0.5493	0.837
7.3	Dilution Water	0.9229	0.752	0.8673	0.9486	0.8524

Graphics





Rotifer 48-h Life Cycle Test | **Nautilus Environmental**

Analysis ID:	13-1051-7114	**Endpoint:**	Growth Rate-r	**CETIS Version:**	CETISv1.8.7
Analyzed:	01 Mar-16 12:46	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes
Batch ID:	11-4341-8233	**Test Type:**	Rotifer Growth	**Analyst:**	Bonnie Lo
Start Date:	13 Oct-15	**Protocol:**	SNELL/ET&C 11 (1992)	**Diluent:**	
Ending Date:	15 Oct-15	**Species:**	Brachionus calyciflorus	**Brine:**	
Duration:	48h	**Source:**	Brine Shrimp Direct	**Age:**	
Sample ID:	14-7194-6422	**Code:**	15789	**Client:**	Minnow Environmental
Sample Date:	12 Oct-15 16:02	**Material:**	Copper (total)	**Project:**	
Receive Date:	13 Oct-15 16:02	**Source:**	Minnow Environmental		
Sample Age:	8h	**Station:**	W2/W16		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	20.1%	46.3	88.8	64.12	

Dunnett Multiple Comparison Test

Control	vs	C-ug/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		14	-0.6853	2.362	0.154	8	0.9616	CDF	Non-Significant Effect
		17.1	-1.515	2.362	0.154	8	0.9964	CDF	Non-Significant Effect
		26.2	-1.286	2.362	0.154	8	0.9927	CDF	Non-Significant Effect
		46.3	-0.3519	2.362	0.154	8	0.9166	CDF	Non-Significant Effect
		88.8*	6.357	2.362	0.154	8	<0.0001	CDF	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.9306532	0.1861306	5	17.56	<0.0001	Significant Effect
Error	0.2544462	0.01060192	24			
Total	1.185099		29			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	2.622	15.09	0.7580	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9292	0.9031	0.0467	Normal Distribution

Growth Rate-r Summary

C-ug/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	5	0.7657	0.6089	0.9225	0.8047	0.5493	0.8673	0.05647	16.49%	0.0%
14		5	0.8103	0.6594	0.9613	0.8673	0.602	0.8959	0.05436	15.0%	-5.83%
17.1		5	0.8644	0.7565	0.9722	0.8673	0.7332	0.9486	0.03884	10.05%	-12.89%
26.2		5	0.8494	0.7739	0.9249	0.837	0.7702	0.9229	0.02719	7.16%	-10.93%
46.3		5	0.7886	0.682	0.8953	0.7702	0.6931	0.9096	0.03841	10.89%	-2.99%
88.8		5	0.3518	0.2034	0.5001	0.3866	0.2027	0.4904	0.05343	33.97%	54.06%

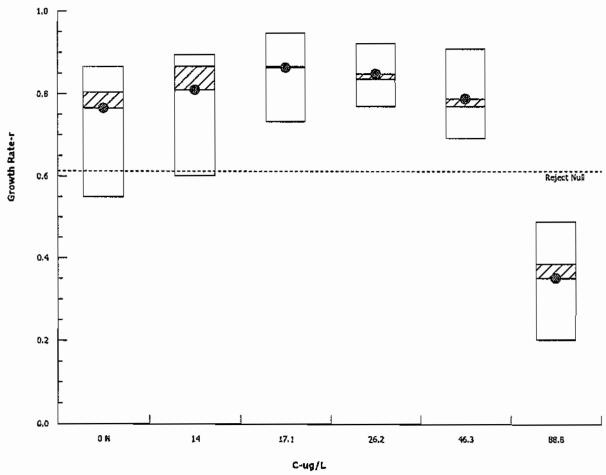
Growth Rate-r Detail

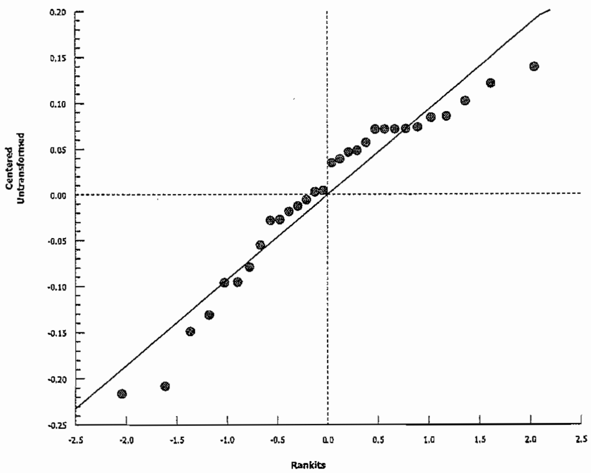
C-ug/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	Negative Control	0.8047	0.7702	0.8673	0.5493	0.837
14		0.8673	0.8047	0.602	0.8959	0.8818
17.1		0.7332	0.9486	0.8673	0.9359	0.837
26.2		0.837	0.7702	0.9229	0.8211	0.8959
46.3		0.6931	0.7702	0.837	0.7332	0.9096
88.8		0.3866	0.2554	0.4904	0.4236	0.2027

Rotifer 48-h Life Cycle Test — **Nautilus Environmental**

Analysis ID:	13-1051-7114	**Endpoint:**	Growth Rate-r	**CETIS Version:**	CETISv1.8.7
Analyzed:	01 Mar-16 12:46	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Graphics





CETIS Analytical Report

Rotifer 48-h Life Cycle Test — **Nautilus Environmental**

Analysis ID:	00-5481-7618	**Endpoint:**	Growth Rate-r	**CETIS Version:**	CETISv1.8.7
Analyzed:	03 May-16 16:38	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes
Batch ID:	19-2235-6244	**Test Type:**	Rotifer Growth	**Analyst:**	Bonnie Lo
Start Date:	13 Oct-15	**Protocol:**	SNELL/ET&C 11 (1992)	**Diluent:**	
Ending Date:	15 Oct-15	**Species:**	Brachionus calyciflorus	**Brine:**	
Duration:	48h	**Source:**	Brine Shrimp Direct	**Age:**	
Sample ID:	08-5664-2093	**Code:**	15789d	**Client:**	Minnow Environmental
Sample Date:	12 Oct-15 16:02	**Material:**	Copper (dissolved)	**Project:**	
Receive Date:	13 Oct-15 16:02	**Source:**	Minnow Environmental		
Sample Age:	8h	**Station:**	W2/W16		

Non-Linear Regression Options

Model Function	X Transform	Y Transform	Weighting Function	PTBS Function
4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]	None	None	Normal [W=1]	Off [Y*=Y]

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
6	56.35	-103.1	-99.1	0.7573	Yes	0.1595	3.403	0.8535	Non-Significant Lack of Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC5	37.25	N/A	44.16
IC10	39.98	N/A	46.94
IC15	42.59	35.18	49.54
IC20	45.15	38.22	52.06
IC25	47.7	41.14	54.57
IC40	55.83	49.63	63
IC50	62.1	55.15	70.73

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
A	0.7641	0.04246	0.6809	0.8474	18	<0.0001	Significant Parameter
C	3.2	0.7002	1.828	4.573	4.57	0.0001	Significant Parameter
D	62.1	4.246	53.78	70.42	14.62	<0.0001	Significant Parameter
E	0.009471	0.00694	-0.00413	0.02307	1.365	0.1841	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	0.927272	0.927272	1	93.51	<0.0001	Significant
Lack of Fit	0.003382	0.001691	2	0.1595	0.8535	Non-Significant
Pure Error	0.254446	0.010602	24			
Residual	0.257828	0.009916	26			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance	2.622	11.07	0.7580	Equal Variances
	Mod Levene Equality of Variance	0.2688	2.773	0.9243	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9347	0.9303	0.0657	Normal Distribution
	Anderson-Darling A2 Normality	0.7051	2.492	0.0656	Normal Distribution

Growth Rate-r Summary

			Calculated Variate						
C-ug/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	5	0.7657	0.5493	0.8673	0.05647	0.1263	16.49%	0.0%
8.7		5	0.8103	0.602	0.8959	0.05436	0.1216	15.0%	-5.83%
12.6		5	0.8644	0.7332	0.9486	0.03884	0.08686	10.05%	-12.89%
17.7		5	0.8494	0.7702	0.9229	0.02719	0.0608	7.16%	-10.93%
32.2		5	0.7886	0.6931	0.9096	0.03841	0.08588	10.89%	-2.99%
64.9		5	0.3518	0.2027	0.4904	0.05343	0.1195	33.97%	54.06%

Rotifer 48-h Life Cycle Test — **Nautilus Environmental**

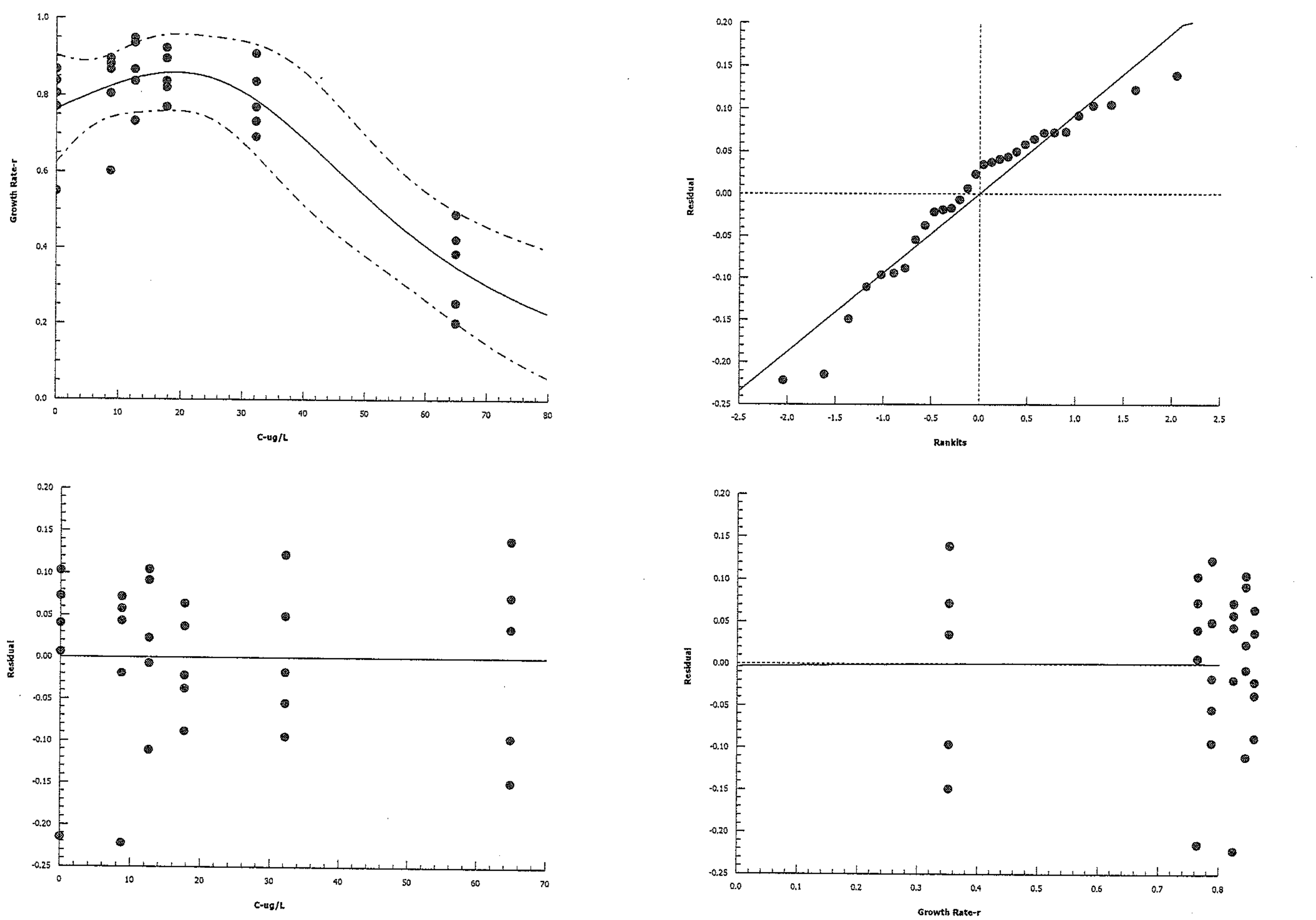
Analysis ID:	00-5481-7618	**Endpoint:**	Growth Rate-r	**CETIS Version:**	CETISv1.8.7
Analyzed:	03 May-16 16:38	**Analysis:**	Nonlinear Regression	**Official Results:**	Yes

Growth Rate-r Detail

C-ug/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	Negative Control	0.8047	0.7702	0.8673	0.5493	0.837
8.7		0.8673	0.8047	0.602	0.8959	0.8818
12.6		0.7332	0.9486	0.8673	0.9359	0.837
17.7		0.837	0.7702	0.9229	0.8211	0.8959
32.2		0.6931	0.7702	0.837	0.7332	0.9096
64.9		0.3866	0.2554	0.4904	0.4236	0.2027

Graphics

4P Log-Logistic+Hormesis EV [Y=A(1+EX)/(1+(2ED+1)(X/D)^C)]



Client: Minnow Environmental

W.O.#: 15789

Hardness and Alkalinity Datasheet

	Alkalinity						Hardness			
Sample ID	Sample Date	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity (mg/L$CaCO_3$)		Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness (mg/L $CaCO_3$)	Technician
MHW Ctrl	Oct13/15	50	4.0	4.4	72		50	5.0	100	EMM/MHL

Notes:

Reviewed by: JOW

Date Reviewed: Nov. 16/15

Nominal (µg/L Cu)	Initial Total Cu	Final Total Cu	Average
0 (Lab Ctrl)	0	0	0
0 (Site Ctrl)	6.91	7.7	7.305
5	11.5	16.6	14.05
10	17.3	16.9	17.1
20	27.7	24.6	26.15
40	50.1	42.5	46.3
80	98.7	78.8	88.75
160	174	162	168

APPENDIX B –*Daphnia magna* Toxicity Test Data

HydroQual Laboratories Ltd.
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Daphnia Bench Sheet

Method 21-d DA | Client JAU104 | Sample SP15-013

Test Log

Date	Day	Time	Technicians	Fed (✓)	Comments
2015/10/07	0	1200	HKS/LO/BS	✓	YAT Expires 10/17
2015/10/08	1	1600	HKS/ML	✓	YAT Expires 10/17
2015/10/09	2	830	DS	✓	YAT Expires 10/17
2015/10/10	3	1300	CQ/JK	✓	YAT Expires 10/24
2015/10/11	4	1305	NM	✓	YAT Expires 10/24
2015/10/12	5	1400	ML	✓	YAT Expires 10/24
2015/10/13	6	915	HKS	✓	YAT Expires 10/24
2015/10/14	7	930	HKS	✓	YAT Expires 10/24
2015/10/15	8	1200	HKS	✓	YAT Expires 11/01
2015/10/16	9	1200	DS	✓	YAT Expires 11/01
2015/10/17	10	1500	CQ	✓	YAT Expires 11/01
2015/10/18	11	920	NM	✓	YAT Expires 11/01
2015/10/19	12	1035	NM	✓	YAT Expires 11/01
2015/10/20	13	900	HKS/JN	✓	YAT Expires 11/01
2015/10/21	14	1000	HKS/JN	✓	YAT Expires 11/01
2015/10/22	15	1015	HKS	✓	YAT Expires 11/08
2015/10/23	16	1130	DS	✓	YAT Expires 11/08
2015/10/24	17	1130	CQ	✓	YAT Expires 11/08
2015/10/25	18	1210	HKS	✓	YAT Expires 11/08
2015/10/26	19	1330	HKS	✓	YAT Expires 11/08
2015/10/27	20	930	ML	✓	YAT Expires 11/08
2015/10/28	21	1025	NM	-	YAT Expires 11/08

Culture
Young jars C1 Jar(s) mortality 7 days prior to test (must be ≤25%) 0%

QA (previous month)
Days to first brood (≤12 days) 9
Average number of young produced (≥15 young) 17

Sample
Duration of pre-aeration (rate of 37.5 ± 12.5 mL/min.L-1) -
Hardness adjustment of sample (must be between 25 - 30 mg CaCO3/L) -

Lab Control Water

Day	Pail	Prep Date	Hardness (mg/L)	Day	Pail	Prep Date	Hardness (mg/L)
2015/10/07	A	2015/10/05	60	-	-	-	-
2015/10/09	D	2015/10/08	74	-	-	-	-
2015/10/12	C	2015/10/07	75	-	-	-	-
2015/10/19	D	2015/10/08	74	-	-	-	-
2015/10/21	D	2015/10/08	74	-	-	-	-
2015/10/26	D	2015/10/08	74	-	-	-	-

Meter/Probe Used: **water** / soil / sample sign-in / products

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Daphnia Bench Sheet

Client JAU104		Sample SP15-013

Chemistry (Monday, Wednesday, Friday)

dose (%) / day	New Solutions: Lab CTL	Site CTL	5	10	20	40	80	160	Old Solutions: Lab CTL	Site CTL	5	10	20	40	80	160
pH (units)									pH (units)							
0	7.3	8.0	8.1	8.1	8.1	8.2	8.2	8.2	-	-	-	-	-	-	-	-
2	8.0	8.1	8.1	8.1	8.1	8.1	8.1	8.1	7.8	8.1	8.1	8.2	8.2	8.2	8.2	8.2
5	7.8	8.1	8.2	8.2	8.2	8.2	8.2	8.2	7.7	8.1	8.1	8.1	8.1	8.1	8.2	8.2
7	7.7	8.2	8.2	8.2	8.2	8.3	8.3	8.3	7.7	8.2	8.2	8.2	8.2	8.3	8.3	8.2
9	7.4	7.9	7.9	8.0	8.0	8.0	8.0	8.1	7.6	8.0	8.0	8.1	8.2	8.1	8.2	8.2
12	7.3	7.8	7.8	7.9	7.9	8.0	8.0	8.0	7.8	8.1	8.1	8.0	8.0	8.0	8.1	8.0
14	7.9	8.1	8.2	8.2	8.3	7.3	8.2	-	7.9	8.2	8.3	8.3	8.3	8.3	8.3	-
16	7.7	8.0	8.1	8.1	8.1	8.3	8.2	-	7.7	8.0	8.1	8.1	8.1	8.1	8.2	-
19	8.2	8.3	8.3	8.3	8.4	8.4	8.4	-	8.1	8.3	8.4	8.4	8.4	8.4	8.4	-
21	-	-	-	-	-	-	-	-	8.0	8.3	8.3	8.3	8.3	8.3	8.4	-
conductance (uS/cm)									conductance (uS/cm)							
0	195	336	360	360	360	361	389	395	-	-	-	-	-	-	-	-
2	225	344	354	356	360	361	363	367	193	347	364	363	367	375	398	432
5	179	339	355	361	363	368	375	366	202	365	373	379	370	387	414	418
7	192	357	367	366	367	370	381	381	215	389	387	380	383	394	464	425
9	198	367	384	390	394	304	394	402	220	391	406	409	406	415	463	554
12	233	365	391	397	407	411	406	407	237	436	447	416	440	464	447	503
14	193	358	372	372	376	380	378	-	224	379	372	382	382	388	438	-
16	203	355	364	377	377	384	386	-	221	379	386	383	380	399	470	-
19	202	355	369	365	369	365	380	-	244	385	384	402	381	398	433	-
21	-	-	-	-	-	-	-	-	227	385	373	372	381	403	419	-
dissolved oxygen (mg/L)									dissolved oxygen (mg/L)							
0	8.0	8.1	8.2	8.2	8.2	8.2	8.1	8.2	-	-	-	-	-	-	-	-
2	8.0	8.0	8.0	8.1	8.1	8.1	8.1	8.1	7.9	7.8	7.8	7.8	7.7	7.7	7.8	7.8
5	8.1	8.2	8.2	8.2	8.2	8.1	8.2	8.3	8.2	8.1	8.1	8.1	8.1	8.0	7.9	7.9
7	8.4	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.4	8.6	8.5	8.4	8.4	8.4	8.5	8.6
9	8.1	8.2	8.2	8.3	8.3	8.3	8.2	8.3	8.1	8.1	8.2	8.2	8.1	8.1	8.2	8.3
12	8.3	8.3	8.3	8.3	8.2	8.2	8.5	8.5	8.0	7.8	7.9	7.7	7.9	8.2	8.2	8.1
14	7.9	8.0	8.1	8.1	8.1	8.1	8.0	-	8.0	8.1	8.0	7.9	7.6	7.6	7.9	-
16	8.1	8.2	8.2	8.1	8.2	8.2	8.3	-	8.0	8.1	8.0	8.0	7.9	8.0	7.9	-
19	8.4	8.4	8.4	8.3	8.3	8.3	8.3	-	8.3	8.1	8.0	7.9	7.9	7.9	8.1	-
21	-	-	-	-	-	-	-	-	8.1	7.9	7.9	8.0	8.1	8.1	8.3	-
temperature (^{o}C)									temperature (^{o}C)							
0	19.3	19.1	19.1	19.3	19.3	19.3	19.1	18.8	-	-	-	-	-	-	-	-
2	19.2	19.5	19.5	19.3	19.3	19.1	18.9	19.0	19.4	19.4	19.4	19.5	19.3	19.2	18.8	18.8
5	18.9	18.8	19.2	19.3	19.3	19.1	18.9	19.1	18.0	18.1	18.1	18.3	18.3	18.3	18.0	18.5
7	18.6	19.1	19.3	19.3	19.1	18.9	19.1	18.9	17.9	17.5	17.9	18.0	18.1	18.1	18.3	18.2
9	18.4	18.5	18.5	18.4	18.4	18.5	18.6	18.6	18.3	18.3	18.2	18.1	18.1	18.1	18.1	18.1
12	18.3	18.2	18.6	18.8	18.7	18.5	18.2	18.3	18.9	18.6	18.6	18.9	18.9	18.6	19.0	19.0
14	19.8	19.9	20.0	20.0	19.6	19.3	19.6	-	18.1	18.3	18.7	19.0	19.3	19.3	18.9	-
16	18.8	18.8	18.8	18.7	18.5	18.5	18.4	-	18.4	18.3	18.4	18.5	18.4	18.4	18.9	-
19	18.8	19.1	19.3	19.5	19.3	19.1	19.0	-	18.5	18.6	18.7	18.7	18.5	18.3	18.6	-
21	-	-	-	-	-	-	-	-	17.6	17.7	17.9	17.8	17.6	17.6	17.6	-

Alkalinity (mg/L CaCO3) day 21: Site Ctl -98 , 5 ug/L - 198, 10 ug/lL - 160, 20 ug/L - 153, 40 ug/L - 155, 80 ug/L - 168, 160 ug/L - 190

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Daphnia Bench Sheet

Client JAU104		Sample SP15-013

Biology (#, young produced; 0, no young; blank, dead; bold, number of young produced on the day it died)

dose (%)	Lab CT	Site CT	5	10	20	40	80	160	Lab CT	Site CT	5	10	20	40	80	160
replicate	day 1								day 5							
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	day 2								day 6							
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
3	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	-
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	day 3								day 7							
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
3	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	-
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
8	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	-
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
	day 4								day 8							
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
3	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	-
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
8	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	-
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-

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Daphnia Bench Sheet

Client	JAU104		Sample	SP15-013

Biology (#, young produced; 0, no young; blank, dead; bold, number of young produced on the day it died)

dose (%)	Lab CT	Site CT	5	10	20	40	80	160
replicate	day 9							
1	0	0	8	21	0	0	-	-
2	0	0	0	0	0	0	0	-
3	0	0	19	15	0	0	0	-
4	0	0	0	0	0	0	0	0
5	0	0	25	0	7	10	9	-
6	0	0	0	17	0	10	0	-
7	0	0	0	0	0	23	0	-
8	0	0	0	0	0	0	0	-
9	0	0	0	9	13	9	0	-
10	0	0	0	0	**0**	0	0	-
	day 10							
1	0	18	0	0	16	20	-	-
2	0	20	26	23	23	27	0	-
3	0	20	4	0	14	24	11	-
4	0	0	20	24	16	25	0	0
5	0	12	0	19	0	0	0	-
6	0	21	19	0	20	0	0	-
7	0	23	24	22	11	0	0	-
8	0	20	23	22	12	21	0	-
9	0	0	29	0	0	0	0	-
10	0	19	31	12	-	24	0	-
	day 11							
1	10	0	0	0	0	0	-	-
2	13	0	0	0	0	0	13	-
3	6	0	0	0	0	0	0	-
4	7	0	0	0	0	0	23	0
5	14	3	0	0	0	27	24	-
6	12	3	0	0	0	26	0	-
7	**0**	0	0	0	0	0	27	-
8	0	11	0	0	0	0	18	-
9	15	15	0	26	0	0	22	-
10	20	0	0	0	-	0	20	-
	day 12							
1	0	0	30	0	0	0	-	-
2	0	0	0	0	0	0	0	-
3	0	2	0	0	0	0	0	-
4	2	0	0	0	0	0	0	-
5	0	0	0	0	22	0	0	**0**
6	0	0	0	0	0	0	0	-
7	-	0	0	0	0	18	0	-
8	6	0	0	0	0	0	3	-
9	0	0	0	0	28	31	0	-
10	0	0	0	0	-	0	0	-

dose (%)	Lab CT	Site CT	5	10	20	40	80	160
replicate	day 13							
1	0	0	0	34	40	42	-	-
2	0	0	32	41	39	0	0	-
3	0	30	35	30	**28**	32	12	-
4	0	0	23	43	35	35	0	-
5	0	43	39	37	0	0	0	-
6	0	38	33	35	**2**	**0**	25	-
7	0	0	26	42	35	18	0	-
8	0	0	35	30	19	31	0	-
9	0	0	23	0	0	0	0	-
10	0	0	2	41	-	48	0	-
	day 14							
1	0	32	0	0	0	0	-	-
2	29	35	0	0	0	38	0	-
3	0	0	0	0	-	0	0	-
4	22	29	0	0	0	0	29	-
5	27	2	0	0	0	0	0	-
6	21	0	0	0	-	-	**0**	-
7	-	39	0	0	0	0	27	-
8	0	17	0	0	0	0	**27**	-
9	0	38	0	0	0	0	36	-
10	0	42	35	0	-	0	0	-
	day 15							
1	26	0	33	0	6	0	-	-
2	0	0	0	0	0	0	0	-
3	0	0	0	0	-	0	0	-
4	0	0	0	0	0	0	0	-
5	0	0	0	0	16	0	5	-
6	0	0	0	0	-	-	-	-
7	-	0	0	0	0	0	0	-
8	26	0	0	0	0	0	-	-
9	31	0	0	27	27	20	0	-
10	29	0	0	0	-	0	0	-
	day 16							
1	0	0	3	28	32	0	-	-
2	0	0	25	22	0	0	0	-
3	0	0	32	29	-	23	0	-
4	0	0	26	40	25	0	0	-
5	0	25	23	33	0	22	0	-
6	0	33	37	26	-	-	-	-
7	0	0	26	25	25	9	0	-
8	0	0	22	30	15	0	-	-
9	0	0	0	0	0	0	0	-
10	0	0	0	0	-	0	0	-

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Daphnia Bench Sheet

Client JAU104		Sample SP15-013

Biology (#, young produced; 0, no young; blank, dead; bold, number of young produced on the day it died)

dose (%)	ab CT	Site CT	5	10	20	40	80	160
replicate	day 17							
1	0	0	0	0	0	26	-	-
2	0	19	0	0	26	23	0	-
3	0	22	0	0	0	0	0	-
4	25	17	0	0	0	44	0	-
5	0	0	0	0	0	0	0	-
6	0	0	0	0	0	0	-	-
7	-	22	0	0	0	0	0	-
8	0	0	0	0	0	14	-	-
9	0	0	25	0	0	0	0	-
10	0	33	26	20	0	29	0	-
	day 18							
1	32	30	0	0	0	0	-	-
2	34	0	0	0	0	0	0	-
3	0	0	0	0	-	**0**	0	-
4	0	0	0	0	0	0	2	-
5	30	0	0	0	0	31	0	-
6	27	0	0	0	-	-	-	-
7	-	0	0	0	0	0	0	-
8	28	27	0	0	0	0	-	-
9	36	33	0	31	32	28	0	-
10	31	0	0	0	-	0	0	-
	day 19							
1	0	0	32	0	0	0	-	-
2	0	0	0	0	0	0	0	-
3	0	0	36	27	-	-	0	-
4	0	0	29	29	37	0	0	-
5	0	0	33	32	17	0	0	-
6	0	0	17	27	-	-	-	-
7	-	0	0	23	35	27	0	-
8	0	0	23	29	**0**	0	-	-
9	0	0	0	0	0	0	0	-
10	0	0	0	0	-	0	0	-
	day 20							
1	0	0	0	12	36	0	-	-
2	0	0	24	15	35	0	0	-
3	0	0	0	0	-	-	**0**	-
4	0	0	0	0	0	0	0	-
5	0	19	0	0	0	0	0	-
6	0	41	13	0	-	-	-	-
7	-	0	26	0	0	0	0	-
8	0	0	2	0	-	0	-	-
9	0	0	28	0	0	0	**0**	-
10	0	0	7	34	-	26	11	-

replicate	Lab CT	Site CT	5	10	20	40	80	160
	day 21							
1	0	0	0	0	0	31	-	-
2	0	22	0	0	0	30	0	-
3	0	16	0	0	-	-	-	-
4	39	15	0	0	0	26	0	-
5	38	0	0	0	0	0	0	-
6	44	0	0	0	-	-	-	-
7	-	28	0	0	0	0	0	-
8	0	0	0	0	-	22	-	-
9	0	0	0	28	0	0	-	-
10	0	36	15	0	-	0	0	-

***Daphnia magna* 21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	20-8026-4996	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 14:03	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Daphnia magna	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
4P Log-Logistic+Hormesis: μ=α[1+ε·x]/[1+[2ε·δ+1]·[x/δ]^γ]	Normal: ω=1	Off: μ*=μ	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
77	-268.1	544.8	553.8	0.5689	Yes	5.946	2.499	0.0003	Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	66.46	n/a	n/a	1.505	n/a	n/a
IC10	68.17	n/a	n/a	1.467	n/a	n/a
IC15	69.63	n/a	n/a	1.436	n/a	n/a
IC20	70.95	n/a	n/a	1.409	n/a	n/a
IC25	72.17	n/a	n/a	1.386	n/a	n/a
IC40	75.56	n/a	n/a	1.323	n/a	n/a
IC50	77.81	n/a	n/a	1.285	n/a	n/a

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	90.19	6.413	77.41	103	14.06	<1.0E-37	Significant Parameter
γ	12.11	251.9	-489.6	513.8	0.04806	0.9618	Non-Significant Parameter
δ	77.81	45.24	-12.3	167.9	1.72	0.0895	Non-Significant Parameter
ε	0.002035	0.004909	-0.00774	0.01181	0.4145	0.6796	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Lack of Fit	15990	3997	4	5.946	3.4E-04	Significant
Model	534400	133600	4	157.7	<1.0E-37	Significant
Pure Error	48400	672.3	72			
Residual	64390	847.3	76			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.313	3.306	0.0486	Outlier Detected
Variances	Mod Levene Equality of Variance	6.975	2.14	2.4E-06	Unequal Variances
Distribution	Shapiro-Wilk W Normality Test	0.8766	0.9691	1.4E-06	Non-Normal Distribution
	Anderson-Darling A2 Normality Te	2.902	2.492	<1.0E-37	Non-Normal Distribution

Daphnia magna **21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	20-8026-4996	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 14:03	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

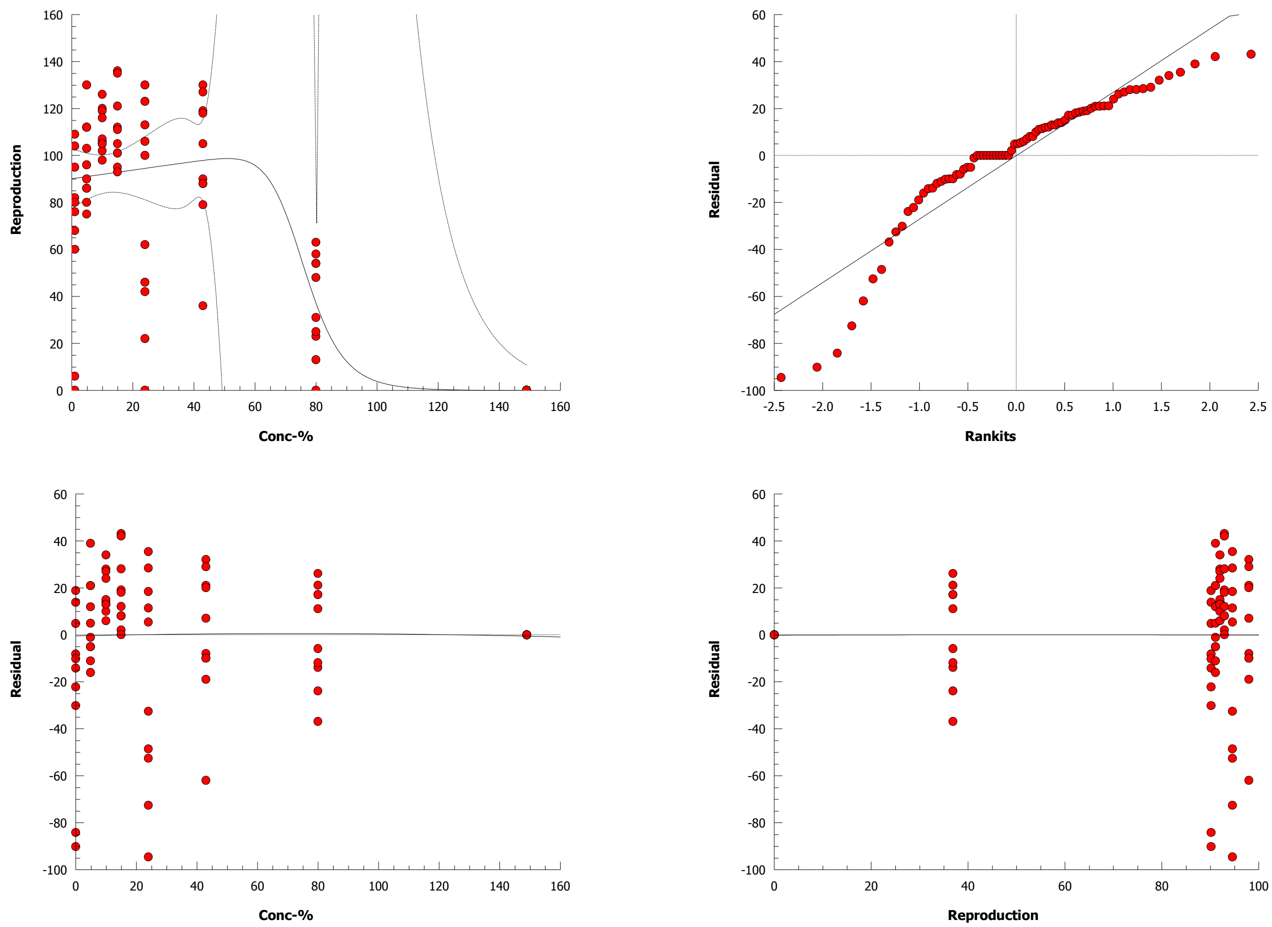
Reproduction Summary

Conc-%	Code	Count	Calculated Variate Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	10	68	0	109	11.85	37.48	55.12%	0.00%
4.9		10	97	75	130	5.416	17.13	17.66%	-42.65%
10		10	110.4	98	126	2.895	9.155	8.29%	-62.35%
15		10	111	93	136	4.851	15.34	13.82%	-63.24%
24		10	74.4	0	130	14.49	45.81	61.57%	-9.41%
43		10	98	36	130	8.959	28.33	28.91%	-44.12%
80		10	36.9	0	63	6.78	21.44	58.10%	45.74%
149		10	0	0	0	0	0		100.00%

Reproduction Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	68	76	6	95	109	104	0	60	82	80
4.9		80	96	90	86	112	103	112	75	86	130
10		106	107	126	98	120	119	102	105	105	116
15		95	101	101	136	121	105	112	111	93	135
24		130	123	42	113	62	22	106	46	100	0
43		119	118	79	130	90	36	105	88	88	127
80		0	13	23	54	63	25	54	48	58	31
149		0	0	0	0	0	0	0	0	0	0

Graphics Model: 4P Log-Logistic+Hormesis: μ=α[1+ε·x]/[1+[2ε·δ+1]·[x/δ]^γ] Distribution: Normal [ω=1]



***Daphnia magna* 21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	09-8333-3709	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:24	**Analysis:**	Nonparametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Daphnia magna	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Untransformed	C > T	n/a	n/a	n/a	43	80	58.65	2.326	42.7%

Steel Many-One Rank Sum Test

Control vs	Conc-%	Test Stat	Critical	Ties	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	4.9	131.5	74	1	18	Asymp	0.9998	Non-Significant Effect
	10	147	74	0	18	Asymp	1.0000	Non-Significant Effect
	15	144.5	74	1	18	Asymp	1.0000	Non-Significant Effect
	24	111.5	74	1	18	Asymp	0.9520	Non-Significant Effect
	43	132	74	0	18	Asymp	0.9998	Non-Significant Effect
	80*	74.5	74	1	18	Asymp	0.0484	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.809	3.258	0.2738	No Outliers Detected
Treatment Effect	Kruskal-Wallis Omnibus Test	29.92	12.59	4.1E-05	Significant Overall Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	43490.6	7248.43	6	9.434	2.2E-07	Significant Effect
Error	48403.7	768.313	63			
Total	91894.3		69			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	27.83	16.81	1.0E-04	Unequal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9599	0.9526	0.0248	Normal Distribution

Reproduction Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	10	68	41.19	94.81	78	0	109	11.85	55.12%	0.00%
4.9		10	97	84.75	109.3	93	75	130	5.416	17.66%	-42.65%
10		10	110.4	103.9	116.9	106.5	98	126	2.895	8.29%	-62.35%
15		10	111	100	122	108	93	136	4.851	13.82%	-63.24%
24		10	74.4	41.63	107.2	81	0	130	14.49	61.57%	-9.41%
43		10	98	77.73	118.3	97.5	36	130	8.959	28.91%	-44.12%
80		10	36.9	21.56	52.24	39.5	0	63	6.78	58.10%	45.74%
149		10	0	0	0	0	0	0	0		100.00%

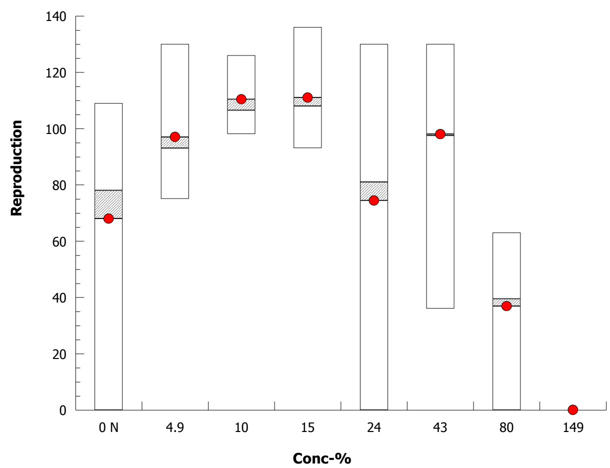
Daphnia magna **21-d Survival and Reproduction Test** **HydroQual Laboratories, Ltd**

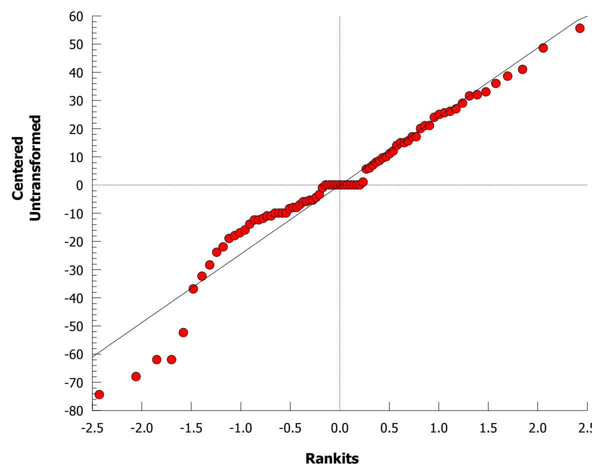
Analysis ID: 09-8333-3709 **Endpoint:** Reproduction **CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 10:24 **Analysis:** Nonparametric-Control vs Treatments **Official Results:** Yes

Reproduction Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	68	76	6	95	109	104	0	60	82	80
4.9		80	96	90	86	112	103	112	75	86	130
10		106	107	126	98	120	119	102	105	105	116
15		95	101	101	136	121	105	112	111	93	135
24		130	123	42	113	62	22	106	46	100	0
43		119	118	79	130	90	36	105	88	88	127
80		0	13	23	54	63	25	54	48	58	31
149		0	0	0	0	0	0	0	0	0	0

Graphics





***Daphnia magna* 21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	18-1388-8174	**Endpoint:**	21-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 9:37	**Analysis:**	Untrimmed Spearman-Kärber	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Daphnia magna	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Spearman-Kärber Estimates

Threshold Option	Threshold	Trim	Mu	Sigma	LC50	95% LCL	95% UCL
Control Threshold	0.1	0.00%	1.768	0.06529	58.67	43.44	79.25

21-d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-%	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	N	10	0.9000	0.0000	1.0000	0.1000	0.3162	35.14%	0.00%	9	10
4.9		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
10		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
15		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
24		10	0.6000	0.0000	1.0000	0.1633	0.5164	86.07%	33.33%	6	10
43		10	0.8000	0.0000	1.0000	0.1333	0.4216	52.70%	11.11%	8	10
80		10	0.5000	0.0000	1.0000	0.1667	0.5270	105.41%	44.44%	5	10
149		10	0.0000	0.0000	0.0000	0.0000	0.0000		100.00%	0	10

21-d Survival Rate Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000
4.9		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
15		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
24		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000
43		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
80		0.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000
149		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

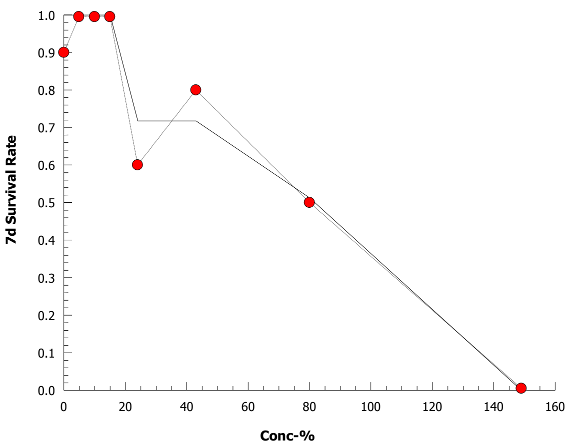
21-d Survival Rate Binomials

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1/1	1/1	1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1
4.9		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
10		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
15		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
24		1/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	1/1	0/1
43		1/1	1/1	0/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1
80		0/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	0/1	1/1
149		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Daphnia magna **21-d Survival and Reproduction Test** | **HydroQual Laboratories, Ltd**

Analysis ID:	18-1388-8174	**Endpoint:**	21-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 9:37	**Analysis:**	Untrimmed Spearman-Kärber	**Official Results:**	Yes

Graphics



CETIS Analytical Report

***Daphnia magna* 21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID: 16-7744-2771 **Endpoint:** 21-d Survival Rate **CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 9:38 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

Batch ID: **Test Type:** **Analyst:**
Start Date: **Protocol:** **Diluent:**
Ending Date: **Species:** Daphnia magna **Brine:**
Duration: **Source:** **Age:**

Sample ID: **Code:** **Client:**
Sample Date: **Material:** Total copper **Project:**
Receipt Date: **Source:**
Sample Age: **Station:**

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1645540	200	Yes	Two-Point Interpolation

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	16.32	15.78	23.45	6.128	4.265	6.336
LC10	17.74	16.61	35.62	5.636	2.808	6.022
LC15	19.29	17.47	46.49	5.185	2.151	5.725
LC20	20.96	18.37	58.18	4.772	1.719	5.443
LC25	22.76	19.32	81.8	4.393	1.222	5.176
LC40	61.5	22.46	92.25	1.626	1.084	4.453
LC50	81.26	54.31	99.94	1.231	1.001	1.841

21-d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-%	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0	N	10	0.9000	0.0000	1.0000	0.1000	0.3162	35.14%	0.00%	9	10
4.9		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
10		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
15		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
24		10	0.6000	0.0000	1.0000	0.1633	0.5164	86.07%	33.33%	6	10
43		10	0.8000	0.0000	1.0000	0.1333	0.4216	52.70%	11.11%	8	10
80		10	0.5000	0.0000	1.0000	0.1667	0.5270	105.41%	44.44%	5	10
149		10	0.0000	0.0000	0.0000	0.0000	0.0000		100.00%	0	10

21-d Survival Rate Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000
4.9		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
15		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
24		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000
43		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
80		0.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000
149		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

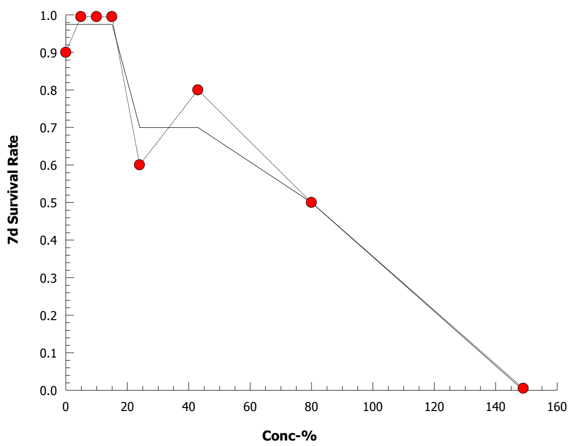
21-d Survival Rate Binomials

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1/1	1/1	1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1
4.9		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
10		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
15		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
24		1/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	1/1	0/1
43		1/1	1/1	0/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1
80		0/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	0/1	1/1
149		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Daphnia magna **21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	16-7744-2771	**Endpoint:**	21-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 9:38	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Daphnia magna **21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	02-4479-2757	**Endpoint:**	21-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 9:39	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Daphnia magna	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Angular (Corrected)	C > T	n/a	n/a	n/a	43	80	58.65	2.326	42.1%

Dunnett Multiple Comparison Test

Control vs	Conc-%	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	4.9	-0.6524	2.342	0.188	18	CDF	0.9681	Non-Significant Effect
	10	-0.6524	2.342	0.188	18	CDF	0.9681	Non-Significant Effect
	15	-0.6524	2.342	0.188	18	CDF	0.9681	Non-Significant Effect
	24	1.957	2.342	0.188	18	CDF	0.1106	Non-Significant Effect
	43	0.6524	2.342	0.188	18	CDF	0.6120	Non-Significant Effect
	80*	2.61	2.342	0.188	18	CDF	0.0268	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.697139	0.11619	6	3.608	0.0039	Significant Effect
Error	2.02875	0.032202	63			
Total	2.72589		69			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Levene Equality of Variance Test	25.43	3.103	<1.0E-37	Unequal Variances
Variances	Mod Levene Equality of Variance Test	5.449	3.103	1.4E-04	Unequal Variances
Distribution	Shapiro-Wilk W Normality Test	0.8536	0.9526	8.7E-07	Non-Normal Distribution

7d Survival Rate Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	10	0.9000	0.6738	1.0000	1.0000	0.0000	1.0000	0.1000	35.14%	0.00%
4.9		10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.00%	-11.11%
10		10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.00%	-11.11%
15		10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.00%	-11.11%
24		10	0.6000	0.2306	0.9694	1.0000	0.0000	1.0000	0.1633	86.07%	33.33%
43		10	0.8000	0.4984	1.0000	1.0000	0.0000	1.0000	0.1333	52.70%	11.11%
80		10	0.5000	0.1230	0.8770	0.5000	0.0000	1.0000	0.1667	105.41%	44.44%
149		10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		100.00%

Angular (Corrected) Transformed Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	10	0.9948	0.8764	1.113	1.047	0.5236	1.047	0.05236	16.64%	0.00%
4.9		10	1.047	1.047	1.047	1.047	1.047	1.047	0	0.00%	-5.26%
10		10	1.047	1.047	1.047	1.047	1.047	1.047	0	0.00%	-5.26%
15		10	1.047	1.047	1.047	1.047	1.047	1.047	0	0.00%	-5.26%
24		10	0.8378	0.6443	1.031	1.047	0.5236	1.047	0.0855	32.27%	15.79%
43		10	0.9425	0.7845	1.1	1.047	0.5236	1.047	0.06981	23.42%	5.26%
80		10	0.7854	0.588	0.9828	0.7854	0.5236	1.047	0.08727	35.14%	21.05%
149		10	0.5236	0.5235	0.5237	0.5236	0.5236	0.5236	0	0.00%	47.37%

***Daphnia magna* 21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID: 02-4479-2757 **Endpoint:** 21-d Survival Rate **CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 9:39 **Analysis:** Parametric-Control vs Treatments **Official Results:** Yes

21-d Survival Rate Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000
4.9		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
15		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
24		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000
43		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
80		0.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000
149		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

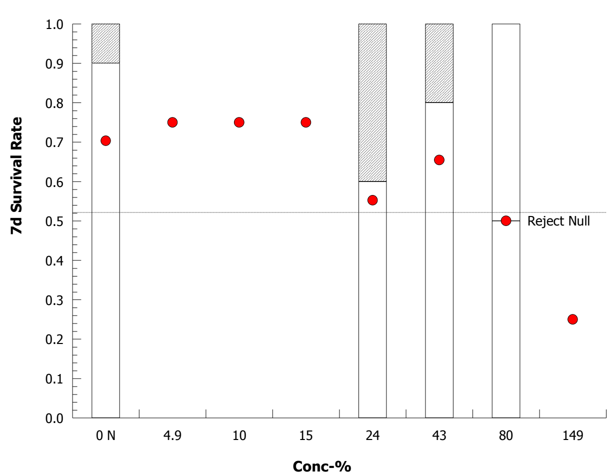
Angular (Corrected) Transformed Detail

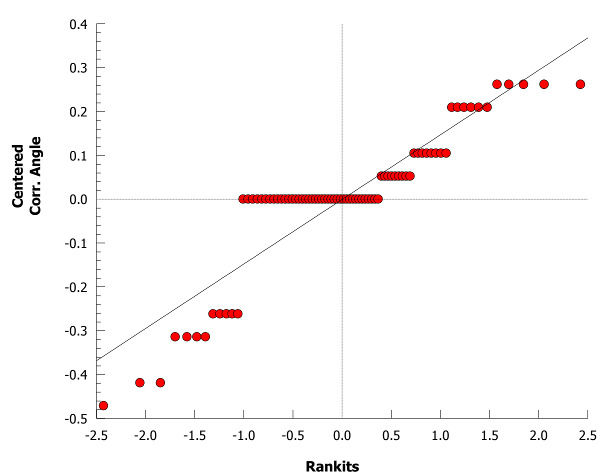
Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1.047	1.047	1.047	1.047	1.047	1.047	0.5236	1.047	1.047	1.047
4.9		1.047	1.047	1.047	1.047	1.047	1.047	1.047	1.047	1.047	1.047
10		1.047	1.047	1.047	1.047	1.047	1.047	1.047	1.047	1.047	1.047
15		1.047	1.047	1.047	1.047	1.047	1.047	1.047	1.047	1.047	1.047
24		1.047	1.047	0.5236	1.047	1.047	0.5236	1.047	0.5236	1.047	0.5236
43		1.047	1.047	0.5236	1.047	1.047	0.5236	1.047	1.047	1.047	1.047
80		0.5236	1.047	0.5236	1.047	1.047	0.5236	1.047	0.5236	0.5236	1.047
149		0.5236	0.5236	0.5236	0.5236	0.5236	0.5236	0.5236	0.5236	0.5236	0.5236

21-d Survival Rate Binomials

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1/1	1/1	1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1
4.9		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
10		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
15		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
24		1/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	1/1	0/1
43		1/1	1/1	0/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1
80		0/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	0/1	1/1
149		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Graphics





CETIS Analytical Report

***Daphnia magna* 21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	16-7458-6842	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 9:49	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Daphnia magna	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
4P Log-Logistic+Hormesis: μ=α[1+ε·x]/[1+[2ε·δ+1]·[x/δ]^γ]	Normal: ω=1	Off: μ*=μ	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
42	-268	544.6	553.6	0.5700	Yes	5.886	2.499	0.0004	Significant Lack of Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	46.77	n/a	61.12	2.138	1.636	n/a
IC10	49.16	n/a	64.05	2.034	1.561	n/a
IC15	51.38	n/a	66.62	1.946	1.501	n/a
IC20	53.52	n/a	68.89	1.868	1.452	n/a
IC25	55.62	38.54	70.92	1.798	1.41	2.595
IC40	62.01	50.73	76.31	1.613	1.31	1.971
IC50	66.69	56.75	80.79	1.5	1.238	1.762

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	87.5	7.097	73.36	101.6	12.33	<1.0E-37	Significant Parameter
γ	4.603	2.172	0.2776	8.929	2.119	0.0373	Significant Parameter
δ	66.69	5.537	55.66	77.71	12.04	<1.0E-37	Significant Parameter
ε	0.006153	0.007643	-0.00907	0.02137	0.8051	0.4233	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Lack of Fit	15830	3957	4	5.886	3.7E-04	Significant
Model	534600	133700	4	158.1	<1.0E-37	Significant
Pure Error	48400	672.3	72			
Residual	64230	845.1	76			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.435	3.306	0.0291	Outlier Detected
Variances	Mod Levene Equality of Variance	6.975	2.14	2.4E-06	Unequal Variances
Distribution	Shapiro-Wilk W Normality Test	0.8722	0.9691	9.8E-07	Non-Normal Distribution
	Anderson-Darling A2 Normality Te	3.045	2.492	<1.0E-37	Non-Normal Distribution

***Daphnia magna* 21-d Survival and Reproduction Test** | **HydroQual Laboratories, Ltd**

Analysis ID:	16-7458-6842	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 9:49	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

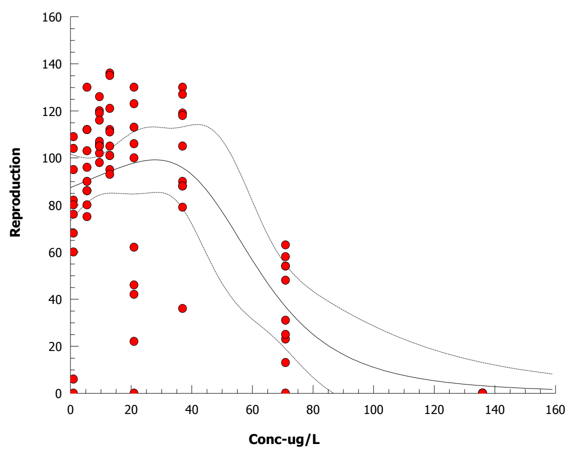
Reproduction Summary

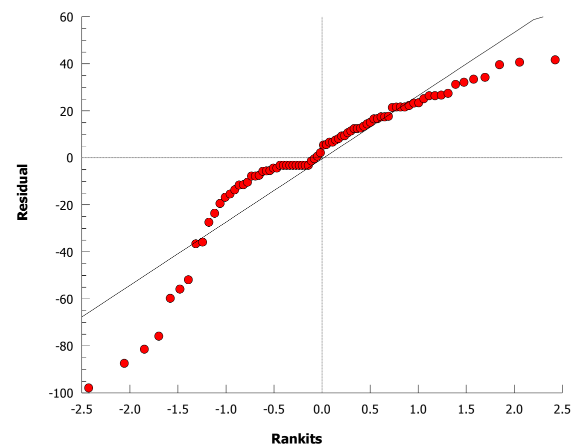
			Calculated Variate						
Conc-ug/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	N	10	68	0	109	11.85	37.48	55.12%	0.00%
5.5		10	97	75	130	5.416	17.13	17.66%	-42.65%
9.6		10	110.4	98	126	2.895	9.155	8.29%	-62.35%
13		10	111	93	136	4.851	15.34	13.82%	-63.24%
21		10	74.4	0	130	14.49	45.81	61.57%	-9.41%
37		10	98	36	130	8.959	28.33	28.91%	-44.12%
71		10	36.9	0	63	6.78	21.44	58.10%	45.74%
136		10	0	0	0	0	0		100.00%

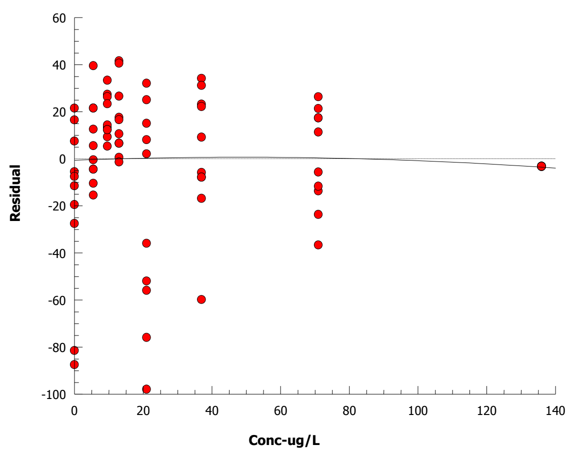
Reproduction Detail

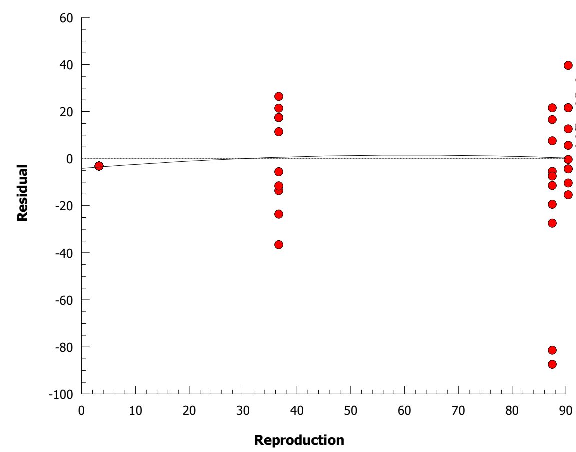
Conc-ug/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 6**	**Rep 7**	**Rep 8**	**Rep 9**	**Rep 10**
0	N	68	76	6	95	109	104	0	60	82	80
5.5		80	96	90	86	112	103	112	75	86	130
9.6		106	107	126	98	120	119	102	105	105	116
13		95	101	101	136	121	105	112	111	93	135
21		130	123	42	113	62	22	106	46	100	0
37		119	118	79	130	90	36	105	88	88	127
71		0	13	23	54	63	25	54	48	58	31
136		0	0	0	0	0	0	0	0	0	0

Graphics Model: 4P Log-Logistic+Hormesis: μ=α[1+ε·x]/[1+[2ε·δ+1]·[x/δ]^γ] Distribution: Normal [ω=1]









***Daphnia magna* 21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	14-7882-6982	**Endpoint:**	21-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 9:36	**Analysis:**	Untrimmed Spearman-Kärber	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Daphnia manga	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Spearman-Kärber Estimates

Threshold Option	Threshold	Trim	Mu	Sigma	LC50	95% LCL	95% UCL
Control Threshold	0.1	0.00%	1.716	0.06677	52	38.24	70.72

21-d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-ug/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	N	10	0.9000	0.0000	1.0000	0.1000	0.3162	35.14%	0.00%	9	10
5.5		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
9.6		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
13		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
21		10	0.6000	0.0000	1.0000	0.1633	0.5164	86.07%	33.33%	6	10
37		10	0.8000	0.0000	1.0000	0.1333	0.4216	52.70%	11.11%	8	10
71		10	0.5000	0.0000	1.0000	0.1667	0.5270	105.41%	44.44%	5	10
136		10	0.0000	0.0000	0.0000	0.0000	0.0000		100.00%	0	10

21-d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000
5.5		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9.6		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
21		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000
37		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
71		0.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000
136		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

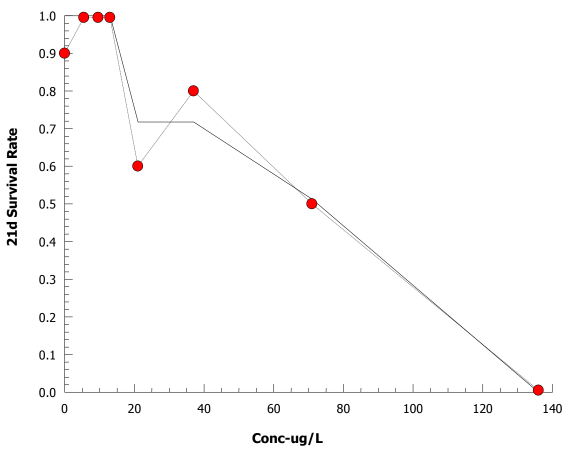
21-d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1/1	1/1	1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1
5.5		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
9.6		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
13		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
21		1/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	1/1	0/1
37		1/1	1/1	0/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1
71		0/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	0/1	1/1
136		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Daphnia magna **21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	14-7882-6982	**Endpoint:**	21-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 9:36	**Analysis:**	Untrimmed Spearman-Kärber	**Official Results:**	Yes

Graphics



CETIS Analytical Report

***Daphnia magna* 21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID: 08-1511-4179 **Endpoint:** 21-d Survival Rate **CETIS Version:** CETISv1.9.0
Analyzed: 15 Apr-16 9:37 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

Batch ID: **Test Type:** **Analyst:**
Start Date: **Protocol:** **Diluent:**
Ending Date: **Species:** Daphnia magna **Brine:**
Duration: **Source:** **Age:**

Sample ID: **Code:** **Client:**
Sample Date: **Material:** Dissolved copper **Project:**
Receipt Date: **Source:**
Sample Age: **Station:**

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	810901	200	Yes	Two-Point Interpolation

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	14.17	13.66	17.78	7.058	5.624	7.318
LC10	15.43	14.36	38.39	6.48	2.605	6.963
LC15	16.8	15.09	41.58	5.951	2.405	6.627
LC20	18.29	15.85	50.2	5.468	1.992	6.307
LC25	19.9	16.65	71.13	5.025	1.406	6.004
LC40	53.87	19.29	81.01	1.856	1.234	5.184
LC50	72.17	40.16	88.33	1.386	1.132	2.49

21-d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-ug/L	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0	N	10	0.9000	0.0000	1.0000	0.1000	0.3162	35.14%	0.00%	9	10
5.5		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
9.6		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
13		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-11.11%	10	10
21		10	0.6000	0.0000	1.0000	0.1633	0.5164	86.07%	33.33%	6	10
37		10	0.8000	0.0000	1.0000	0.1333	0.4216	52.70%	11.11%	8	10
71		10	0.5000	0.0000	1.0000	0.1667	0.5270	105.41%	44.44%	5	10
136		10	0.0000	0.0000	0.0000	0.0000	0.0000		100.00%	0	10

21-d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000
5.5		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9.6		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
13		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
21		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000
37		1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000
71		0.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	0.0000	0.0000	1.0000
136		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

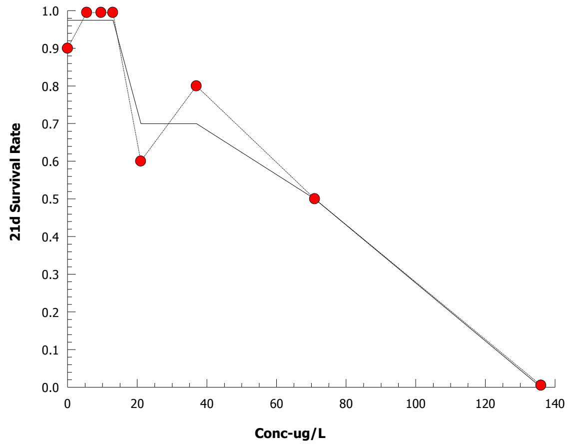
21-d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1/1	1/1	1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1
5.5		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
9.6		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
13		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
21		1/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	1/1	0/1
37		1/1	1/1	0/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1
71		0/1	1/1	0/1	1/1	1/1	0/1	1/1	0/1	0/1	1/1
136		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Daphnia magna **21-d Survival and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	08-1511-4179	**Endpoint:**	21-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 9:37	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



APPENDIX C – *Pimephales promelas* Toxicity Test Data

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference: SP15-013 Initial EC: -

Organism Information

Source: Aquatox Batch: 201508FM Egg Stage: <24 hours

Test Log

Date	Day	Time	Technicians	Chem Cart Used	Fed AM	Fed PM	Feeding Rate	Sample Pre-Aeration Time (minutes)	Bench Sheet Review First	Bench Sheet Review Second
2015/10/08	0	1530	ML/JN	2	-	-	-	-	ML	NM
2015/10/09	1	945	ML	2	--	-	-	45	ML	NM
2015/10/10	2	930	CQ	2	-	-	-	50	CQ	JK
2015/10/11	3	845	NM	2	-	-	-	50	NM	HKS
2015/10/12	4	945	NM	2	-	✓	1 mL	45	NM	ML
2015/10/13	5	1030	ML	2	✓	✓	1 mL	40	ML	HKS
2015/10/14	6	1000	ML	2	✓	✓	1 mL	45	ML	HKS
2015/10/15	7	1145	ML	2	✓	✓	1 mL	45	ML	NM
2015/10/16	8	945	ML	2	✓	✓	1 mL	45	ML	CQ
2015/10/17	9	1030	CQ	2	✓	✓	1 mL	50	CQ	-
2015/10/18	10	1115	NM	2	✓	✓	1 mL	45	NM	HKS
2015/10/19	11	1100	ML	2	✓	✓	1 mL	40	ML	HKS
2015/10/20	12	1035	ML	2	✓	✓	1 mL	40	HKS	DS
2015/10/21	13	1130	ML	2	✓	✓	1 mL	40	ML	JP
2015/10/22	14	1100	HKS	2	✓	✓	1 mL	40	ML	DS
2015/10/23	15	1120	ML	2	✓	✓	1 mL*	30	CQ	DS
2015/10/24	16	1020	CQ	2	✓	✓	1 mL*	40	ML	JN
2015/10/25	17	1510	ML	2	✓	✓	1 mL*	45	ML	HKS
2015/10/26	18	1400	ML	2	✓	✓	1 mL*	30	ML	HKS
2015/10/27	19	1100	ML	2	✓	✓	1 mL*	30	HKS	HKS
2015/10/28	20	1030	HKS	2	✓	✓	1 mL*	40	HKS	JP
2015/10/29	21	1130	HKS	2	✓	✓	1 mL*	40	ML	DS
2015/10/30	22	1400	ML	2	✓	✓	1 mL*	30	CQ	DS
2015/10/31	23	1130	CQ	2	✓	✓	1 mL*	40	NM	JN
2015/11/01	24	1445	NM	2	✓	✓	1 mL*	45	CQ	ML
2015/11/02	25	1400	CQ	2	✓	✓	1 mL*	50	NM	DS
2015/11/03	26	900	NM	2	✓	✓	1 mL*	50	CQ	JP
2015/11/04	27	905	NM	2	✓	✓	1 mL*	40	NM	HKS
2015/11/05	28	930	CQ	2	✓	✓	1 mL*	45	DS	HKS
2015/11/06	29	1130	NM	2	✓	✓	1 mL*	50	NM	CQ
2015/11/07	30	1300	HKS	2	✓	✓	1 mL*	50	HKS	JN
2015/11/08	31	1400	DS	2	✓	✓	1 mL*	50	DS	ML
2015/11/09	32	1500	NM/ML	2	-	-	-	-	NM	ML

* 1 mL to site control, 5 ug/l and 10 ug/L; 1.5 mL to all other test concentrations

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference: SP15-013

Control hatching success must be >66% (≥10 per replicate). Post hatch survival must be >70%.

Number of Alive Embryos and Hatched Organisms

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 1		Day 1		Day 1		Day 1		Day 1		Day 1		Day 1		Day 1	
replicate	Alive Embryos	Dead Embryos	Alive Embryos	Dead Embryos	Alive Embryos	Dead Embryos	Alive Embryos	Dead Embryos	Alive Embryos	Dead Embryos	Alive Embryos	Dead Embryos	Alive Embryos	Dead Embryos	Alive Embryos	Dead Embryos
a	13	2	14	1	14	1	13	2	14	1	15	0	13	2	15	0
b	14	1	14	1	13	2	13	2	15	0	15	0	13	2	15	0
c	14	1	14	1	13	2	15	0	14	1	14	1	15	0	12	3
d	14	1	14	1	14	1	14	1	15	0	15	0	13	2	14	1
e	28	2	29	1	27	3	26	4	26	4	28	2	30	0	30	0
f	17	3	22	8	29	1	30	0	29	1	24	6	27	3	28	2

Comments/Observations:

Number of Alive Embryos and Hatched Organisms

	Lab CTL			**Site CTL**			**5 ug/L Cu**			**10 ug/L Cu**		
	Day 2			Day 2			Day 2			Day 2		
replicate	Alive Embryos	Dead Embryos	Cull to 15	Alive Embryos	Dead Embryos	Cull to 15	Alive Embryos	Dead Embryos	Cull to 15	Alive Embryos	Dead Embryos	Cull to 15
a	13	0	15	13	1	15	13	1	15	13	0	15
b	14	0	15	13	1	15	13	0	15	13	0	15
c	12	2	15	13	1	15	13	0	15	15	0	15
d	14	0	15	11	3	15	15	0	15	13	1	15
e	8	0		27	2		26	0		26	0	
f	27	0		22	0		27	3		29	1	

	20 ug/L Cu			**40 ug/L Cu**			**80 ug/L Cu**			**160 ug/L Cu**		
	Day 2			Day 2			Day 2			Day 2		
replicate	Alive Embryos	Dead Embryos	Cull to 15	Alive Embryos	Dead Embryos	Cull to 15	Alive Embryos	Dead Embryos	Cull to 15	Alive Embryos	Dead Embryos	Cull to 15
a	12	2	15	12	3	15	13	0	15	13	2	15
b	15	0	15	15	0	15	13	0	15	14	1	15
c	14	0	15	14	0	15	15	0	15	11	1	15
d	15	0	15	14	1	15	13	0	15	14	0	15
e	25	1		26	2		28	2		26	2	
f	29	0		23	1		25	2		23	3	

Day 2 - Poor looking and dead embryos in replicates a, b, c and d are replaced with healthy embryos from replicates e and f. Replicates e and f are discarded after day 2

Comments/Observations: None

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference: SP15-013

Number of Alive Embryos and Hatched Organisms

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 3		Day 3		Day 3		Day 3		Day 3		Day 3		Day 3		Day 3	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	12	3	12	3	15	0	15	0	15	0	12	3	14	1	12	3
b	11	4	11	3	14	1	9	6	15	0	8	7	15	0	13	2
c	12	3	14	0	13	2	15	0	14	1	14	1	15	0	11	4
d	13	2	12	3	13	2	14	0	8	7	15	0	12	3	14	1

Comments/Observations:

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 4		Day 4		Day 4		Day 4		Day 4		Day 4		Day 4		Day 4	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	2	12	0	12	0	14	0	15	2	13	2	13	0	14	4	11
b	2	13	1	9	0	13	0	15	0	15	1	14	3	11	1	14
c	1	14	3	11	1	13	0	15	4	11	1	13	8	7	3	12
d	1	14	6	8	3	11	1	12	2	13	0	14	0	15	9	6

Comments/Observations:

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 5		Day 5		Day 5		Day 5		Day 5		Day 5		Day 5		Day 5	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	14 (1)	-	11	-	14 (1)	-	15	-	13 (1)	-	14	-	14	-	15
b	-	13	-	10	-	12	-	15	-	15 (1)	-	15	-	12	-	15
c	-	15	-	14	-	14	-	15	-	13 (1)	-	13	-	14 (1)	-	13
d	-	14 (1)	-	11	-	14	-	12 (2)	-	15 (1)	-	14 (1)	-	15	2	11 (1)

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 6		Day 6		Day 6		Day 6		Day 6		Day 6		Day 6		Day 6	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	14 (1)	-	11	-	14 (2)	-	15	-	13 (1)	-	14	-	14	-	15
b	-	13	-	10	-	12	-	15	-	14	-	15	-	12	-	14
c	-	14	-	14	-	14	-	15	-	12	-	13	-	13	-	13
d	-	13	-	11	-	14	-	11 (1)	-	14 (1)	-	14	-	15	-	12 (1)

Comments/Observations: Stressed fish noted in ()

Fathead Minnow Bench Sheet

Method: FMD 32 Day ELS Client: NAU104 Reference: SP15-013

Number of Alive Embryos and Hatched Organisms

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 7		Day 7		Day 7		Day 7		Day 7		Day 7		Day 7		Day 7	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	13 (1)	-	8	-	4	-	13	-	13 (1)	-	14	-	14 (1)	-	15
b	-	13	-	7	-	10 (1)	-	12	-	14	-	15	-	12	-	14
c	-	14	-	14	-	10	-	13	-	12	-	13	-	13	-	13
d	-	13	-	8 (2)	-	8	-	8	-	14 (2)	-	14	-	15	-	12 (1)

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 8		Day 8		Day 8		Day 8		Day 8		Day 8		Day 8		Day 8	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	13 (1)	-	6	-	1	-	13	-	13 (1)	-	14	-	14	-	15
b	-	13	-	7	-	8	-	7	-	14	-	15	-	12	-	14
c	-	14	-	14	-	6	-	9 (1)	-	12	-	13	-	13	-	13
d	-	13	-	6 (1)	-	4	-	7	-	14 (2)	-	14	-	15	-	12 (1)

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 9		Day 9		Day 9		Day 9		Day 9		Day 9		Day 9		Day 9	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	13 (1)	-	5	-	1	-	7	-	12	-	14	-	14	-	15
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	6 (1)	-	6	-	12	-	13	-	13	-	13
d	-	13	-	6 (1)	-	3	-	6	-	14 (2)	-	14	-	15	-	12 (1)

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 10		Day 10		Day 10		Day 10		Day 10		Day 10		Day 10		Day 10	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	13 (1)	-	4	-	1	-	7	-	12	-	14	-	14	-	15
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	6 (1)	-	6	-	12	-	13	-	13	-	13
d	-	13	-	6 (2)	-	3	-	6	-	14 (2)	-	14	-	15	-	12 (1)

Comments/Observations: Stressed fish noted in ()

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference: SP15-013

Number of Alive Embryos and Hatched Organisms

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 11		Day 11		Day 11		Day 11		Day 11		Day 11		Day 11		Day 11	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	13 (1)	-	4	-	1	-	7	-	12	-	14	-	14	-	15
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	13
d	-	13	-	6 (2)	-	3	-	6	-	14 (2)	-	14 (1)	-	15	-	12 (1)

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 12		Day 12		Day 12		Day 12		Day 12		Day 12		Day 12		Day 12	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	13 (1)	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	13 (1)
d	-	13	-	5	-	3	-	6	-	13(1)	-	13	-	15	-	11

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 13		Day 13		Day 13		Day 13		Day 13		Day 13		Day 13		Day 13	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	13 (1)	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	13
d	-	13	-	5 (1)	-	3	-	6	-	12	-	13	-	15	-	11

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 14		Day 14		Day 14		Day 14		Day 14		Day 14		Day 14		Day 14	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	13
d	-	13	-	5	-	3	-	6	-	12	-	13	-	15 (1)	-	11

Comments/Observations: Stressed fish noted in ()

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference: SP15-013

Number of Alive Embryos and Hatched Organisms

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 15		Day 15		Day 15		Day 15		Day 15		Day 15		Day 15		Day 15	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	13
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 16		Day 16		Day 16		Day 16		Day 16		Day 16		Day 16		Day 16	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	13 (1)
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 17		Day 17		Day 17		Day 17		Day 17		Day 17		Day 17		Day 17	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 18		Day 18		Day 18		Day 18		Day 18		Day 18		Day 18		Day 18	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	14
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method: FMD 32 Day ELS   Client: NAU104   Reference: SP15-013

Number of Alive Embryos and Hatched Organisms

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 19		Day 19		Day 19		Day 19		Day 19		Day 19		Day 19		Day 19	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations: 20 ug/L replicate d - one fish is smaller than the others; 160 ug/L replicate b - one fish killed by technician

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 20		Day 20		Day 20		Day 20		Day 20		Day 20		Day 20		Day 20	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 21		Day 21		Day 21		Day 21		Day 21		Day 21		Day 21		Day 21	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 22		Day 22		Day 22		Day 22		Day 22		Day 22		Day 22		Day 22	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	13
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations: two fish in replicates a (80 ug/L), a (160 ug/L) and b (160 ug/L) are smaller than the others

HydroQual
Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference: SP15-013

Number of Alive Embryos and Hatched Organisms

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 23		Day 23		Day 23		Day 23		Day 23		Day 23		Day 23		Day 23	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	15	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 24		Day 24		Day 24		Day 24		Day 24		Day 24		Day 24		Day 24	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	14	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 25		Day 25		Day 25		Day 25		Day 25		Day 25		Day 25		Day 25	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	14	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 26		Day 26		Day 26		Day 26		Day 26		Day 26		Day 26		Day 26	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	14	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference: SP15-013

Number of Alive Embryos and Hatched Organisms

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 27		Day 27		Day 27		Day 27		Day 27		Day 27		Day 27		Day 27	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	14	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12 (1)	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations: Stressed fish noted in ()

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 28		Day 28		Day 28		Day 28		Day 28		Day 28		Day 28		Day 28	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	14	-	12	-	13
c	-	14	-	14	-	5	-	6	-	11	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 29		Day 29		Day 29		Day 29		Day 29		Day 29		Day 29		Day 29	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14	-	14	-	12	-	13
c	-	14	-	14	-	5	-	6	-	11	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

	Lab CTL		**Site CTL**		**5 ug/L Cu**		**10 ug/L Cu**		**20 ug/L Cu**		**40 ug/L Cu**		**80 ug/L Cu**		**160 ug/L Cu**	
	Day 30		Day 30		Day 30		Day 30		Day 30		Day 30		Day 30		Day 30	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	14 (1)	-	14	-	12	-	13
c	-	14	-	14	-	5	-	6	-	12	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations: Stressed fish noted in ()

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference: SP15-013

Number of Alive Embryos and Hatched Organisms

	Lab CTL		Site CTL		5 ug/L Cu		10 ug/L Cu		20 ug/L Cu		40 ug/L Cu		80 ug/L Cu		160 ug/L Cu	
	Day 31		Day 31		Day 31		Day 31		Day 31		Day 31		Day 31		Day 31	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	14	-	14
b	-	13	-	6	-	8	-	5	-	13	-	14	-	12	-	13
c	-	14	-	14	-	5	-	5	-	11	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

	Lab CTL		Site CTL		5 ug/L Cu		10 ug/L Cu		20 ug/L Cu		40 ug/L Cu		80 ug/L Cu		160 ug/L Cu	
	Day 32		Day 32		Day 32		Day 32		Day 32		Day 32		Day 32		Day 32	
replicate	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched	Alive Embryos	Alive Hatched
a	-	12	-	4	-	1	-	7	-	12	-	14	-	13	-	14
b	-	13	-	6	-	8	-	5	-	13	-	14	-	12	-	13
c	-	14	-	14	-	5	-	5	-	11	-	13	-	13	-	12
d	-	13	-	5	-	3	-	6	-	12	-	13	-	14	-	11

Comments/Observations:

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day Client NAU104 Reference SP15-013

Chemistry

pH (units)

Conc. (ug/L) Day	New Solutions Lab CTL	Site CTL	5	10	20	40	80	160	Day	Old Solutions Lab CTL	Site CTL	5	10	20	40	80	160
0	8.2	8.1	8.2	8.1	8.1	8.1	8.1	8.1	0	-	-	-	-	-	-	-	-
1	8.0	8.2	8.2	8.1	8.1	8.0	8.2	8.3	1	7.8	8.0	8.0	8.0	8.0	8.0	8.0	8.0
2	8.1	8.2	8.2	8.2	8.2	8.3	8.3	8.3	2	7.9	8.1	8.1	8.1	8.1	8.1	8.1	8.1
3	8.0	8.1	8.1	8.1	8.1	8.1	8.1	8.1	3	8.0	8.2	8.2	8.2	8.2	8.2	8.2	8.2
4	8.0	8.2	8.2	8.2	8.2	8.2	8.2	8.2	4	8.0	8.1	8.2	8.2	8.2	8.2	8.2	8.3
5	8.1	8.2	8.2	8.2	8.2	8.2	8.2	8.2	5	8.1	8.2	8.3	8.3	8.3	8.3	8.3	8.3
6	8.0	8.2	8.2	8.2	8.2	8.2	8.2	8.2	6	8.0	8.2	8.2	8.2	8.2	8.2	8.3	8.2
7	8.0	8.1	8.1	8.1	8.1	8.1	8.1	8.0	7	7.9	8.1	8.1	8.1	8.1	8.1	8.1	8.1
8	8.2	8.3	8.2	8.2	8.2	8.2	8.3	8.2	8	8.1	8.4	8.3	8.4	8.4	8.3	8.4	8.4

Conductance (µS/cm)

Day	Lab CTL	Site CTL	5	10	20	40	80	160	Day	Lab CTL	Site CTL	5	10	20	40	80	160
0	432	366	367	366	363	361	364	366	0	-	-	-	-	-	-	-	-
1	420	366	364	365	366	366	367	366	1	439	373	370	369	366	366	365	366
2	453	372	367	365	361	365	366	366	2	447	373	375	373	374	376	371	379
3	443	365	362	362	363	363	363	362	3	445	374	372	372	370	370	367	368
4	419	364	363	363	364	364	363	363	4	453	373	374	372	368	372	370	367
5	443	365	366	364	365	364	364	364	5	447	375	376	369	368	370	367	368
6	433	360	359	359	360	360	360	360	6	445	368	363	366	364	372	362	363
7	463	362	359	359	359	359	360	359	7	447	372	366	367	363	364	363	364
8	463	361	359	359	360	359	358	338	8	457	371	366	363	364	367	364	363

Dissolved Oxygen (mg/L) (**40-100% saturation**)

Day	Lab CTL	Site CTL	5	10	20	40	80	160	Day	Lab CTL	Site CTL	5	10	20	40	80	160
0	7.2	7.4	7.4	7.4	7.4	7.4	7.4	7.4	0	-	-	-	-	-	-	-	-
1	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	1	7.2	7.2	7.1	6.9	6.9	6.9	7.3	7.2
2	7.3	7.3	7.3	7.4	7.3	7.3	7.3	7.3	2	7.2	7.0	6.9	7.0	7.0	7.0	7.0	7.0
3	7.3	7.2	7.1	7.1	7.1	7.1	7.1	7.1	3	6.9	6.9	6.9	6.9	6.9	6.8	6.9	6.9
4	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	4	7.1	7.1	7.1	7.0	7.0	7.1	7.0	7.0
5	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	5	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
6	7.3	7.3	7.2	7.3	7.2	7.2	7.2	7.2	6	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
7	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
8	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.2	8	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3

Temperature (°C)

Day	Lab CTL	Site CTL	5	10	20	40	80	160	Day	Lab CTL	Site CTL	5	10	20	40	80	160
0	22.8	25.7	25.2	25.2	25.6	24.9	25.0	24.9	0	-	-	-	-	-	-	-	-
1	24.2	23.9	23.7	23.8	23.6	23.9	23.5	23.5	1	23.5	23.5	23.5	23.5	23.6	23.7	23.5	23.7
2	23.6	23.6	23.8	23.8	23.9	24.0	23.9	23.9	2	23.6	23.2	23.7	23.7	23.7	23.8	23.8	23.8
3	23.5	24.4	24.5	24.6	24.5	24.5	24.7	24.6	3	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
4	24.0	24.1	24.1	24.3	24.0	24.2	24.2	24.2	4	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
5	24.1	24.1	24.3	24.3	23.6	23.7	24.2	24.3	5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
6	24.1	24.4	24.9	24.4	24.9	25.0	25.0	24.9	6	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
7	24.2	24.4	24.4	24.4	24.4	24.4	25.0	25.0	7	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
8	23.5	24.3	24.4	24.4	24.4	24.4	24.4	24.7	8	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5

DO Levels (60-100% saturation) -
4.4 to 7.3 mg/L at 24°C
4.5 to 7.2 mg/L at 25°C
4.3 to 7.1 mg/L at 26°C

Comments:

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day Client NAU104 Reference SP15-013

Chemistry

New Solutions

Conc. (ug/L) / Day	Lab CTL	Site CTL	5	10	20	40	80	160
pH (units)								
9	8.1	8.3	8.3	8.3	8.3	8.3	8.3	8.4
10	8.0	8.0	8.1	8.1	8.0	8.1	8.1	8.2
11	8.0	8.2	8.3	8.2	8.1	8.2	8.2	8.3
12	8.0	8.2	8.0	8.0	8.0	8.1	8.1	8.2
13	8.2	8.3	8.2	8.2	8.1	8.2	8.2	8.3
14	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
15	8.0	8.2	8.1	8.1	8.0	8.1	8.1	8.1
16	8.0	8.1	8.1	8.1	8.0	8.1	8.1	8.2
17	8.2	8.4	8.2	8.2	8.1	8.3	8.2	8.3
Conductance (µS/cm)								
9	429	367	362	362	363	362	362	362
10	433	362	361	351	361	362	360	364
11	427	369	364	359	361	358	359	358
12	450	363	360	361	361	359	361	359
13	465	381	377	378	378	377	378	377
14	479	375	378	379	378	379	378	376
15	471	378	378	378	379	378	378	378
16	486	388	385	384	383	386	385	385
17	478	380	376	378	380	376	377	376
Dissolved Oxygen (mg/L) (40-100% saturation)								
9	7.3	7.3	7.3	7.3	7.4	7.3	7.3	7.3
10	7.3	7.2	7.2	7.3	7.2	7.2	7.2	7.3
11	7.2	7.3	7.2	7.2	7.3	7.3	7.2	7.2
12	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.2
13	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.2
14	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2
15	7.2	7.3	7.2	7.2	7.2	7.2	7.2	7.2
16	7.6	7.5	7.5	7.5	7.6	7.5	7.5	7.5
17	7.3	7.3	7.3	7.2	7.2	7.3	7.3	7.1
Temperature (°C)								
9	23.7	23.8	23.2	23.8	23.8	23.8	23.4	23.8
10	24.1	24.6	24.6	24.4	24.5	24.5	23.9	24.3
11	24.6	24.4	24.7	24.6	24.4	24.4	24.6	24.6
12	23.7	24.4	24.4	24.4	24.4	24.4	24.4	24.8
13	23.6	24.4	24.4	24.4	24.4	24.9	24.9	24.8
14	23.4	24.2	24.0	24.2	23.8	23.9	23.7	24.6
15	24.8	24.4	24.9	24.8	24.8	24.9	24.5	24.7
16	23.6	23.5	23.5	23.7	23.6	23.9	24.8	22.4
17	23.6	23.9	24.0	24.3	24.2	24.3	24.3	24.1

24.3

Old Solutions

Day	Lab CTL	Site CTL	5	10	20	40	80	160
pH (units)								
9	8.2	8.3	8.4	8.3	8.4	7.4	8.4	8.4
10	8.0	8.2	8.2	8.2	8.3	8.1	8.3	8.2
11	8.0	8.2	8.3	8.2	8.3	8.3	8.3	8.3
12	7.9	8.1	8.2	8.1	8.2	8.2	8.2	8.2
13	8.0	8.3	8.3	8.3	8.3	8.3	8.2	8.3
14	8.1	8.3	8.2	8.2	8.3	8.3	8.2	8.3
15	7.9	8.2	8.1	8.2	8.2	8.1	8.2	8.2
16	8.0	8.2	8.2	8.1	8.2	8.2	8.2	8.2
17	8.1	8.3	8.3	8.2	8.3	8.3	8.2	8.3
Conductance (µS/cm)								
9	466	377	368	372	368	368	370	368
10	475	365	363	361	363	365	363	363
11	427	369	364	366	365	364	365	365
12	444	364	362	362	362	362	361	362
13	463	385	381	382	381	382	383	379
14	488	394	384	383	385	382	384	383
15	485	391	382	382	385	382	382	380
16	487	387	387	381	381	382	381	380
17	488	385	384	385	387	384	386	388
Dissolved Oxygen (mg/L) (40-100% saturation)								
9	7.3	7.3	7.3	7.3	7.3	7.2	7.2	7.2
10	7.3	7.2	7.3	7.1	7.1	7.0	6.7	7.0
11	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
12	7.2	7.2	7.2	7.3	7.3	7.3	7.2	7.2
13	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.1
14	7.6	7.6	7.6	7.4	7.3	7.3	7.2	7.2
15	7.2	7.2	7.3	7.1	7.2	7.1	7.1	7.1
16	7.4	7.4	7.4	7.4	7.3	7.3	7.2	7.3
17	7.2	7.3	7.3	7.2	7.3	7.3	7.2	7.1
Temperature (°C)								
9	23.6	23.6	23.5	23.9	23.5	23.6	23.7	23.5
10	23.7	23.5	23.5	23.6	23.6	23.8	23.8	24.0
11	23.5	23.5	23.5	23.5	23.5	23.5	23.6	23.5
12	23.7	23.7	23.7	23.8	23.9	24.0	23.8	23.8
13	23.5	23.5	23.5	23.5	23.6	23.6	24.4	23.8
14	23.8	23.9	24.3	24.0	24.1	24.3	24.2	24.3
15	23.5	23.5	23.5	23.5	23.6	23.6	23.6	23.6
16	24.0	24.1	24.2	24.2	24.4	24.7	23.9	23.7
17	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5

DO Levels (60-100% saturation) -
4.4 to 7.3 mg/L at 24°C
4.5 to 7.2 mg/L at 25°C
4.3 to 7.1 mg/L at 26°C

Comments:

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day Client NAU104 Reference SP15-013

Chemistry

New Solutions

pH (units)

Conc. (ug/L) / Day	Lab CTL	Site CTL	5	10	20	40	80	160
18	8.0	8.2	8.1	8.0	8.0	8.1	8.0	8.1
19	8.0	8.1	8.1	8.1	8.0	8.1	8.1	8.1
20	8.0	8.1	8.1	8.1	8.1	8.1	8.1	8.2
21	8.1	8.2	8.1	8.2	8.0	8.1	8.1	8.2
22	8.0	8.2	8.2	8.2	8.0	8.1	8.2	8.2
23	7.9	8.1	8.1	8.2	7.9	8.0	8.1	8.1
24	8.1	8.1	8.1	8.1	7.8	8.1	8.2	8.2
25	7.9	8.1	8.1	8.1	8.0	8.1	8.1	8.2
26	8.0	8.1	8.1	8.0	8.0	8.1	8.1	8.1

Conductance (µS/cm)

Day	Lab CTL	Site CTL	5	10	20	40	80	160
18	493	358	374	376	378	373	377	376
19	484	378	377	378	379	377	377	377
20	500	392	386	382	384	383	384	383
21	494	378	381	382	386	384	384	383
22	487	384	384	385	387	386	383	381
23	467	394	389	389	390	386	385	390
24	465	389	384	386	388	386	360	384
25	477	392	384	389	389	390	380	392
26	482	386	386	385	386	385	385	386

Dissolved Oxygen (mg/L) (**40-100% saturation**)

Day	Lab CTL	Site CTL	5	10	20	40	80	160
18	7.3	7.3	7.3	7.2	7.2	7.2	7.2	7.2
19	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.3
20	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
21	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
22	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
23	7.4	7.4	7.4	7.4	7.6	7.4	7.4	7.4
24	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.5
25	7.5	7.6	7.5	7.5	7.4	7.4	7.4	7.4
26	7.5	7.3	7.3	7.3	7.3	7.2	7.3	7.3

Temperature (°C)

Day	Lab CTL	Site CTL	5	10	20	40	80	160
18	23.5	24.1	24.4	24.5	24.5	24.6	24.6	24.3
19	23.5	24.3	24.4	24.4	24.4	24.4	24.7	24.4
20	23.6	24.9	24.8	24.8	24.8	23.8	24.7	24.3
21	23.8	23.9	24.8	23.9	24.0	24.1	24.2	24.1
22	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
23	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.6
24	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
25	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
26	23.5	24.1	23.6	23.7	23.5	23.6	23.5	23.5

Old Solutions

pH (units)

Day	Lab CTL	Site CTL	5	10	20	40	80	160
18	8.4	8.4	8.4	8.4	8.4	8.4	8.2	8.3
19	7.9	8.1	8.1	8.2	8.0	8.1	8.2	8.2
20	8.0	8.2	8.2	8.2	8.2	8.2	8.2	8.2
21	8.0	8.1	8.1	8.1	8.0	8.1	8.1	8.1
22	7.9	8.1	8.1	8.2	8.1	8.1	8.1	8.1
23	7.9	8.1	8.1	8.2	8.1	8.1	8.1	8.1
24	8.0	8.3	8.3	8.3	8.2	8.2	8.2	8.3
25	8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.2
26	7.9	8.2	8.1	8.2	8.2	8.1	8.1	8.2

Conductance (µS/cm)

Day	Lab CTL	Site CTL	5	10	20	40	80	160
18	491	392	385	384	384	386	386	385
19	511	392	381	382	385	382	383	390
20	516	400	387	388	388	391	388	391
21	502	393	388	389	394	398	391	391
22	529	394	388	387	389	388	388	384
23	504	397	390	390	321	392	390	394
24	463	393	389	386	390	388	393	389
25	485	379	388	393	392	390	340	397
26	477	394	390	388	387	390	391	392

Dissolved Oxygen (mg/L) (**40-100% saturation**)

Day	Lab CTL	Site CTL	5	10	20	40	80	160
18	7.2	7.2	7.3	7.2	7.3	7.2	6.9	6.9
19	7.3	7.3	7.3	7.2	7.2	7.1	7.2	7.2
20	7.3	7.3	7.3	7.3	7.2	7.1	7.2	7.2
21	7.3	7.3	7.2	7.2	7.2	7.1	7.1	7.1
22	7.2	7.3	7.1	7.1	7.2	7.2	7.9	6.9
23	7.5	7.4	7.3	7.3	7.2	7.2	7.1	7.1
24	7.0	7.1	7.0	6.9	6.9	6.7	6.8	6.9
25	7.4	7.5	7.4	7.3	7.2	7.1	7.1	7.2
26	7.3	7.2	7.0	7.2	7.2	7.1	7.1	7.3

Temperature (°C)

Day	Lab CTL	Site CTL	5	10	20	40	80	160
18	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
19	23.5	23.5	23.6	23.5	23.5	23.5	23.5	23.6
20	23.7	23.7	23.4	23.8	23.5	23.6	23.5	23.9
21	23.5	23.7	23.6	23.6	23.8	23.9	23.8	23.9
22	23.5	23.5	23.5	23.5	23.5	23.5	32.5	23.5
23	23.7	23.7	23.7	23.7	23.5	23.6	23.6	23.5
24	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
25	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
26	23.5	23.5	23.5	23.5	23.5	23.5	25.5	23.5

DO Levels (60-100% saturation) -
4.4 to 7.3 mg/L at 24°C
4.5 to 7.2 mg/L at 25°C
4.3 to 7.1 mg/L at 26°C

Comments:

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FHM 32 Day   Client NAU104   Reference SP15-013

Chemistry

New Solutions

Conc. (ug/L)	Lab CTL	Site CTL	5	10	20	40	80	160
Day								
pH (units)								
27	8.0	7.9	7.9	7.8	7.8	7.9	7.9	8.0
28	8.0	8.2	8.2	8.2	8.2	8.2	8.2	8.2
29	7.9	8.0	8.0	8.0	8.0	8.0	7.9	8.0
30	8.0	8.1	8.1	8.2	8.2	8.2	8.2	8.2
31	8.0	8.1	8.1	8.1	8.1	8.1	8.1	8.1
32	-	-	-	-	-	-	-	-
Conductance (µS/cm)								
27	435	373	370	366	351	369	362	370
28	455	380	377	378	379	381	385	381
29	465	373	370	371	382	372	374	371
30	478	363	369	370	370	371	370	371
31	489	382	373	372	370	373	372	372
32	-	-	-	-	-	-	-	-
Dissolved Oxygen (mg/L) (40-100% saturation)								
27	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
28	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
29	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
30	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
31	7.3	7.2	7.1	7.2	7.3	7.3	7.3	7.3
32	-	-	-	-	-	-	-	-
Temperature (°C)								
27	23.5	23.5	23.9	23.9	23.7	23.6	23.6	23.8
28	23.5	23.5	23.5	23.8	23.6	23.8	23.8	23.9
29	23.5	23.5	23.6	23.6	23.5	23.6	23.7	23.8
30	23.9	23.7	23.5	23.7	23.6	23.8	23.6	23.9
31	23.6	23.9	23.8	23.8	23.7	23.8	23.9	23.9
32	-	-	-	-	-	-	-	-

Old Solutions

Day	Lab CTL	Site CTL	5	10	20	40	80	160
pH (units)								
27	7.8	8.0	7.9	8.1	8.0	8.1	8.1	8.1
28	8.0	8.2	8.2	8.2	8.3	8.3	8.2	8.3
29	7.8	8.0	7.8	8.1	8.0	8.1	7.9	8.0
30	7.7	8.1	8.0	8.0	8.0	8.0	8.1	8.1
31	7.9	8.2	8.2	8.2	8.2	8.1	8.1	8.1
32	7.7	8.2	8.2	8.2	8.2	8.2	8.2	8.3
Conductance (µS/cm)								
27	437	377	377	373	375	375	374	377
28	458	387	382	383	381	379	382	386
29	450	380	378	381	379	377	378	380
30	476	383	379	377	380	376	379	376
31	477	383	376	375	377	377	377	37
32	450	368	375	379	379	377	377	374
Dissolved Oxygen (mg/L) (40-100% saturation)								
27	7.1	7.0	7.0	6.8	6.9	6.9	7.0	7.0
28	7.1	7.0	7.1	7.2	7.1	7.0	7.1	7.0
29	7.2	7.3	6.9	6.6	6.9	6.9	7.0	6.9
30	7.1	7.2	7.1	7.0	6.9	7.0	7.0	7.0
31	7.1	7.1	7.2	7.1	7.1	7.1	7.0	7.0
32	7.3	7.3	7.3	7.3	7.3	7.3	7.2	7.2
Temperature (°C)								
27	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
28	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
29	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
30	23.6	23.6	23.6	23.6	23.7	23.6	23.5	23.5
31	23.6	23.6	23.6	23.7	23.7	23.8	23.8	23.8
32	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5

DO Levels (60-100% saturation) -
4.4 to 7.3 mg/L at 24°C
4.5 to 7.2 mg/L at 25°C
4.3 to 7.1 mg/L at 26°C

Comments:

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference SP15-013

Test Termination

For normal/abnormal column, use the following notation:

N=Normal, A= Abnormal And note location: H=head, O=oral, E=eyes, G=gills, F=fins, S=spine

Conc.

Lab CTL

Replicate # A			Replicate # B			Replicate # C			Replicate # D		
Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal
1	11	N	1	8	N	1	12	N	1	10	N
2	11	N	2	9	N	2	11	N	2	10	N
3	7	N	3	9	N	3	12	N	3	10	N
4	9	N	4	11	N	4	11	N	4	10	N
5	11	N	5	11	N	5	10	N	5	10	N
6	11	N	6	10	N	6	9	N	6	11	N
7	9	N	7	10	N	7	11	N	7	7	N
8	8	N	8	9	N	8	10	N	8	9	N
9	11	N	9	11	N	9	11	N	9	9	N
10	12	N	10	8	N	10	11	N	10	10	N
11	10	N	11	12	N	11	9	N	11	10	N
12	10	N	12	11	N	12	11	N	12	8	N
13	-	-	13	11	N	13	10	N	13	10	N
14	-	-	14	-	-	14	11	N	14	-	-
15	-	-	15	-	-	15	-	-	15	-	-

Comments

Site CTL

Replicate # A			Replicate # B			Replicate # C			Replicate # D		
Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal
1	12	N	1	11	N	1	9	N	1	12	N
2	14	N	2	11	N	2	11	N	2	13	N
3	11	N	3	14	N	3	11	N	3	12	N
4	14	N	4	10	N	4	10	N	4	13	N
5	-	-	5	13	N	5	11	N	5	10	N
6	-	-	6	12	N	6	9	N	6	-	-
7	-	-	7	-	-	7	10	N	7	-	-
8	-	-	8	-	-	8	7	N	8	-	-
9	-	-	9	-	-	9	6	N	9	-	-
10	-	-	10	-	-	10	11	N	10	-	-
11	-	-	11	-	-	11	10	N	11	-	-
12	-	-	12	-	-	12	10	N	12	-	-
13	-	-	13	-	-	13	9	N	13	-	-
14	-	-	14	-	-	14	9	N	14	-	-
15	-	-	15	-	-	15	-	-	15	-	-

Comments

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference SP15-013

Test Termination

For normal/abnormal column, use the following notation:

N=Normal, A= Abnormal And note location: H=head, O=oral, E=eyes, G=gills, F=fins, S=spine

Conc.

5 ug/L

Replicate # A			Replicate # B			Replicate # C			Replicate # D		
Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal
1	15	N	1	10	N	1	13	N	1	15	N
2	-	-	2	11	N	2	12	N	2	15	N
3	-	-	3	11	N	3	13	N	3	13	N
4	-	-	4	12	N	4	14	N	4	-	-
5	-	-	5	11	N	5	12	N	5	-	-
6	-	-	6	11	N	6	-	-	6	-	-
7	-	-	7	11	N	7	-	-	7	-	-
8	-	-	8	11	N	8	-	-	8	-	-
9	-	-	9	-	-	9	-	-	9	-	-
10	-	-	10	-	-	10	-	-	10	-	-
11	-	-	11	-	-	11	-	-	11	-	-
12	-	-	12	-	-	12	-	-	12	-	-
13	-	-	13	-	-	13	-	-	13	-	-
14	-	-	14	-	-	14	-	-	14	-	-
15	-	-	15	-	-	15	-	-	15	-	-

Comments

10 ug/L

Replicate # A			Replicate # B			Replicate # C			Replicate # D		
Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal
1	13	N	1	14	N	1	12	N	1	11	N
2	11	N	2	14	N	2	13	N	2	12	N
3	13	N	3	11	N	3	12	N	3	12	N
4	12	N	4	11	N	4	12	N	4	12	N
5	12	N	5	13	N	5	11	N	5	12	N
6	13	N	6	-	-	6	-	-	6	12	N
7	13	N	7	-	-	7	-	-	7	-	-
8	-	-	8	-	-	8	-	-	8	-	-
9	-	-	9	-	-	9	-	-	9	-	-
10	-	-	10	-	-	10	-	-	10	-	-
11	-	-	11	-	-	11	-	-	11	-	-
12	-	-	12	-	-	12	-	-	12	-	-
13	-	-	13	-	-	13	-	-	13	-	-
14	-	-	14	-	-	14	-	-	14	-	-
15	-	-	15	-	-	15	-	-	15	-	-

Comments

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference SP15-013

Test Termination

For normal/abnormal column, use the following notation:

N=Normal, A= Abnormal And note location: H=head, O=oral, E=eyes, G=gills, F=fins, S=spine

Conc.

20 ug/L

Replicate # A			Replicate # B			Replicate # C			Replicate # D		
Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal
1	10	N	1	10	N	1	10	N	1	11	N
2	9	N	2	10	N	2	10	N	2	11	N
3	9	N	3	10	N	3	10	N	3	6	N
4	10	N	4	11	N	4	12	N	4	10	N
5	12	N	5	9	N	5	9	N	5	13	N
6	9	N	6	9	N	6	10	N	6	12	N
7	12	N	7	11	N	7	10	N	7	10	N
8	11	N	8	10	N	8	12	N	8	10	N
9	11	N	9	10	N	9	10	N	9	10	N
10	10	N	10	10	N	10	13	N	10	10	N
11	10	N	11	10	N	11	9	N	11	11	N
12	10	N	12	7	N	12	-	-	12	10	N
13	-	-	13	8	N	13	-	-	13	-	-
14	-	-	14	-	-	14	-	-	14	-	-
15	-	-	15	-	-	15	-	-	15	-	-

Comments

40 ug/L

Replicate # A			Replicate # B			Replicate # C			Replicate # D		
Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal	Fish	Length (mm)	Normal/ Abnormal
1	10	N	1	9	N	1	10	N	1	10	N
2	12	N	2	10	N	2	11	N	2	10	N
3	10	N	3	8	N	3	12	N	3	8	N
4	10	N	4	10	N	4	8	N	4	11	N
5	10	N	5	10	N	5	10	N	5	8	N
6	10	N	6	10	N	6	11	N	6	12	N
7	12	N	7	9	N	7	10	N	7	10	N
8	12	N	8	10	N	8	10	N	8	10	N
9	10	N	9	10	N	9	12	N	9	8	N
10	10	N	10	10	N	10	10	N	10	10	N
11	10	N	11	9	N	11	10	N	11	10	N
12	12	N	12	11	N	12	13	N	12	10	N
13	12	N	13	10	N	13	10	N	13	10	N
14	11	N	14	10	N	14	-	-	14	-	-
15	-	-	15	-	-	15	-	-	15	-	-

Comments

HydroQual Laboratories Ltd.

Fathead Minnow Bench Sheet

Method FMD 32 Day ELS Client NAU104 Reference SP15-013

Test Termination

For normal/abnormal column, use the following notation:

N=Normal, A= Abnormal And note location: H=head, O=oral, E=eyes, G=gills, F=fins, S=spine

Conc.

80 ug/L

Fish	Replicate # A Length (mm)	Replicate # A Normal/ Abnormal	Replicate # B Length (mm)	Replicate # B Normal/ Abnormal	Replicate # C Length (mm)	Replicate # C Normal/ Abnormal	Replicate # D Length (mm)	Replicate # D Normal/ Abnormal
1	10	N	12	N	13	N	8	N
2	10	N	10	N	12	N	8	N
3	11	N	14	N	8	N	11	N
4	11	N	8	N	11	N	12	N
5	11	N	11	N	6	N	12	N
6	8	N	10	N	12	N	9	N
7	11	N	7	N	12	N	9	N
8	13	N	9	N	11	N	11	N
9	12	A-S	10	N	12	N	8	N
10	9	N	10	N	10	N	10	N
11	11	N	12	N	8	N	14	N
12	7	N	12	N	11	N	10	N
13	10	N	-	-	11	N	10	N
14	-	-	-	-	-	-	8	N
15	-	-	-	-	-	-	-	-

Comments

160 ug/L

Fish	Replicate # A Length (mm)	Replicate # A Normal/ Abnormal	Replicate # B Length (mm)	Replicate # B Normal/ Abnormal	Replicate # C Length (mm)	Replicate # C Normal/ Abnormal	Replicate # D Length (mm)	Replicate # D Normal/ Abnormal
1	10	N	11	N	10	N	10	N
2	10	N	6	N	12	N	10	N
3	10	N	10	N	9	N	9	N
4	14	N	8	N	9	N	11	N
5	10	N	10	N	12	N	11	N
6	12	N	8	A-S	6	N	10	N
7	8	N	11	N	11	N	11	N
8	5	N	10	N	11	N	13	N
9	10	N	10	N	11	N	12	N
10	11	N	12	N	12	N	9	N
11	10	N	8	N	11	N	10	N
12	8	N	10	N	7	N	-	-
13	10	N	9	N	-	-	-	-
14	10	N	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-

Comments

HydroQual Laboratories Ltd.

#4, 6125 12th Street SE Calgary, Alberta Canada T2H 2K1
Tel (403) 253-7121 Fax (403) 252-9363 www.hydroqual.ca

Organism Weights Bench Sheet

Client NAU104 Sample SP15-013 Organism FM

Initial Weight (mg) (dried pan)

Date: 11/6/2015 Initials: JW Balance*: Mettler 1

Conc. (ug/L Cu)	Lab CTL	Site CTL	5	10	20	40	80	160
Replicate								
a	1013.99	1012.88	1025.98	995.94	1011.55	1004.13	979.68	989.6
b	1022.74	1013.93	1011.66	1009.79	1002.9	1009	1004.31	986.41
c	1018.06	1008.4	1001.58	1025.95	1005.73	994.95	1007.82	1021.18
d	1016.65	994.69	1033.59	1010.34	995.96	989.13	1001.46	1014.64
e								

Final Weight (mg) (dried pan+organisms)

Date: 11/14/2015 Initials: JW Balance*: Mettler 1

Conc. (ug/L Cu)	Lab CTL	Site CTL	5	10	20	40	80	160
Replicate								
a	1041.49	1035.13	1041.92	1029.3	1039.31	1035.82	1006.87	1018.25
b	1048.72	1039.35	1035.65	1037.12	1026.62	1036.42	1038.93	1017.03
c	1044.78	1031.44	1024.29	1046.89	1028.41	1030.33	1040.06	1053.25
d	1040.65	1019.2	1058.72	1034.89	1024.71	1019.83	1032.42	1042.73
e								

Test Validity Met: **Yes**

Results are Logical:** **Yes**

**no negative numbers, consistent values across replicates

*Same balance must be used for initial and final weights
*For FM/HA/CT must use scale with 0.01 mg accuracy

Balance Calibration Check:

	Initial		Final
first pan weighed:	Lab CTL A	first pan+org weighed:	Lab CTL A
weight of first pan:	1013.99	weight of first pan + org:	1041.49
re-weigh of first pan after all weights measured :	1013.99	re-weigh of first pan + org after all weights measured:	1041.49
% difference <5%:	**Yes**	**% difference <5%:**	**Yes**

Calculation: % difference = [initial weight-reweight/((initial weight+reweight)/2)]x100

If "no" is circled for any parameter, notify Lab Supervisor/QA Group to determine appropriate action

CETIS Analytical Report

Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID: 00-7531-5326 **Endpoint:** Hatching Sucess **CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 10:37 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

Batch ID: **Test Type:** **Analyst:**
Start Date: **Protocol:** **Diluent:**
Ending Date: **Species:** Pimephales promelas **Brine:**
Duration: **Source:** **Age:**

Sample ID: **Code:** **Client:**
Sample Date: **Material:** Total copper) **Project:**
Receipt Date: **Source:**
Sample Age: **Station:**

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	503366	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.207	2.938	0.7130	No Outliers Detected

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	>148	n/a	n/a	<0.7194	n/a	n/a
LC10	>148	n/a	n/a	<0.7194	n/a	n/a
LC15	>148	n/a	n/a	<0.7194	n/a	n/a
LC20	>148	n/a	n/a	<0.7194	n/a	n/a
LC25	>148	n/a	n/a	<0.7194	n/a	n/a
LC40	>148	n/a	n/a	<0.7194	n/a	n/a
LC50	>148	n/a	n/a	<0.7194	n/a	n/a

Hatching Success Summary

			Calculated Variate(A/B)								
Conc-%	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0	N	4	0.9333	0.8667	1.0000	0.0272	0.0544	5.83%	0.00%	56	60
5.2		4	0.7833	0.6667	0.9333	0.0569	0.1139	14.53%	16.07%	47	60
10		4	0.9167	0.8667	0.9333	0.0167	0.0333	3.64%	1.79%	55	60
14.5		4	0.9500	0.8000	1.0000	0.0500	0.1000	10.53%	-1.79%	57	60
24		4	0.9333	0.8667	1.0000	0.0385	0.0770	8.25%	0.00%	56	60
43		4	0.9333	0.8667	1.0000	0.0272	0.0544	5.83%	0.00%	56	60
81		4	0.9167	0.8000	1.0000	0.0419	0.0839	9.15%	1.79%	55	60
148		4	0.9333	0.8667	1.0000	0.0385	0.0770	8.25%	0.00%	56	60

Hatching Success Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.9333	0.8667	1.0000	0.9333
5.2		0.8000	0.6667	0.9333	0.7333
10		0.9333	0.8667	0.9333	0.9333
14.5		1.0000	1.0000	1.0000	0.8000
24		0.8667	1.0000	0.8667	1.0000
43		0.9333	1.0000	0.8667	0.9333
81		0.9333	0.8000	0.9333	1.0000
148		1.0000	1.0000	0.8667	0.8667

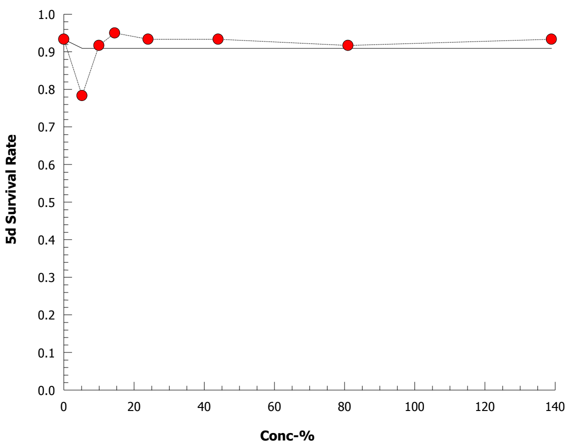
Fathead Minnow 32-d Survival and Growth Test | **HydroQual Laboratories, Ltd**

Analysis ID:	00-7531-5326	**Endpoint:**	Hatching Success	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:37	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

5d Survival Rate Binomials

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	14/15	13/15	15/15	14/15
5.2		12/15	10/15	14/15	11/15
10		14/15	13/15	14/15	14/15
14.5		15/15	15/15	15/15	12/15
24		13/15	15/15	13/15	15/15
43		14/15	15/15	13/15	14/15
81		14/15	12/15	14/15	15/15
148		15/15	15/15	13/15	13/15

Graphics



Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID:	12-4348-2951	**Endpoint:**	Hatching Success	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:39	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	**Test Type:**	**Analyst:**
Start Date:	**Protocol:**	**Diluent:**
Ending Date:	**Species:** Pimephales promelas	**Brine:**
Duration:	**Source:**	**Age:**

Sample ID:	**Code:**	**Client:**
Sample Date:	**Material:** Total copper	**Project:**
Receipt Date:	**Source:**	
Sample Age:	**Station:**	

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Angular (Corrected)	C > T	n/a	n/a	n/a	139	> 139	n/a	0.7194	16.0%

Dunnett Multiple Comparison Test

Control vs	Conc-%	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	5.2	2.349	2.482	0.227	6	CDF	0.0650	Non-Significant Effect
	10	0.3608	2.482	0.227	6	CDF	0.7623	Non-Significant Effect
	14.5	-0.4754	2.482	0.227	6	CDF	0.9574	Non-Significant Effect
	24	-0.05222	2.482	0.227	6	CDF	0.8875	Non-Significant Effect
	43	0	2.482	0.227	6	CDF	0.8750	Non-Significant Effect
	81	0.2462	2.482	0.227	6	CDF	0.8030	Non-Significant Effect
	148	-0.05222	2.482	0.227	6	CDF	0.8875	Non-Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.207	2.938	0.7130	No Outliers Detected

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.174326	0.024904	7	1.495	0.2163	Non-Significant Effect
Error	0.399738	0.016656	24			
Total	0.574065		31			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	3.57	18.48	0.8278	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9538	0.9081	0.1849	Normal Distribution

Hatching Success Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	0.9333	0.8467	1.0000	0.9333	0.8667	1.0000	0.0272	5.83%	0.00%
5.2		4	0.7833	0.6022	0.9645	0.7667	0.6667	0.9333	0.0569	14.53%	16.07%
10		4	0.9167	0.8636	0.9697	0.9333	0.8667	0.9333	0.0167	3.64%	1.79%
14.5		4	0.9500	0.7909	1.0000	1.0000	0.8000	1.0000	0.0500	10.53%	-1.79%
24		4	0.9333	0.8108	1.0000	0.9333	0.8667	1.0000	0.0385	8.25%	0.00%
43		4	0.9333	0.8467	1.0000	0.9333	0.8667	1.0000	0.0272	5.83%	0.00%
81		4	0.9167	0.7832	1.0000	0.9333	0.8000	1.0000	0.0419	9.15%	1.79%
148		4	0.9333	0.8108	1.0000	0.9333	0.8667	1.0000	0.0385	8.25%	0.00%

Fathead Minnow 32-d Survival and Growth Test **HydroQual Laboratories, Ltd**

Analysis ID:	12-4348-2951	**Endpoint:**	Hatching Success	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:39	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Angular (Corrected) Transformed Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	1.314	1.155	1.473	1.31	1.197	1.441	0.04995	7.60%	0.00%
5.2		4	1.1	0.8568	1.343	1.068	0.9553	1.31	0.07643	13.90%	16.31%
10		4	1.281	1.192	1.371	1.31	1.197	1.31	0.02816	4.39%	2.50%
14.5		4	1.358	1.092	1.624	1.441	1.107	1.441	0.08355	12.31%	-3.30%
24		4	1.319	1.095	1.544	1.319	1.197	1.441	0.07053	10.69%	-0.36%
43		4	1.314	1.155	1.473	1.31	1.197	1.441	0.04995	7.60%	0.00%
81		4	1.292	1.072	1.511	1.31	1.107	1.441	0.06898	10.68%	1.71%
148		4	1.319	1.095	1.544	1.319	1.197	1.441	0.07053	10.69%	-0.36%

Hatching Success Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.9333	0.8667	1.0000	0.9333
5.2		0.8000	0.6667	0.9333	0.7333
10		0.9333	0.8667	0.9333	0.9333
14.5		1.0000	1.0000	1.0000	0.8000
24		0.8667	1.0000	0.8667	1.0000
43		0.9333	1.0000	0.8667	0.9333
81		0.9333	0.8000	0.9333	1.0000
148		1.0000	1.0000	0.8667	0.8667

Angular (Corrected) Transformed Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	1.31	1.197	1.441	1.31
5.2		1.107	0.9553	1.31	1.028
10		1.31	1.197	1.31	1.31
14.5		1.441	1.441	1.441	1.107
24		1.197	1.441	1.197	1.441
43		1.31	1.441	1.197	1.31
81		1.31	1.107	1.31	1.441
148		1.441	1.441	1.197	1.197

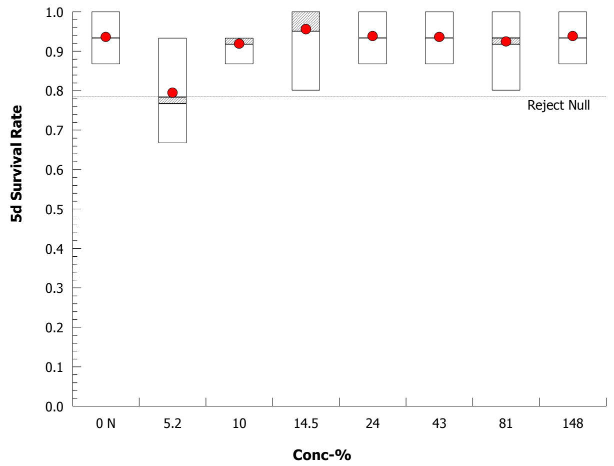
Hatching Success

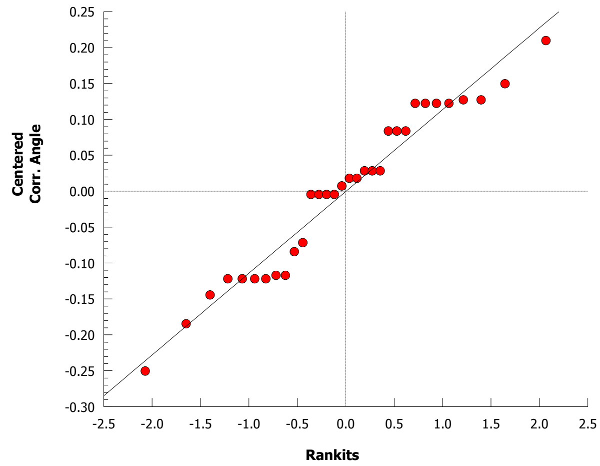
Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	14/15	13/15	15/15	14/15
5.2		12/15	10/15	14/15	11/15
10		14/15	13/15	14/15	14/15
14.5		15/15	15/15	15/15	12/15
24		13/15	15/15	13/15	15/15
43		14/15	15/15	13/15	14/15
81		14/15	12/15	14/15	15/15
148		15/15	15/15	13/15	13/15

Fathead Minnow 32-d Survival and Growth Test | **HydroQual Laboratories, Ltd**

Analysis ID:	12-4348-2951	**Endpoint:**	Hatching Success	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:39	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Graphics





Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID: 04-6095-6814 **Endpoint:** 32d Survival Rate **CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 10:49 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

Batch ID: **Test Type:** **Analyst:**
Start Date: **Protocol:** **Diluent:**
Ending Date: **Species:** Pimephales promelas **Brine:**
Duration: **Source:** **Age:**

Sample ID: **Code:** **Client:**
Sample Date: **Material:** Total copper **Project:**
Receipt Date: **Source:**
Sample Age: **Station:**

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1399593	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	1.941	2.708	0.8568	No Outliers Detected

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	>155	n/a	n/a	<0.6452	n/a	n/a
LC10	>155	n/a	n/a	<0.6452	n/a	n/a
LC15	>155	n/a	n/a	<0.6452	n/a	n/a
LC20	>155	n/a	n/a	<0.6452	n/a	n/a
LC25	>155	n/a	n/a	<0.6452	n/a	n/a
LC40	>155	n/a	n/a	<0.6452	n/a	n/a
LC50	>155	n/a	n/a	<0.6452	n/a	n/a

32d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-%	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0	N	4	0.8667	0.8000	0.9333	0.0272	0.0544	6.28%	0.00%	52	60
24		4	0.8000	0.7333	0.8667	0.0272	0.0544	6.80%	7.69%	48	60
43		4	0.9000	0.8667	0.9333	0.0193	0.0385	4.28%	-3.85%	54	60
82		4	0.8667	0.8000	0.9333	0.0272	0.0544	6.28%	0.00%	52	60
155		4	0.8333	0.7333	0.9333	0.0430	0.0861	10.33%	3.85%	50	60

32d Survival Rate Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.8000	0.8667	0.9333	0.8667
24		0.8000	0.8667	0.7333	0.8000
43		0.9333	0.9333	0.8667	0.8667
82		0.8667	0.8000	0.8667	0.9333
155		0.9333	0.8667	0.8000	0.7333

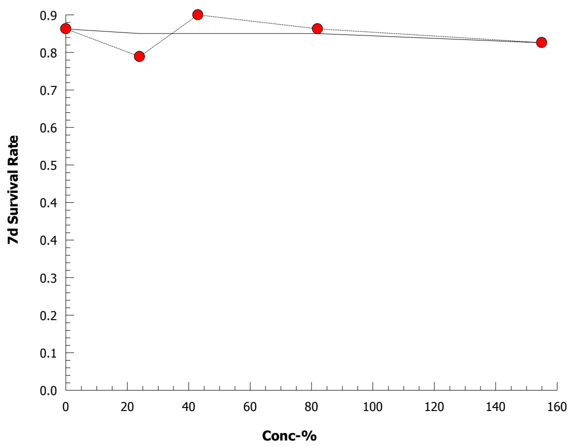
32d Survival Rate Binomials

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	12/15	13/15	14/15	13/15
24		12/15	13/15	11/15	12/15
43		14/15	14/15	13/15	13/15
82		13/15	12/15	13/15	14/15
155		14/15	13/15	12/15	11/15

Fathead Minnow 32-d Survival and Growth Test | **HydroQual Laboratories, Ltd**

Analysis ID:	04-6095-6814	**Endpoint:**	32d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:49	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID: 09-8125-8939 **Endpoint:** 32 d Survival Rate **CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 10:50 **Analysis:** Parametric-Control vs Treatments **Official Results:** Yes

Batch ID: **Test Type:** **Analyst:**
Start Date: **Protocol:** **Diluent:**
Ending Date: **Species:** Pimephales promelas **Brine:**
Duration: **Source:** **Age:**

Sample ID: **Code:** **Client:**
Sample Date: **Material:** total copper **Project:**
Receipt Date: **Source:**
Sample Age: **Station:**

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Angular (Corrected)	C > T	n/a	n/a	n/a	155	> 155	n/a	0.6452	28.0%

Dunnett Multiple Comparison Test

Control vs	Control II	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	5.1*	3.523	2.482	0.292	6	CDF	0.0050	Significant Effect
	10*	5.633	2.482	0.292	6	CDF	2.8E-05	Significant Effect
	15*	4.553	2.482	0.292	6	CDF	4.0E-04	Significant Effect
	24	0.7889	2.482	0.292	6	CDF	0.5795	Non-Significant Effect
	43	-0.4302	2.482	0.292	6	CDF	0.9523	Non-Significant Effect
	82	0	2.482	0.292	6	CDF	0.8750	Non-Significant Effect
	155	0.3587	2.482	0.292	6	CDF	0.7631	Non-Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.561	2.938	0.0018	Outlier Detected

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	2.20439	0.314913	7	11.37	2.8E-06	Significant Effect
Error	0.664747	0.027698	24			
Total	2.86914		31			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	17.95	18.48	0.0122	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.8961	0.9081	0.0049	Non-Normal Distribution

32d Survival Rate Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	0.8667	0.7801	0.9533	0.8667	0.8000	0.9333	0.0272	6.28%	0.00%
5.1		4	0.4833	0.0000	0.9685	0.3667	0.2667	0.9333	0.1524	63.08%	44.23%
10		4	0.2833	0.0000	0.6001	0.2667	0.0667	0.5333	0.0995	70.26%	67.31%
15		4	0.3833	0.2818	0.4849	0.3667	0.3333	0.4667	0.0319	16.65%	55.77%
24		4	0.8000	0.7134	0.8866	0.8000	0.7333	0.8667	0.0272	6.80%	7.69%
43		4	0.9000	0.8388	0.9612	0.9000	0.8667	0.9333	0.0193	4.28%	-3.85%
82		4	0.8667	0.7801	0.9533	0.8667	0.8000	0.9333	0.0272	6.28%	0.00%
155		4	0.8333	0.6964	0.9703	0.8333	0.7333	0.9333	0.0430	10.33%	3.85%

Fathead Minnow 32-d Survival and Growth Test | **HydroQual Laboratories, Ltd**

Analysis ID:	09-8125-8939	**Endpoint:**	32d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:50	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Angular (Corrected) Transformed Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	1.203	1.071	1.335	1.197	1.107	1.31	0.04146	6.90%	0.00%
5.1		4	0.7881	0.2272	1.349	0.6501	0.5426	1.31	0.1762	44.72%	34.47%
10		4	0.5398	0.1643	0.9152	0.5396	0.2612	0.8188	0.118	43.71%	55.12%
15		4	0.6669	0.5628	0.7711	0.6501	0.6155	0.752	0.03273	9.81%	44.55%
24		4	1.11	1	1.22	1.107	1.028	1.197	0.0345	6.22%	7.72%
43		4	1.253	1.15	1.357	1.253	1.197	1.31	0.03251	5.19%	-4.21%
82		4	1.203	1.071	1.335	1.197	1.107	1.31	0.04146	6.90%	0.00%
155		4	1.16	0.9679	1.353	1.152	1.028	1.31	0.06051	10.43%	3.51%

32-d Survival Rate Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.8000	0.8667	0.9333	0.8667
5.1		0.2667	0.4000	0.9333	0.3333
10		0.0667	0.5333	0.3333	0.2000
15		0.4667	0.3333	0.3333	0.4000
24		0.8000	0.8667	0.7333	0.8000
43		0.9333	0.9333	0.8667	0.8667
82		0.8667	0.8000	0.8667	0.9333
155		0.9333	0.8667	0.8000	0.7333

Angular (Corrected) Transformed Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	1.107	1.197	1.31	1.197
5.1		0.5426	0.6847	1.31	0.6155
10		0.2612	0.8188	0.6155	0.4636
15		0.752	0.6155	0.6155	0.6847
24		1.107	1.197	1.028	1.107
43		1.31	1.31	1.197	1.197
82		1.197	1.107	1.197	1.31
155		1.31	1.197	1.107	1.028

32-d Survival Rate Binomials

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	12/15	13/15	14/15	13/15
5.1		4/15	6/15	14/15	5/15
10		1/15	8/15	5/15	3/15
15		7/15	5/15	5/15	6/15
24		12/15	13/15	11/15	12/15
43		14/15	14/15	13/15	13/15
82		13/15	12/15	13/15	14/15
155		14/15	13/15	12/15	11/15

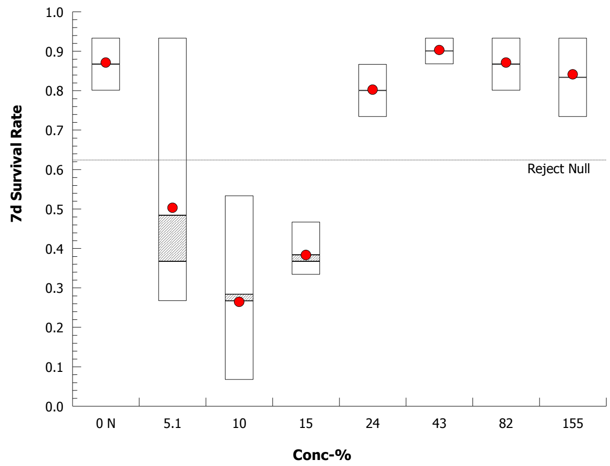
CETIS Analytical Report

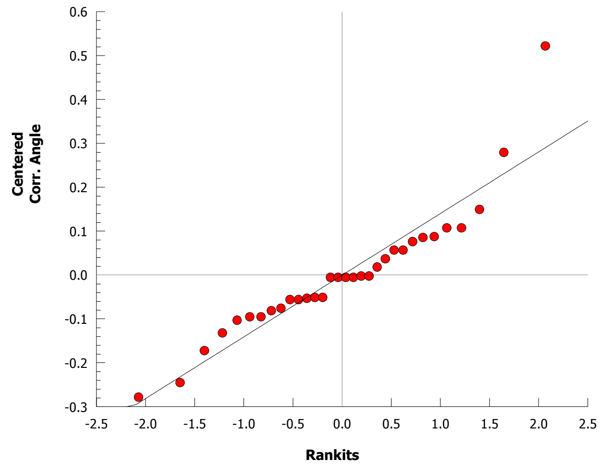
Report Date: 03 Dec-15 10:51 (p 3 of 3)
Test Code: SP15-013 Cu FM | 14-2835-3287

Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID:	09-8125-8939	**Endpoint:**	32-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:50	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Graphics





CETIS Analytical Report

Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID:	11-0255-2477	**Endpoint:**	Post Hatch Survival	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:43	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Pimephales promelas	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1605717	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	1.815	2.708	1.0000	No Outliers Detected

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	>155	n/a	n/a	<0.6452	n/a	n/a
LC10	>155	n/a	n/a	<0.6452	n/a	n/a
LC15	>155	n/a	n/a	<0.6452	n/a	n/a
LC20	>155	n/a	n/a	<0.6452	n/a	n/a
LC25	>155	n/a	n/a	<0.6452	n/a	n/a
LC40	>155	n/a	n/a	<0.6452	n/a	n/a
LC50	>155	n/a	n/a	<0.6452	n/a	n/a

Post Hatch Survival Summary

			Calculated Variate(A/B)								
Conc-%	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	N	4	0.9298	0.8571	1.0000	0.0292	0.0584	6.28%	0.00%	52	56
24		4	0.8590	0.8000	0.9231	0.0255	0.0510	5.94%	7.61%	48	56
43		4	0.9655	0.9286	1.0000	0.0200	0.0399	4.13%	-3.84%	54	56
82		4	0.9476	0.9286	1.0000	0.0175	0.0350	3.69%	-1.92%	52	55
155		4	0.8923	0.8462	0.9333	0.0213	0.0425	4.76%	4.03%	50	56

Post Hatch Survival Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.8571	1.0000	0.9333	0.9286
24		0.9231	0.8667	0.8462	0.8000
43		1.0000	0.9333	1.0000	0.9286
82		0.9286	1.0000	0.9286	0.9333
155		0.9333	0.8667	0.9231	0.8462

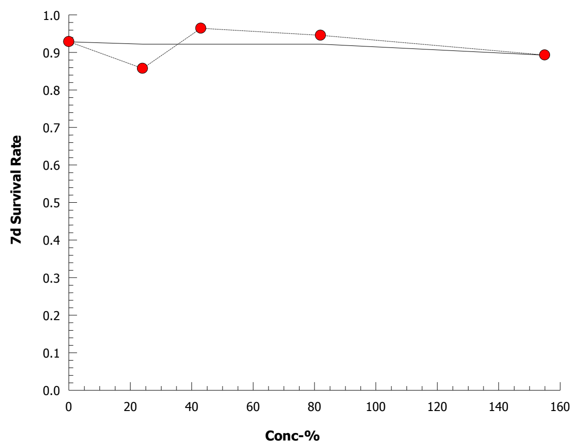
Post Hatch Survival Binomials

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	12/14	13/13	14/15	13/14
24		12/13	13/15	11/13	12/15
43		14/14	14/15	13/13	13/14
82		13/14	12/12	13/14	14/15
155		14/15	13/15	12/13	11/13

Fathead Minnow 32-d Survival and Growth Test **HydroQual Laboratories, Ltd**

Analysis ID:	11-0255-2477	**Endpoint:**	Post Hatch Survival	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:43	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID: 12-3233-6214 **Endpoint:** Post Hatch Survival **CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 10:45 **Analysis:** Parametric-Control vs Treatments **Official Results:** Yes

Batch ID: **Test Type:** **Analyst:**
Start Date: **Protocol:** **Diluent:**
Ending Date: **Species:** Pimephales promelas **Brine:**
Duration: **Source:** **Age:**

Sample ID: **Code:** **Client:**
Sample Date: **Material:** Total copper **Project:**
Receipt Date: **Source:**
Sample Age: **Station:**

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Angular (Corrected)	C > T	n/a	n/a	n/a	155	> 155	n/a	0.6452	15.9%

Dunnett Multiple Comparison Test

Control vs	Control II	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	5.1*	5.818	2.493	0.24	5	CDF	2.1E-05	Significant Effect
	10*	8.235	2.493	0.222	6	CDF	8.1E-07	Significant Effect
	15*	6.903	2.493	0.222	6	CDF	2.3E-06	Significant Effect
	24	1.301	2.493	0.222	6	CDF	0.3502	Non-Significant Effect
	43	-0.7125	2.493	0.222	6	CDF	0.9785	Non-Significant Effect
	82	-0.3128	2.493	0.222	6	CDF	0.9392	Non-Significant Effect
	155	0.7324	2.493	0.222	6	CDF	0.6108	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	2.90546	0.415065	7	26.22	<1.0E-37	Significant Effect
Error	0.364077	0.015829	23			
Total	3.26953		30			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	11.09	18.48	0.1348	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9423	0.9056	0.0953	Normal Distribution

Post Hatch Survival Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	0.9298	0.8369	1.0000	0.9310	0.8571	1.0000	0.0292	6.28%	0.00%
5.1		3	0.4626	0.1310	0.7943	0.4545	0.3333	0.6000	0.0771	28.86%	50.24%
10		4	0.3146	0.0000	0.6837	0.2857	0.0714	0.6154	0.1160	73.75%	66.17%
15		4	0.4083	0.2688	0.5478	0.4000	0.3333	0.5000	0.0438	21.47%	56.08%
24		4	0.8590	0.7778	0.9402	0.8564	0.8000	0.9231	0.0255	5.94%	7.61%
43		4	0.9655	0.9020	1.0000	0.9667	0.9286	1.0000	0.0200	4.13%	-3.84%
82		4	0.9476	0.8919	1.0000	0.9310	0.9286	1.0000	0.0175	3.69%	-1.92%
155		4	0.8923	0.8247	0.9599	0.8949	0.8462	0.9333	0.0213	4.76%	4.03%

Angular (Corrected) Transformed Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	1.306	1.145	1.468	1.305	1.183	1.432	0.05076	7.77%	0.00%
5.1		3	0.7471	0.4107	1.084	0.7399	0.6155	0.8861	0.0782	18.13%	42.80%
10		4	0.5735	0.15	0.9971	0.5609	0.2705	0.9018	0.1331	46.41%	56.09%
15		4	0.6921	0.5497	0.8345	0.6838	0.6155	0.7854	0.04476	12.93%	47.01%
24		4	1.19	1.069	1.311	1.182	1.107	1.29	0.03804	6.39%	8.86%
43		4	1.37	1.251	1.489	1.371	1.3	1.437	0.03738	5.46%	-4.85%
82		4	1.334	1.236	1.432	1.305	1.3	1.426	0.03072	4.61%	-2.13%
155		4	1.241	1.131	1.351	1.243	1.168	1.31	0.03463	5.58%	4.99%

Fathead Minnow 32-d Survival and Growth Test **HydroQual Laboratories, Ltd**

Analysis ID:	12-3233-6214	**Endpoint:**	Post Hatch Survival	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 10:45	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Post Hatch Survival Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.8571	1.0000	0.9333	0.9286
5.1		0.3333	0.6000	Outlier	0.4545
10		0.0714	0.6154	0.3571	0.2143
15		0.4667	0.3333	0.3333	0.5000
24		0.9231	0.8667	0.8462	0.8000
43		1.0000	0.9333	1.0000	0.9286
82		0.9286	1.0000	0.9286	0.9333
155		0.9333	0.8667	0.9231	0.8462

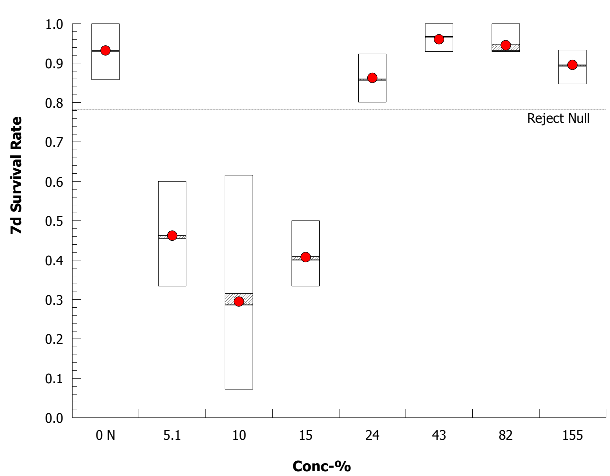
Angular (Corrected) Transformed Detail

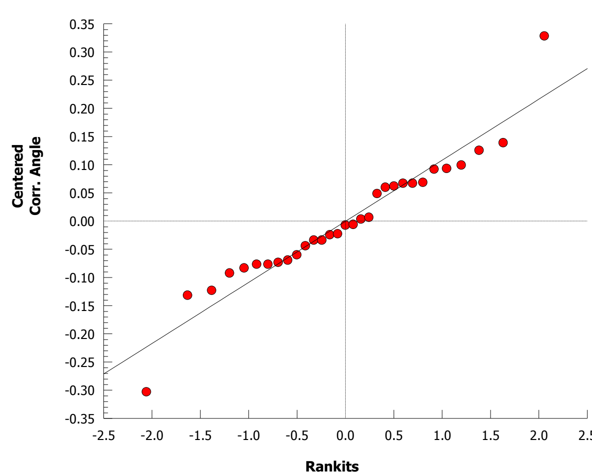
Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	1.183	1.432	1.31	1.3
5.1		0.6155	0.8861	0.7399	
10		0.2705	0.9018	0.6405	0.4813
15		0.752	0.6155	0.6155	0.7854
24		1.29	1.197	1.168	1.107
43		1.437	1.31	1.432	1.3
82		1.3	1.426	1.3	1.31
155		1.31	1.197	1.29	1.168

Post HatchSurvival Binomials

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	12/14	13/13	14/15	13/14
5.1		4/12	6/10	14/14	5/11
10		1/14	8/13	5/14	3/14
15		7/15	5/15	5/15	6/12
24		12/13	13/15	11/13	12/15
43		14/14	14/15	13/13	13/14
82		13/14	12/12	13/14	14/15
155		14/15	13/15	12/13	11/13

Graphics





CETIS Analytical Report

Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID:	17-3874-3160	**Endpoint:**	Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:01	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Pimephales promelas	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**		**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	132465	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.266	2.938	0.5976	No Outliers Detected

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	>155	n/a	n/a	<0.6452	n/a	n/a
IC10	>155	n/a	n/a	<0.6452	n/a	n/a
IC15	>155	n/a	n/a	<0.6452	n/a	n/a
IC20	>155	n/a	n/a	<0.6452	n/a	n/a
IC25	>155	n/a	n/a	<0.6452	n/a	n/a
IC40	>155	n/a	n/a	<0.6452	n/a	n/a
IC50	>155	n/a	n/a	<0.6452	n/a	n/a

Mean Dry Biomass-mg Summary

			Calculated Variate						
Conc-%	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	4	1.747	1.64	1.833	0.04114	0.08227	4.71%	0.00%
5.1		4	1.587	1.483	1.695	0.04756	0.09513	5.99%	9.14%
10		4	1.463	1.063	1.675	0.1374	0.2748	18.79%	16.25%
15		4	1.736	1.396	2.091	0.1468	0.2936	16.91%	0.59%
24		4	1.715	1.512	1.917	0.09923	0.1985	11.57%	1.80%
43		4	2.086	1.828	2.359	0.1092	0.2185	10.47%	-19.46%
82		4	2.083	1.813	2.308	0.1035	0.2069	9.93%	-19.28%
155		4	1.991	1.873	2.138	0.06104	0.1221	6.13%	-13.96%

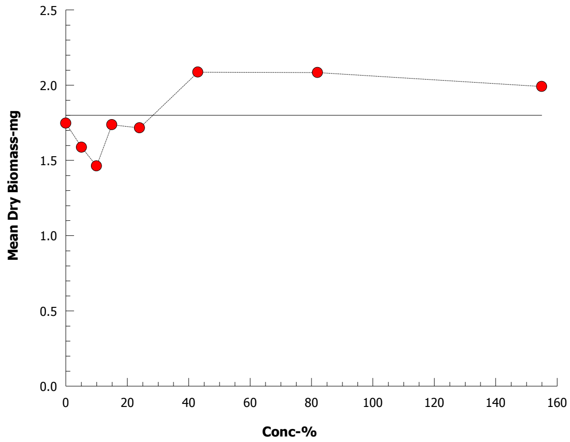
Mean Dry Biomass-mg Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	1.833	1.732	1.781	1.64
5.1		1.483	1.695	1.536	1.634
10		1.063	1.599	1.514	1.675
15		2.091	1.822	1.396	1.637
24		1.851	1.581	1.512	1.917
43		2.113	1.828	2.359	2.047
82		1.813	2.308	2.149	2.064
155		1.91	2.041	2.138	1.873

Fathead Minnow 32-d Survival and Growth Test **HydroQual Laboratories, Ltd**

Analysis ID:	17-3874-3160	**Endpoint:**	Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:01	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	03 Dec-15 11:03 (p 1 of 2)
Test Code:	SP15-013 Cu FM | 14-2835-3287

Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID:	08-8202-3790	**Endpoint:**	Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:02	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Pimephales promelas	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Untransformed	C > T	n/a	n/a	n/a	155	> 155	n/a	0.6452	20.2%

Dunnett Multiple Comparison Test

Control vs	Conc-%	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	5.1	1.125	2.482	0.352	6	CDF	0.4235	Non-Significant Effect
	10	2	2.482	0.352	6	CDF	0.1234	Non-Significant Effect
	15	0.0728	2.482	0.352	6	CDF	0.8559	Non-Significant Effect
	24	0.2219	2.482	0.352	6	CDF	0.8110	Non-Significant Effect
	43	-2.394	2.482	0.352	6	CDF	0.9999	Non-Significant Effect
	82	-2.373	2.482	0.352	6	CDF	0.9999	Non-Significant Effect
	155	-1.718	2.482	0.352	6	CDF	0.9991	Non-Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.266	2.938	0.5976	No Outliers Detected

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	1.48752	0.212503	7	5.273	9.5E-04	Significant Effect
Error	0.967135	0.040297	24			
Total	2.45466		31			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	7.138	18.48	0.4146	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.985	0.9081	0.9247	Normal Distribution

Mean Dry Biomass-mg Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	1.747	1.616	1.878	1.757	1.64	1.833	0.04114	4.71%	0.00%
5.1		4	1.587	1.436	1.738	1.585	1.483	1.695	0.04756	5.99%	9.14%
10		4	1.463	1.026	1.9	1.557	1.063	1.675	0.1374	18.79%	16.25%
15		4	1.736	1.269	2.204	1.729	1.396	2.091	0.1468	16.91%	0.59%
24		4	1.715	1.399	2.031	1.716	1.512	1.917	0.09923	11.57%	1.80%
43		4	2.086	1.739	2.434	2.08	1.828	2.359	0.1092	10.47%	-19.46%
82		4	2.083	1.754	2.413	2.107	1.813	2.308	0.1035	9.93%	-19.28%
155		4	1.991	1.796	2.185	1.976	1.873	2.138	0.06104	6.13%	-13.96%

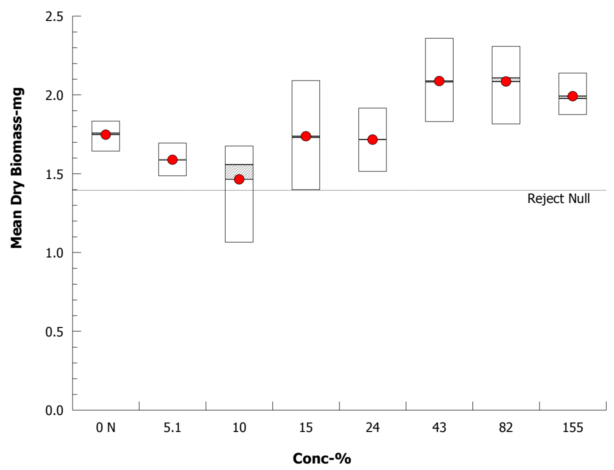
Fathead Minnow 32-d Survival and Growth Test | **HydroQual Laboratories, Ltd**

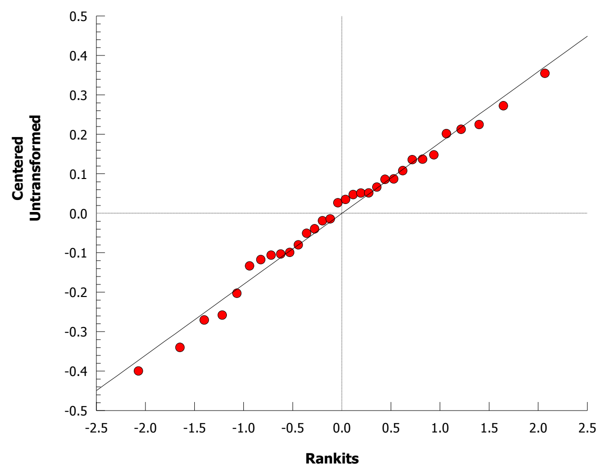
Analysis ID:	08-8202-3790	**Endpoint:**	Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:02	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Mean Dry Biomass-mg Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	1.833	1.732	1.781	1.64
5.1		1.483	1.695	1.536	1.634
10		1.063	1.599	1.514	1.675
15		2.091	1.822	1.396	1.637
24		1.851	1.581	1.512	1.917
43		2.113	1.828	2.359	2.047
82		1.813	2.308	2.149	2.064
155		1.91	2.041	2.138	1.873

Graphics





CETIS Analytical Report

Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID: 03-6664-9346 **Endpoint:** Hatching Success **CETIS Version:** CETISv1.9.0
Analyzed: 15 Apr-16 13:37 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

Batch ID: **Test Type:** **Analyst:**
Start Date: **Protocol:** **Diluent:**
Ending Date: **Species:** Pimephales promelas **Brine:**
Duration: **Source:** **Age:**

Sample ID: **Code:** **Client:**
Sample Date: **Material:** Dissolved copper **Project:**
Receipt Date: **Source:**
Sample Age: **Station:**

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1354874	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.207	2.938	0.7130	No Outliers Detected

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	>144	n/a	n/a	<0.6944	n/a	n/a
LC10	>144	n/a	n/a	<0.6944	n/a	n/a
LC15	>144	n/a	n/a	<0.6944	n/a	n/a
LC20	>144	n/a	n/a	<0.6944	n/a	n/a
LC25	>144	n/a	n/a	<0.6944	n/a	n/a
LC40	>144	n/a	n/a	<0.6944	n/a	n/a
LC50	>144	n/a	n/a	<0.6944	n/a	n/a

Hatching Success Summary

			Calculated Variate(A/B)								
Conc-ug/L	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0	N	4	0.9333	0.8667	1.0000	0.0272	0.0544	5.83%	0.00%	56	60
5		4	0.7833	0.6667	0.9333	0.0569	0.1139	14.53%	16.07%	47	60
9.9		4	0.9167	0.8667	0.9333	0.0167	0.0333	3.64%	1.79%	55	60
13		4	0.9500	0.8000	1.0000	0.0500	0.1000	10.53%	-1.79%	57	60
23		4	0.9333	0.8667	1.0000	0.0385	0.0770	8.25%	0.00%	56	60
38		4	0.9333	0.8667	1.0000	0.0272	0.0544	5.83%	0.00%	56	60
75		4	0.9167	0.8000	1.0000	0.0419	0.0839	9.15%	1.79%	55	60
144		4	0.9333	0.8667	1.0000	0.0385	0.0770	8.25%	0.00%	56	60

Hatching Success Summary

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.9333	0.8667	1.0000	0.9333
5		0.8000	0.6667	0.9333	0.7333
9.9		0.9333	0.8667	0.9333	0.9333
13		1.0000	1.0000	1.0000	0.8000
23		0.8667	1.0000	0.8667	1.0000
38		0.9333	1.0000	0.8667	0.9333
75		0.9333	0.8000	0.9333	1.0000
144		1.0000	1.0000	0.8667	0.8667

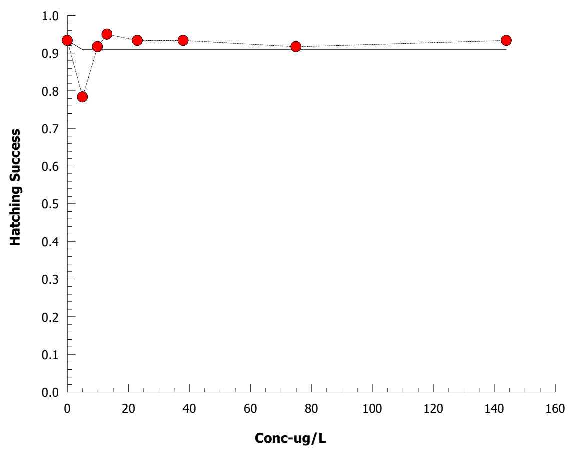
Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID: 03-6664-9346 **Endpoint:** Hatching Success **CETIS Version:** CETISv1.9.0
Analyzed: 15 Apr-16 13:37 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

Hatching Success

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	14/15	13/15	15/15	14/15
5		12/15	10/15	14/15	11/15
9.9		14/15	13/15	14/15	14/15
13		15/15	15/15	15/15	12/15
23		13/15	15/15	13/15	15/15
38		14/15	15/15	13/15	14/15
75		14/15	12/15	14/15	15/15
144		15/15	15/15	13/15	13/15

Graphics



Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID:	04-5624-0596	**Endpoint:**	Overall Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 13:17	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Pimephales promelas	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	737769	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	1.941	2.708	0.8568	No Outliers Detected

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	>139	n/a	n/a	<0.7194	n/a	n/a
LC10	>139	n/a	n/a	<0.7194	n/a	n/a
LC15	>139	n/a	n/a	<0.7194	n/a	n/a
LC20	>139	n/a	n/a	<0.7194	n/a	n/a
LC25	>139	n/a	n/a	<0.7194	n/a	n/a
LC40	>139	n/a	n/a	<0.7194	n/a	n/a
LC50	>139	n/a	n/a	<0.7194	n/a	n/a

Overall Survival Rate Summary

			Calculated Variate(A/B)								
Conc-ug/L	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0	N	4	0.8667	0.8000	0.9333	0.0272	0.0544	6.28%	0.00%	52	60
21		4	0.8000	0.7333	0.8667	0.0272	0.0544	6.80%	7.69%	48	60
38		4	0.9000	0.8667	0.9333	0.0193	0.0385	4.28%	-3.85%	54	60
73		4	0.8667	0.8000	0.9333	0.0272	0.0544	6.28%	0.00%	52	60
139		4	0.8333	0.7333	0.9333	0.0430	0.0861	10.33%	3.85%	50	60

Overall Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.8000	0.8667	0.9333	0.8667
21		0.8000	0.8667	0.7333	0.8000
38		0.9333	0.9333	0.8667	0.8667
73		0.8667	0.8000	0.8667	0.9333
139		0.9333	0.8667	0.8000	0.7333

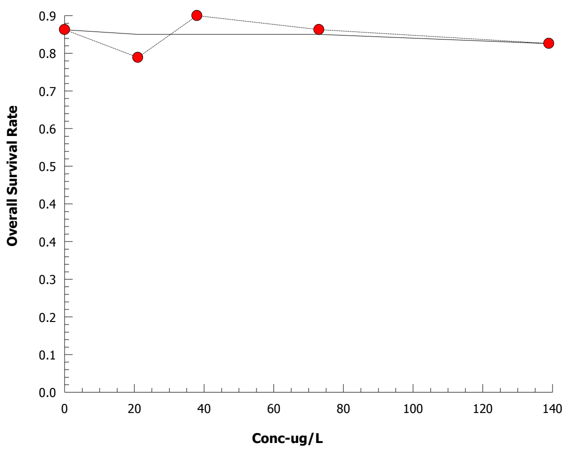
Overall Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	12/15	13/15	14/15	13/15
21		12/15	13/15	11/15	12/15
38		14/15	14/15	13/15	13/15
73		13/15	12/15	13/15	14/15
139		14/15	13/15	12/15	11/15

Fathead Minnow 32-d Survival and Growth Test **HydroQual Laboratories, Ltd**

Analysis ID:	04-5624-0596	**Endpoint:**	Overall Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 13:17	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID:	03-5822-5531	**Endpoint:**	Post Hatch Survival	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 13:32	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Pimephales promelas	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1339431	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	1.815	2.708	1.0000	No Outliers Detected

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	>139	n/a	n/a	<0.7194	n/a	n/a
LC10	>139	n/a	n/a	<0.7194	n/a	n/a
LC15	>139	n/a	n/a	<0.7194	n/a	n/a
LC20	>139	n/a	n/a	<0.7194	n/a	n/a
LC25	>139	n/a	n/a	<0.7194	n/a	n/a
LC40	>139	n/a	n/a	<0.7194	n/a	n/a
LC50	>139	n/a	n/a	<0.7194	n/a	n/a

Post Hatch Survival Summary

			Calculated Variate(A/B)								
Conc-ug/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	N	4	0.9298	0.8571	1.0000	0.0292	0.0584	6.28%	0.00%	52	56
21		4	0.8590	0.8000	0.9231	0.0255	0.0510	5.94%	7.61%	48	56
38		4	0.9655	0.9286	1.0000	0.0200	0.0399	4.13%	-3.84%	54	56
73		4	0.9476	0.9286	1.0000	0.0175	0.0350	3.69%	-1.92%	52	55
139		4	0.8923	0.8462	0.9333	0.0213	0.0425	4.76%	4.03%	50	56

Post Hatch Survival Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.8571	1.0000	0.9333	0.9286
21		0.9231	0.8667	0.8462	0.8000
38		1.0000	0.9333	1.0000	0.9286
73		0.9286	1.0000	0.9286	0.9333
139		0.9333	0.8667	0.9231	0.8462

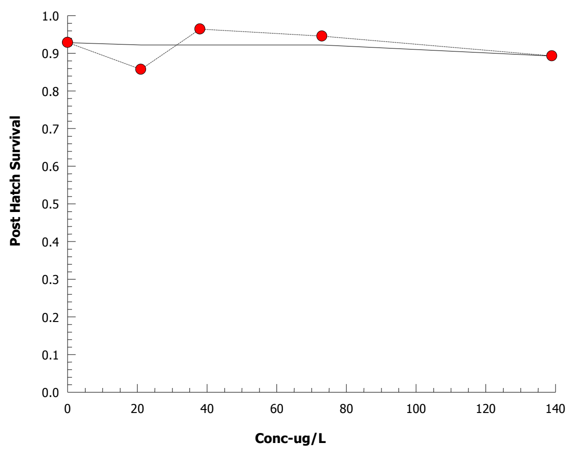
Post Hatch Survival Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	12/14	13/13	14/15	13/14
21		12/13	13/15	11/13	12/15
38		14/14	14/15	13/13	13/14
73		13/14	12/12	13/14	14/15
139		14/15	13/15	12/13	11/13

Fathead Minnow 32-d Survival and Growth Test | **HydroQual Laboratories, Ltd**

Analysis ID:	03-5822-5531	**Endpoint:**	Post Hatch Survival	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 13:32	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Fathead Minnow 32-d Survival and Growth Test — **HydroQual Laboratories, Ltd**

Analysis ID:	19-7488-2010	**Endpoint:**	Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 13:26	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Pimephales promelas	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	621607	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.266	2.938	0.5976	No Outliers Detected

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	>139	n/a	n/a	<0.7194	n/a	n/a
IC10	>139	n/a	n/a	<0.7194	n/a	n/a
IC15	>139	n/a	n/a	<0.7194	n/a	n/a
IC20	>139	n/a	n/a	<0.7194	n/a	n/a
IC25	>139	n/a	n/a	<0.7194	n/a	n/a
IC40	>139	n/a	n/a	<0.7194	n/a	n/a
IC50	>139	n/a	n/a	<0.7194	n/a	n/a

Mean Dry Biomass-mg Summary

			Calculated Variate						
Conc-ug/L	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	4	1.747	1.64	1.833	0.04114	0.08227	4.71%	0.00%
5.4		4	1.587	1.483	1.695	0.04756	0.09513	5.99%	9.14%
8.9		4	1.463	1.063	1.675	0.1374	0.2748	18.79%	16.25%
13		4	1.736	1.396	2.091	0.1468	0.2936	16.91%	0.59%
21		4	1.715	1.512	1.917	0.09923	0.1985	11.57%	1.80%
38		4	2.086	1.828	2.359	0.1092	0.2185	10.47%	-19.46%
73		4	2.083	1.813	2.308	0.1035	0.2069	9.93%	-19.28%
139		4	1.991	1.873	2.138	0.06104	0.1221	6.13%	-13.96%

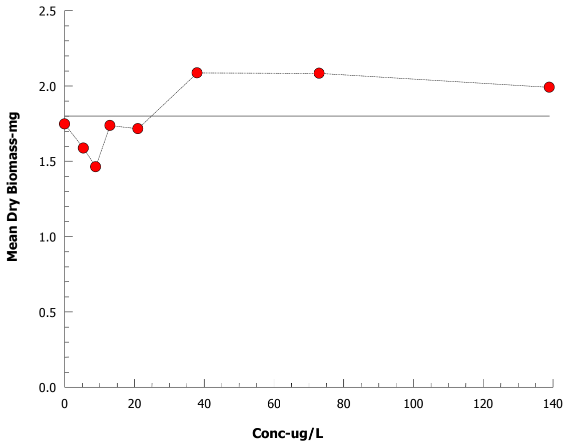
Mean Dry Biomass-mg Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	1.833	1.732	1.781	1.64
5.4		1.483	1.695	1.536	1.634
8.9		1.063	1.599	1.514	1.675
13		2.091	1.822	1.396	1.637
21		1.851	1.581	1.512	1.917
38		2.113	1.828	2.359	2.047
73		1.813	2.308	2.149	2.064
139		1.91	2.041	2.138	1.873

Fathead Minnow 32-d Survival and Growth Test | **HydroQual Laboratories, Ltd**

Analysis ID:	19-7488-2010	**Endpoint:**	Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 13:26	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



APPENDIX D – *Hyalella azteca* Toxicity Test Data

#3, 6125 12th Street SE Calgary, Alberta Canada T2H 2K1
Tel (403) 253-7121 Fax (403) 252-9363 www.hydroqual.ca

Hyalella Bench Sheet

Method 42-d HA | Client NAU104 | Sample SP15-013

Test Log

Date	Day	Time	Technicians	Temp (°C)*	Chem Cart Used	Fed	Feeding Rate (per replicate) YAT	Tetramin	YAT Expiry Date	Bench Sheet Review First	Second
2015/10/08	0	1000	ML/JN	22	3	✓	1 mL	0.25 mg	17-Oct	ML	NM
2015/10/09	1	900	ML	22	3	✓	1 mL	0.25 mg	17-Oct	ML	NM
2015/10/10	2	830	CQ	22	-	✓	1 mL	0.25 mg	24-Oct	CQ	JK
2015/10/11	3	1000	NM	22	-	✓	1 mL	0.25 mg	24-Oct	NM	HKS
2015/10/12	4	1030	DS	22	3	✓	1 mL	0.25 mg	24-Oct	DS	ML
2015/10/13	5	1330	DS	22	-	✓	1 mL	0.25 mg	24-Oct	DS	ML
2015/10/14	6	830	NM	22	3	✓	1 mL	0.25 mg	24-Oct	NM	HKS
2015/10/15	7	945	ML	21	-	✓	1 mL	0.5 mg	24-Oct	ML	NM
2015/10/16	8	1100	DS	21	3	✓	1 mL	0.5 mg	1-Nov	DS	CQ
2015/10/17	9	1230	CQ/JN	23	-	✓	1 mL	0.5 mg	1-Nov	JN	CQ
2015/10/18	10	1500	NM	22	-	✓	1 mL	0.5 mg	1-Nov	NM	HKS
2015/10/19	11	1400	DS	21	3	✓	1 mL	0.5 mg	1-Nov	HKS	DS
2015/10/20	12	1000	ML/JN	22	-	✓	1 mL	0.5 mg	1-Nov	ML	HKS
2015/10/21	13	1430	DS	22	1	✓	1 mL	0.5 mg	1-Nov	DS	JP
2015/10/22	14	1030	ML	22	-	✓	1 mL	1.0 mg	8-Nov	ML	DS
2015/10/23	15	1200	ML	21	3	✓	1 mL	1.0 mg	8-Nov	ML	DS
2015/10/24	16	1320	JN	21	-	✓	1 mL	1.0 mg	8-Nov	JN	CQ
2015/10/25	17	1315	NM	20	-	✓	1 mL	1.0 mg	8-Nov	NM	HKS
2015/10/26	18	1430	DS	21	1	✓	1 mL	1.0 mg	8-Nov	DS	NM
2015/10/27	19	1200	HKS	20	-	✓	1 mL	1.0 mg	8-Nov	HKS	ML
2015/10/28	20	1000	ML	22	3	✓	1 mL	1.0 mg	8-Nov	ML	JP
2015/10/29	21	800	ML	23	-	✓	1 mL	1.5 mg	15-Nov	ML	DS
2015/10/30	22	1500	ML	23	3	✓	1 mL	1.5 mg	15-Nov	ML	DS
2015/10/31	23	1345	JN	23	-	✓	1 mL	1.5 mg	15-Nov	JN	CQ
2015/11/01	24	830	NM	23	-	✓	1 mL	1.5 mg	15-Nov	NM	HKS
2015/11/02	25	1200	DS	23	3	✓	1 mL	1.5 mg	22-Nov	DS	CQ
2015/11/03	26	1030	NM	23	-	✓	1 mL	1.5 mg	22-Nov	NM	HS
2015/11/04	27	1600	ML/CQ	23	3	✓	1 mL	1.5 mg	22-Nov	ML	JN
2015/11/05	28	900	ML/HKS	23	-	✓	1 mL	2.0 mg	22-Nov	ML	CQ
2015/11/06	29	900	JN	23	1	✓	1 mL	2.0 mg	22-Nov	JN	HKS
2015/11/07	30	1415	JN	23	-	✓	1 mL	2.0 mg	28-Nov	JN	HKS
2015/11/08	31	1630	DS	23	-	✓	1 mL	2.0 mg	28-Nov	DS	ML
2015/11/09	32	950	NM	23	3	✓	1 mL	2.0 mg	28-Nov	NM	DS
2015/11/10	33	1030	DS	23	-	✓	1 mL	2.0 mg	28-Nov	DS	JP
2015/11/11	34	1100	HKS	23	-	✓	1 mL	2.0 mg	28-Nov	HKS	JN
2015/11/12	35	850	NM	23	-	✓	1 mL	2.5 mg	28-Nov	NM	-
2015/11/13	36	1330	JN	23	3	✓	1 mL	2.5 mg	5-Dec	JN	JP
2015/11/14	37	1100	DS	23	-	✓	1 mL	2.5 mg	5-Dec	DS	JN
2015/11/15	38	1200	DS	23	-	✓	1 mL	2.5 mg	5-Dec	DS	ML
2015/11/16	39	1415	NM	23	3	✓	1 mL	2.5 mg	5-Dec	NM	JP
2015/11/17	40	1030	HKS	23	-	✓	1 mL	2.5 mg	5-Dec	HKS	DS
2015/11/18	41	730	HKS	23	3	✓	1 mL	2.5 mg	5-Dec	HKS	DS
2015/11/19	42	800	NM	23	-	-	-	-	-	HKS	LO

*23 ± 1°C (23 ± 3°C instantaneous)

Comments:

HydroQual Laboratories Ltd.

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Hyalella Bench Sheet

Method 42-d HA | Client NAU104 | Sample SP15-013

Chemistry (Monday, Wednesday, Friday)

New Solutions (left block); second block (right) as printed without label.

pH (units)

dose (ug/L) / day	Lab CTL	Site CTL	5	10	20	40	80	160	Lab CTL	Site CTL	5	10	20	40	80	160
2015/10/08	7.5	8.1	8.1	8.1	8.1	8.1	8.1	8.1	-	-	-	-	-	-	-	-
2015/10/09	7.8	7.8	7.8	7.8	7.8	7.8	7.7	7.7	7.5	7.7	-	8.0	8.0	8.0	8.0	8.1
2015/10/12	7.4	7.7	7.8	7.8	7.9	7.9	7.8	7.8	7.7	7.9	-	7.9	7.9	7.9	8.0	8.0
2015/10/13	7.4	7.7	7.7	7.7	7.7	7.8	7.7	7.7	7.3	7.6	7.7	7.7	7.7	7.7	7.7	7.7
2015/10/16	7.6	7.9	7.9	8.0	8.0	8.0	8.0	8.0	7.4	7.7	7.7	7.8	7.8	7.8	7.8	7.8
2015/10/19	7.3	7.6	7.7	7.7	7.6	7.6	7.7	7.7	7.3	7.7	7.7	7.8	7.8	7.8	7.8	7.8
2015/10/21	7.4	7.7	7.9	7.9	8.0	7.9	7.9	7.8	7.5	7.9	7.8	7.9	8.0	7.9	7.0	8.0
2015/10/23	8.3	8.1	7.8	7.8	7.8	7.8	7.8	7.8	7.3	7.6	7.7	7.6	7.6	7.6	7.6	7.8
2015/10/26	7.9	8.1	8.1	8.1	8.1	8.1	8.1	8.1	7.5	7.9	7.9	7.9	7.9	7.9	8.0	7.9
2015/10/28	7.6	7.8	7.9	7.8	7.8	7.9	7.8	7.8	7.4	7.5	7.7	7.6	7.6	7.6	7.7	7.7
2015/10/30	7.5	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.6	7.8	7.9	7.9	7.9	7.8	8.0	7.9
2015/11/02	7.3	7.6	7.7	7.7	7.7	7.8	7.7	7.7	7.1	7.9	7.5	7.5	7.5	7.6	7.5	7.6
2015/11/04	7.5	7.7	7.7	7.8	7.6	7.7	7.7	7.7	7.2	7.4	7.5	7.5	7.5	7.6	7.6	7.6
2015/11/06	7.6	7.9	7.9	8.0	7.9	8.1	8.0	7.9	7.3	7.6	7.6	7.6	7.6	7.6	7.7	7.8
2015/11/09	7.6	7.6	7.8	7.8	7.8	7.9	7.9	7.9	7.3	7.5	7.6	7.5	7.5	7.6	7.6	7.5
2015/11/13	8.1	8.1	8.1	8.1	8.2	8.2	8.2	8.1	7.3	7.9	7.9	7.9	7.8	7.8	8.0	8.1
2015/11/16	8.3	8.4	8.5	8.4	8.5	8.6	8.6	8.5	8.1	8.2	8.1	8.1	8.0	8.0	8.1	8.1
2015/11/18	7.7	8.0	8.0	7.9	7.9	8.1	8.1	8.1	7.2	7.8	7.9	7.8	7.8	7.8	7.8	7.8
2015/11/19	-	-	-	-	-	-	-	-	7.3	7.7	7.7	7.7	7.7	7.6	7.6	7.6

conductance (uS/cm)

day	Lab CTL	Site CTL	5	10	20	40	80	160	Lab CTL	Site CTL	5	10	20	40	80	160
2015/10/08	386	437	443	438	438	417	427	424	-	-	-	-	-	-	-	-
2015/10/09	375	436	441	440	442	444	442	444	394	453	-	459	452	458	448	447
2015/10/12	383	441	445	444	446	448	446	447	426	454	-	452	456	455	451	466
2015/10/13	414	468	473	472	475	478	472	479	414	477	481	480	481	481	482	488
2015/10/16	246	491	452	484	482	471	478	481	436	486	482	492	488	496	494	496
2015/10/19	408	476	472	477	478	478	479	478	429	485	478	491	491	497	497	497
2015/10/21	428	442	461	458	460	462	460	462	4736	449	481	481	481	482	485	493
2015/10/23	401	456	458	459	460	462	465	463	402	473	479	478	478	476	479	484
2015/10/26	402	454	492	463	461	461	467	470	417	463	460	467	468	467	472	474
2015/10/28	415	468	475	479	477	476	481	478	445	478	482	483	484	484	484	480
2015/10/30	481	476	474	460	463	457	456	464	429	475	479	480	479	472	489	484
2015/11/02	427	473	471	477	475	477	480	477	431	480	481	488	490	486	487	489
2015/11/04	370	410	415	417	422	417	418	420	389	427	435	440	439	440	440	443
2015/11/06	387	427	420	433	433	433	431	434	425	441	432	442	440	440	434	442
2015/11/09	362	410	416	411	418	416	421	420	280	427	431	324	431	430	431	430
2015/11/13	332	364	367	372	373	369	370	371	323	362	369	369	370	370	371	372
2015/11/16	338	364	366	369	371	368	369	370	352	372	375	376	377	375	375	377
2015/11/18	394	404	402	405	403	401	403	403	403	423	426	423	425	425	426	424
2015/11/19	-	-	-	-	-	-	-	-	450	439	430	434	426	404	428	390

dissolved oxygen (mg/L)

day	Lab CTL	Site CTL	5	10	20	40	80	160	Lab CTL	Site CTL	5	10	20	40	80	160
2015/10/08	8.0	8.0	8.0	8.2	8.2	8.2	8.2	8.1	-	-	-	-	-	-	-	-
2015/10/09	7.7	7.7	7.7	7.7	7.7	7.8	7.8	7.8	6.9	6.9	-	6.7	6.7	6.7	6.7	6.8
2015/10/12	8.1	8.1	8.1	8.1	8.2	8.3	8.3	8.3	6.6	6.6	-	6.6	6.6	6.6	6.6	6.6
2015/10/13	8.0	8.2	8.8	9.1	9.1	9.0	9.0	9.0	7.5	6.6	6.6	6.6	6.6	6.6	6.6	6.6
2015/10/16	8.3	8.6	8.5	8.4	8.5	8.4	8.5	8.5	6.2	6.3	6.3	6.3	6.5	6.1	6.1	6.0
2015/10/19	7.9	9.1	9.1	9.1	9.1	9.1	9.1	9.1	7.0	6.9	6.9	6.9	6.9	6.9	6.9	7.0
2015/10/21	8.0	8.3	9.1	9.1	9.2	9.1	9.1	9.2	7.0	7.0	7.0	7.0	7.1	6.9	7.0	7.0
2015/10/23	8.0	8.9	8.9	8.9	9.1	9.1	9.1	9.1	6.9	6.6	6.0	6.4	6.0	6.0	6.0	6.0
2015/10/26	8.2	8.9	9.4	9.4	9.4	9.4	9.3	9.2	6.6	6.4	6.0	6.1	5.8	6.0	6.0	6.0
2015/10/28	8.2	9.1	9.0	9.0	9.1	9.1	9.1	9.1	6.8	6.5	6.4	6.4	6.4	5.9	6.3	6.3
2015/10/30	7.4	8.8	8.7	8.8	8.8	8.8	8.8	8.8	6.6	6.6	6.6	6.6	6.6	6.5	6.3	6.0
2015/11/02	7.9	8.1	8.5	8.5	8.6	8.6	8.7	8.8	6.0	6.0	6.0	6.0	6.0	6.1	6.1	6.0
2015/11/04	7.7	8.3	8.6	8.7	8.7	8.8	8.9	8.8	6.0	6.0	6.0	6.0	6.0	5.9	5.8	5.8
2015/11/06	7.9	8.4	8.3	8.4	8.3	8.5	8.5	8.4	5.5	4.4	4.0	3.6	3.7	3.7	4.4	4.5
2015/11/09	7.9	8.0	8.0	8.0	8.0	8.0	8.0	7.9	5.8	4.9	4.6	5.8	4.8	4.6	4.6	4.7
2015/11/13	7.7	8.1	8.1	8.1	8.1	8.5	8.6	8.6	4.5	4.7	4.6	4.6	4.6	4.5	4.4	5.4
2015/11/16	8.7	8.7	8.5	8.3	8.2	8.3	8.3	8.2	6.0	4.8	6.1	5.2	4.8	4.1	4.1	4.6
2015/11/18	7.9	8.3	8.4	8.4	8.3	8.3	8.3	8.3	4.9	5.0	4.9	4.9	5.0	5.0	4.9	4.7
2015/11/19	-	-	-	-	-	-	-	-	5.6	5.9	5.2	5.8	5.4	5.2	5.0	4.9

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Hyalella Bench Sheet

Method	42-d HA	Client	JAU104		Sample	SP15-013

Culture Information:

Organism Batch: 20151006HA
Source: Chesapeake Cultures
Age: 6-7 days old

Culture Acclimation Mortality (%): 0%

Lab Control Water Preparation Date(s):
2015/10/07
2015/10/16
2015/10/27
2015/11/05

Comments:

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Hyalella Bench Sheet

Method 42-d HA | Client JAU104 | Sample SP15-013

Biology (# of surviving organisms)

dose (ug/L)	Lab CTL	Site CTL	5	10	20	40	80	160	Lab CTL	Site CTL	5	10	20	40	80	160
replicate	day 0								day 21							
a	10	10	10	10	10	10	10	10	10	8	9	10	10	10	10	4
b	10	10	10	10	10	10	10	10	10	9	9	10	10	10	10	6
c	10	10	10	10	10	10	10	10	9	10	10	10	10	10	9	5
d	10	10	10	10	10	10	10	10	10	9	10	10	10	10	10	6
e	10	10	10	10	10	10	10	10	10	9	10	10	10	10	9	6
f	10	10	10	10	10	10	10	10	10	10	10	10	10	9	9	6
g	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	7
h	10	10	10	10	10	10	10	10	9	10	10	10	9	10	10	8
i	10	10	10	10	10	10	10	10	10	10	10	10	10	9	8	6
j	10	10	10	10	10	10	10	10	10	10	10	10	10	10	9	8
k	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	8
l	10	10	10	10	10	10	10	10	10	9	10	10	10	10	9	8
	day 7								day 28							
a	10	9	10	10	10	10	10	10	10	8	9	10	10	10	9	1
b	10	10	10	10	10	10	10	10	10	9	9	9	10	10	10	5
c	9	10	10	10	10	10	10	9	8	10	10	10	10	10	9	4
d	10	9	10	10	10	10	10	10	10	9	10	10	10	10	10	3
e	10	10	10	10	10	10	10	9	10	9	10	10	10	10	8	6
f	10	10	10	10	10	10	10	10	10	10	10	10	10	9	8	2
g	10	10	10	10	9	10	10	10	10	10	9	10	10	10	10	4
h	10	10	10	10	10	9	10	10	9	10	10	10	9	9	10	5
i	10	10	10	10	10	10	10	10	9	10	10	10	9	9	8	2
j	10	10	10	10	10	10	10	9	10	10	10	10	10	10	9	3
k	10	10	10	10	10	10	10	10	10	9	10	10	10	10	10	3
l	10	10	10	10	10	10	10	10	10	9	10	10	10	10	8	6
	day 14															
a	10	8	10	10	10	10	10	7								
b	10	10	10	10	10	10	10	9								
c	9	10	10	10	10	10	9	7								
d	10	9	10	10	10	10	10	6								
e	10	9	10	10	10	10	9	8								
f	10	10	10	10	10	10	10	8								
g	10	10	10	10	10	10	10	8								
h	9	10	10	10	9	10	10	8								
i	10	10	10	10	10	10	9	8								
j	10	10	10	10	10	10	10	9								
k	10	10	10	10	10	10	10	8								
l	10	9	10	10	10	10	9	9								

Day 28 - Place HA from replicates I, j, k, l into pre-weighed weigh dishes to determine growth

Comments:

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Hyalella Bench Sheet

Method 42-d HA | Client JAU104 | Sample SP15-013

Biology (# of surviving organisms, young produced - day 35)

*****day 35 - adult survival*****

dose (ug/L) / replicate	Lab CTL	Site CTL	5	10	20	40	80	160
a	10	7	9	10	9	10	7	1
b	10	8	9	10	10	10	10	3
c	8	9	10	10	9	10	7	6
d	10	9	10	10	10	10	8	2
e	10	9	10	10	10	10	5	6
f	10	9	10	9	10	9	8	2
g	10	10	9	10	10	10	10	3
h	8	10	10	10	9	9	10	4

*****day 35 - young produced*****

replicate	Lab CTL	Site CTL	5	10	20	40	80	160
a	15	2	0	0	0	0	8	0
b	11	8	12	1	9	9	0	0
c	8	1	0	1	8	14	0	0
d	0	6	4	3	0	11	3	0
e	0	1	0	6	1	9	0	0
f	4	6	0	16	1	13	0	0
g	12	4	19	14	1	7	0	0
h	10	2	10	10	3	0	7	0

Day 35 - Remove young from the replicates and place the adults back into their appropriate replicate

Biology (# of surviving organisms, young produced - day 42)

*****day 42 - adult survival*****

replicate								
a	10	6	9	10	9	9	7	1
b	10	7	9	8	10	10	10	2
c	8	9	9	10	8	10	7	5
d	10	9	10	10	10	10	7	2
e	10	9	10	10	10	10	5	6
f	10	9	10	9	9	9	7	2
g	10	10	9	10	10	10	8	3
h	8	10	10	10	9	9	10	4

****day 42 - number of males****

replicate								
a	18	0	0	19	9	1	7	0
b	23	30	5	17	8	17	2	0
c	4	7	0	3	8	10	1	0
d	17	34	4	40	18	7	11	0
e	25	14	70	7	22	20	0	0
f	14	16	40	28	2	24	0	0
g	38	77	47	9	29	11	2	2
h	4	44	45	29	10	12	2	0

*****day 42 - young produced*****

replicate								
a	4	5	7	7	2	2	2	0
b	2	2	1	6	5	4	3	1
c	5	5	8	7	3	3	2	0
d	4	5	5	4	1	4	4	1
e	6	4	5	5	4	2	0	4
f	6	5	4	4	6	4	3	1
g	4	3	2	3	4	4	3	0
h	5	3	3	3	5	2	4	1

Day 42 - Place all adult HA into pre-weighed weigh boats to determine growth

Comments:

HydroQual Laboratories Ltd.

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Tel (403) 253-7121 Fax (403) 252-9363 www.hydroqual.ca

Hyalella Bench Sheet

Client NAU104 Sample SP15-013 Organism HA- 28 d

Initial Weight (mg) (dried pan)

Date: 11/4/2015 Initials: JW Balance*: Mettler 1

Conc. (ug/L Cu)	Lab CTL	Site CTL	5	10	20	40	80	160
Replicate								
i	420.24	416.04	418.66	415.78	422.33	418.07	419.68	416.15
j	417.44	420.66	422.32	420.26	417.12	415.66	418.56	420.55
k	418.11	416.89	420.3	412.36	414.58	425.69	420.56	417.42
l	419.85	419.47	419.52	414.98	417.08	419.91	418.3	419.18

Final Weight (mg) (dried pan+organisms)

Date: 11/7/2015 Initials: JW Balance*: Mettler 1

Conc. (ug/L Cu)	Lab CTL	Site CTL	5	10	20	40	80	160
Replicate								
i	424.87	422.62	425.47	422.16	429.26	423.97	423.42	416.55
j	423.71	427.05	429.86	427.5	424.19	421.84	422.07	421.1
k	423.39	423.59	427.64	419.29	421.3	431.1	424.71	417.67
l	425	426.36	427.12	421.78	422.83	425.08	420.33	420.48

Test Validity Met: **NA**

Results are Logical:** **Yes**

**no negative numbers, consistent values across replicates

*Same balance must be used for initial and final weights
*For FM/HA/CT must use scale with 0.01 mg accuracy

Balance Calibration Check:

	Initial		Final
first pan weighed:	Lac Ctl I	first pan+org weighed:	Lab Ctl I
weight of first pan:	420.24	weight of first pan + org:	424.87
re-weigh of first pan after all weights measured :	420.23	re-weigh of first pan + org after all weights measured:	424.86
% difference <5%:	**Yes**	**% difference <5%:**	**Yes**

Calculation: % difference = [initial weight-reweight/((initial weight+reweight)/2)]x100

If "no" is circled for any parameter, notify Lab Supervisor/QA Group to determine appropriate action

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Hyalella Bench Sheet

Client NAU104 Sample SP15-013 Organism HA- 42 d

Initial Weight (mg) (dried pan)

Date: 11/14/2015 Initials: JW Balance*: Mettler 1

Conc. (ug/L Cu)	Lab CTL	Site CTL	5	10	20	40	80	160
Replicate								
a	416.04	422.2	418.78	416.36	417.97	418.32	415.55	418.59
b	420.36	418.28	418.91	422.64	420.54	418.28	415.53	417.82
c	419.57	419.35	420	420.98	418.72	420.25	420.84	416.01
d	423.28	417.58	418.59	418.47	412.2	417.26	421.96	416.26

Final Weight (mg) (dried pan+organisms)

Date: 11/22/2015 Initials: JW Balance*: Mettler 1

Conc. (ug/L Cu)	Lab CTL	Site CTL	5	10	20	40	80	160
Replicate								
a	425.41	426.64	426.51	428.42	426.53	424	420.05	418.81
b	427.55	425.25	425.87	430.74	429.64	425.58	420.61	418.3
c	426.39	427.62	428.58	429.7	425.12	428.13	426.62	416.63
d	431.69	426.24	428.6	426.32	418.95	425.91	426.59	416.95

Test Validity Met: **NA**

Results are Logical:** **Yes**

**no negative numbers, consistent values across replicates

*Same balance must be used for initial and final weights
*For FM/HA/CT must use scale with 0.01 mg accuracy

Balance Calibration Check:

	Initial		Final
first pan weighed:	Lab ctl A	first pan+org weighed:	Lab Clt A
weight of first pan:	416.04	weight of first pan + org:	425.41
re-weigh of first pan after all weights measured :	416.06	re-weigh of first pan + org after all weights measured:	425.43
% difference <5%:	**Yes**	**% difference <5%:**	**Yes**

Calculation: % difference = [initial weight-reweight/((initial weight+reweight)/2)]x100

If "no" is circled for any parameter, notify Lab Supervisor/QA Group to determine appropriate action

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Hyalella Bench Sheet

Client NAU104 Sample SP15-013 Organism HA- 42 d

Initial Weight (mg) (dried pan)

Date: 11/14/2015 Initials: JW Balance*: Mettler 1

Conc. (ug/L Cu)	Lab CTL	Site CTL	5	10	20	40	80	160
Replicate								
e	420.12	420.39	417.24	423.37	422.71	420.38	419.02	423.3
f	414.89	420.11	421.91	417.11	419.92	422.19	416.79	419.65
g	419.64	417.68	417.18	418.32	418.81	418.53	417.7	418.8
h	419.29	420.72	422.08	415.88	415.4	415.85	415.81	421.01

Final Weight (mg) (dried pan+organisms)

Date: 11/22/2015 Initials: JW Balance*: Mettler 1

Conc. (ug/L Cu)	Lab CTL	Site CTL	5	10	20	40	80	160
Replicate								
e	429.05	428.99	426.04	433.03	430.99	427.78	421.23	424.8
f	424.73	429.32	430.68	426.08	427.92	429.97	419.97	420.24
g	430.21	426.4	425.55	427.53	427.32	427.61	422.24	420.24
h	426.11	430.18	431.56	425.14	423.83	420.19	421.89	422.22

Test Validity Met: **NA**

Results are Logical:** **Yes**

**no negative numbers, consistent values across replicates

*Same balance must be used for initial and final weights
*For FM/HA/CT must use scale with 0.01 mg accuracy

Balance Calibration Check:

	Initial		Final
first pan weighed:	Lab Ctl E	first pan+org weighed:	Lab Ctl E
weight of first pan:	420.12	weight of first pan + org:	429.05
re-weigh of first pan after all weights measured :	420.13	re-weigh of first pan + org after all weights measured:	428.99

% difference <5%: **Yes** **% difference <5%:** **Yes**

Calculation: % difference = [initial weight-reweight/((initial weight+reweight)/2)]x100

If "no" is circled for any parameter, notify Lab Supervisor/QA Group to determine appropriate action

Hyalella azteca **42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	15-2735-1278	**Endpoint:**	28d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:19	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Linear Regression Options

Model Name	Link Function	Threshold Option	Thresh	Optimized	Pooled	Het Corr	Weighted
Log-Logit	η=log[π/(1-π)]	Control Threshold	0.025	Yes	No	No	Yes

Regression Summary

Iters	LL	AICc	BIC	Mu	Sigma	Adj R2	F Stat	Critical	P-Value	Decision(α:5%)
7	-25.1	57.05	60.59	2.124	0.1876	0.9842	0.7884	2.621	0.5683	Non-Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	65.92	36.23	83.82	1.517	1.193	2.76
LC10	78.75	49.86	95.57	1.27	1.046	2.006
LC15	87.93	60.55	104	1.137	0.9614	1.652
LC20	95.53	69.87	111.2	1.047	0.8993	1.431
LC25	102.3	78.39	117.9	0.9775	0.8483	1.276
LC40	120.7	101.2	138.7	0.8287	0.7212	0.9879
LC50	132.9	114.9	156	0.7524	0.6409	0.8705

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
Threshold	0.01954	0.009457	0.001001	0.03807	2.066	0.0479	Significant Parameter
Slope	9.669	2.261	5.237	14.1	4.276	1.9E-04	Significant Parameter
Intercept	-20.53	4.772	-29.88	-11.18	-4.303	1.7E-04	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	1721	860.4	2	963.6	<1.0E-37	Significant
Lack of Fit	3.653	0.7305	5	0.7884	0.5683	Non-Significant
Pure Error	22.24	0.9267	24			
Residual	25.89	0.8928	29			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Goodness-of-Fit	Pearson Chi-Sq GOF Test	25.89	42.56	0.6312	Non-Significant Heterogeneity
	Likelihood Ratio GOF Test	23.58	42.56	0.7493	Non-Significant Heterogeneity
Extreme Value	Grubbs Extreme Value Test	2.012	2.938	1.0000	No Outliers Detected
Variances	Mod Levene Equality of Variance	0.9846	2.423	0.4653	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.7917	0.9338	2.9E-05	Non-Normal Distribution
	Anderson-Darling A2 Normality Te	3.72	2.492	<1.0E-37	Non-Normal Distribution

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** **HydroQual Laboratories, Ltd**

Analysis ID: 15-2735-1278 **Endpoint:** 28-d Survival Rate **CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 11:19 **Analysis:** Linear Regression (GLM) **Official Results:** Yes

28-d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-%	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	N	4	0.9750	0.9000	1.0000	0.0250	0.0500	5.13%	0.00%	39	40
5.2		4	0.9500	0.9000	1.0000	0.0289	0.0577	6.08%	2.56%	38	40
10		4	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-2.56%	40	40
15		4	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-2.56%	40	40
24		4	0.9750	0.9000	1.0000	0.0250	0.0500	5.13%	0.00%	39	40
42		4	0.9750	0.9000	1.0000	0.0250	0.0500	5.13%	0.00%	39	40
80		4	0.8750	0.8000	1.0000	0.0479	0.0957	10.94%	10.26%	35	40
153		4	0.3500	0.2000	0.6000	0.0866	0.1732	49.49%	64.10%	14	40

28-d Survival Rate Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.9000	1.0000	1.0000	1.0000
5.2		1.0000	1.0000	0.9000	0.9000
10		1.0000	1.0000	1.0000	1.0000
15		1.0000	1.0000	1.0000	1.0000
24		0.9000	1.0000	1.0000	1.0000
42		0.9000	1.0000	1.0000	1.0000
80		0.8000	0.9000	1.0000	0.8000
153		0.2000	0.3000	0.3000	0.6000

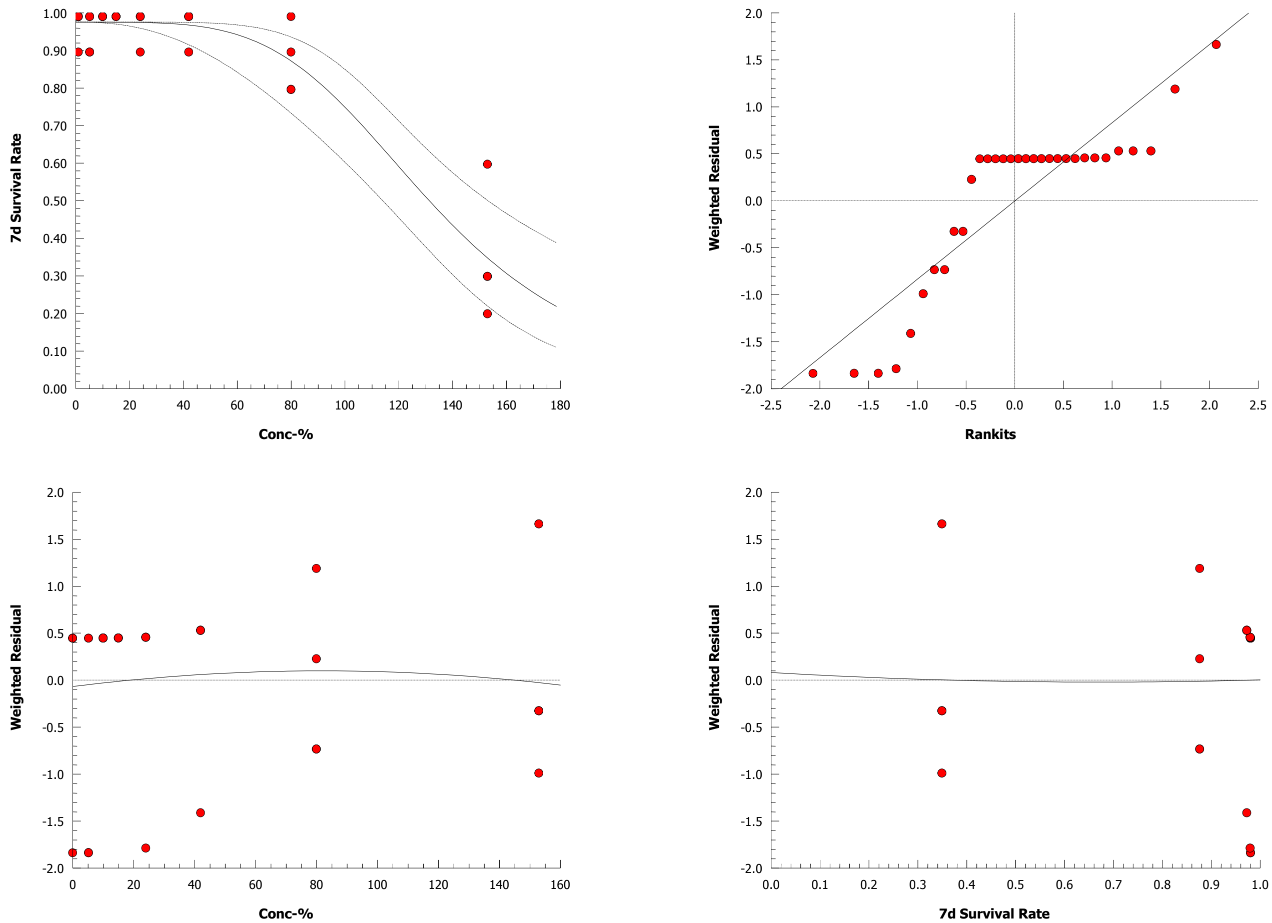
28-d Survival Rate Binomials

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	9/10	10/10	10/10	10/10
5.2		10/10	10/10	9/10	9/10
10		10/10	10/10	10/10	10/10
15		10/10	10/10	10/10	10/10
24		9/10	10/10	10/10	10/10
42		9/10	10/10	10/10	10/10
80		8/10	9/10	10/10	8/10
153		2/10	3/10	3/10	6/10

Hyalella azteca **42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	15-2735-1278	**Endpoint:**	28-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:19	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

Graphics Log-Logit: log[π/[1-π]]=α+β·log[x]



***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** | **HydroQual Laboratories, Ltd**

Analysis ID:	15-0276-2717	**Endpoint:**	28-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:17	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Angular (Corrected)	C > T	n/a	n/a	n/a	80	153	110.6	1.25	11.4%

Dunnett Multiple Comparison Test

Control vs	Conc-%	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	5.2	0.5671	2.482	0.178	6	CDF	0.6792	Non-Significant Effect
	10	-0.5671	2.482	0.178	6	CDF	0.9664	Non-Significant Effect
	15	-0.5671	2.482	0.178	6	CDF	0.9664	Non-Significant Effect
	24	0	2.482	0.178	6	CDF	0.8750	Non-Significant Effect
	42	0	2.482	0.178	6	CDF	0.8750	Non-Significant Effect
	80	2.122	2.482	0.178	6	CDF	0.0995	Non-Significant Effect
	153*	10.36	2.482	0.178	6	CDF	7.6E-07	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.895	2.938	0.0603	No Outliers Detected

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	1.96102	0.280145	7	27.13	<1.0E-37	Significant Effect
Error	0.247788	0.010325	24			
Total	2.20881		31			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Levene Equality of Variance Test	3.473	3.496	0.0103	Equal Variances
Variances	Mod Levene Equality of Variance Test	1.261	3.496	0.3107	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.912	0.9081	0.0127	Normal Distribution

28-d Survival Rate Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	0.9750	0.8954	1.0000	1.0000	0.9000	1.0000	0.0250	5.13%	0.00%
5.2		4	0.9500	0.8581	1.0000	0.9500	0.9000	1.0000	0.0289	6.08%	2.56%
10		4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.00%	-2.56%
15		4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.00%	-2.56%
24		4	0.9750	0.8954	1.0000	1.0000	0.9000	1.0000	0.0250	5.13%	0.00%
42		4	0.9750	0.8954	1.0000	1.0000	0.9000	1.0000	0.0250	5.13%	0.00%
80		4	0.8750	0.7227	1.0000	0.8500	0.8000	1.0000	0.0479	10.94%	10.26%
153		4	0.3500	0.0744	0.6256	0.3000	0.2000	0.6000	0.0866	49.49%	64.10%

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID: 15-0276-2717 **Endpoint:** 28-d Survival Rate **CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 11:17 **Analysis:** Parametric-Control vs Treatments **Official Results:** Yes

Angular (Corrected) Transformed Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	1.371	1.242	1.501	1.412	1.249	1.412	0.04074	5.94%	0.00%
5.2		4	1.331	1.181	1.48	1.331	1.249	1.412	0.04705	7.07%	2.97%
10		4	1.412	1.412	1.412	1.412	1.412	1.412	0	0.00%	-2.97%
15		4	1.412	1.412	1.412	1.412	1.412	1.412	0	0.00%	-2.97%
24		4	1.371	1.242	1.501	1.412	1.249	1.412	0.04074	5.94%	0.00%
42		4	1.371	1.242	1.501	1.412	1.249	1.412	0.04074	5.94%	0.00%
80		4	1.219	0.9879	1.45	1.178	1.107	1.412	0.07256	11.91%	11.12%
153		4	0.6273	0.3392	0.9153	0.5796	0.4636	0.8861	0.0905	28.86%	54.26%

28-d Survival Rate Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.9000	1.0000	1.0000	1.0000
5.2		1.0000	1.0000	0.9000	0.9000
10		1.0000	1.0000	1.0000	1.0000
15		1.0000	1.0000	1.0000	1.0000
24		0.9000	1.0000	1.0000	1.0000
42		0.9000	1.0000	1.0000	1.0000
80		0.8000	0.9000	1.0000	0.8000
153		0.2000	0.3000	0.3000	0.6000

Angular (Corrected) Transformed Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	1.249	1.412	1.412	1.412
5.2		1.412	1.412	1.249	1.249
10		1.412	1.412	1.412	1.412
15		1.412	1.412	1.412	1.412
24		1.249	1.412	1.412	1.412
42		1.249	1.412	1.412	1.412
80		1.107	1.249	1.412	1.107
153		0.4636	0.5796	0.5796	0.8861

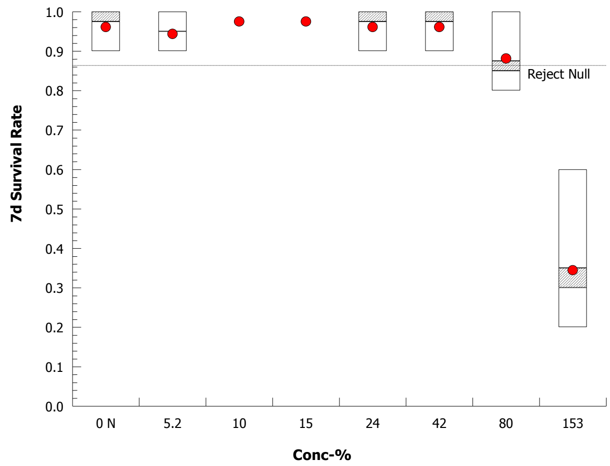
28-d Survival Rate Binomials

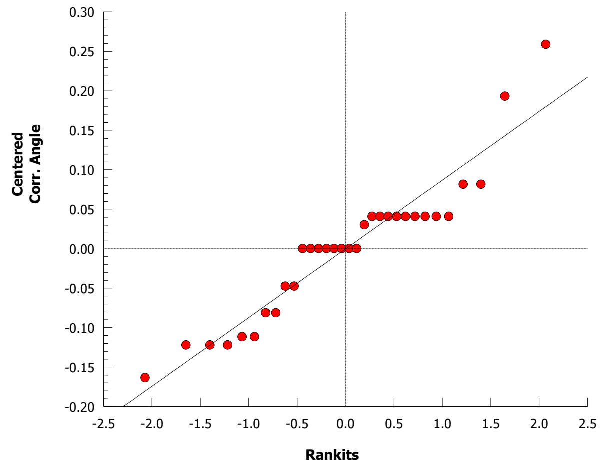
Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	9/10	10/10	10/10	10/10
5.2		10/10	10/10	9/10	9/10
10		10/10	10/10	10/10	10/10
15		10/10	10/10	10/10	10/10
24		9/10	10/10	10/10	10/10
42		9/10	10/10	10/10	10/10
80		8/10	9/10	10/10	8/10
153		2/10	3/10	3/10	6/10

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	15-0276-2717	**Endpoint:**	28-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:17	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Graphics





CETIS Analytical Report

Report Date:	03 Dec-15 15:01 (p 1 of 2)
Test Code:	SP15-013 HA 28 | 09-8775-7495

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	04-2953-8690	**Endpoint:**	**28-d** Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 15:01	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
4P Log-Logistic+Hormesis: μ=α[1+ε·x]/[1+[2ε·δ+1]·[x/δ]^γ]	Normal: ω=1	Off: μ*=μ	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
18	88.9	-168.3	-163.9	0.9117	Yes	3.956	2.776	0.0132	Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	43.8	37.69	50.13	2.283	1.995	2.653
IC10	47.01	40.91	53.52	2.127	1.868	2.445
IC15	50.32	44.17	57.06	1.987	1.753	2.264
IC20	53.8	47.53	60.82	1.859	1.644	2.104
IC25	57.5	51.02	64.9	1.739	1.541	1.96
IC40	70.6	62.66	80.26	1.416	1.246	1.596
IC50	82.06	71.95	95.14	1.219	1.051	1.39

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	0.5698	0.02879	0.5108	0.6288	19.79	<1.0E-37	Significant Parameter
γ	2.306	0.2056	1.885	2.728	11.22	<1.0E-37	Significant Parameter
δ	82.06	6.367	69.02	95.1	12.89	<1.0E-37	Significant Parameter
ε	0.02423	0.009016	0.005763	0.0427	2.688	0.0120	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Lack of Fit	0.04759	0.0119	4	3.956	0.0132	Significant
Model	10.37	2.593	4	606.1	<1.0E-37	Significant
Pure Error	0.07218	0.003007	24			
Residual	0.1198	0.004277	28			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	1.973	2.938	1.0000	No Outliers Detected
Variances	Bartlett Equality of Variance Test	7.081	14.07	0.4205	Equal Variances
	Mod Levene Equality of Variance	0.4835	2.423	0.8370	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9778	0.9338	0.7330	Normal Distribution
	Anderson-Darling A2 Normality Te	0.2582	2.492	0.7439	Normal Distribution

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	04-2953-8690	**Endpoint:**	**28-d** Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 15:01	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

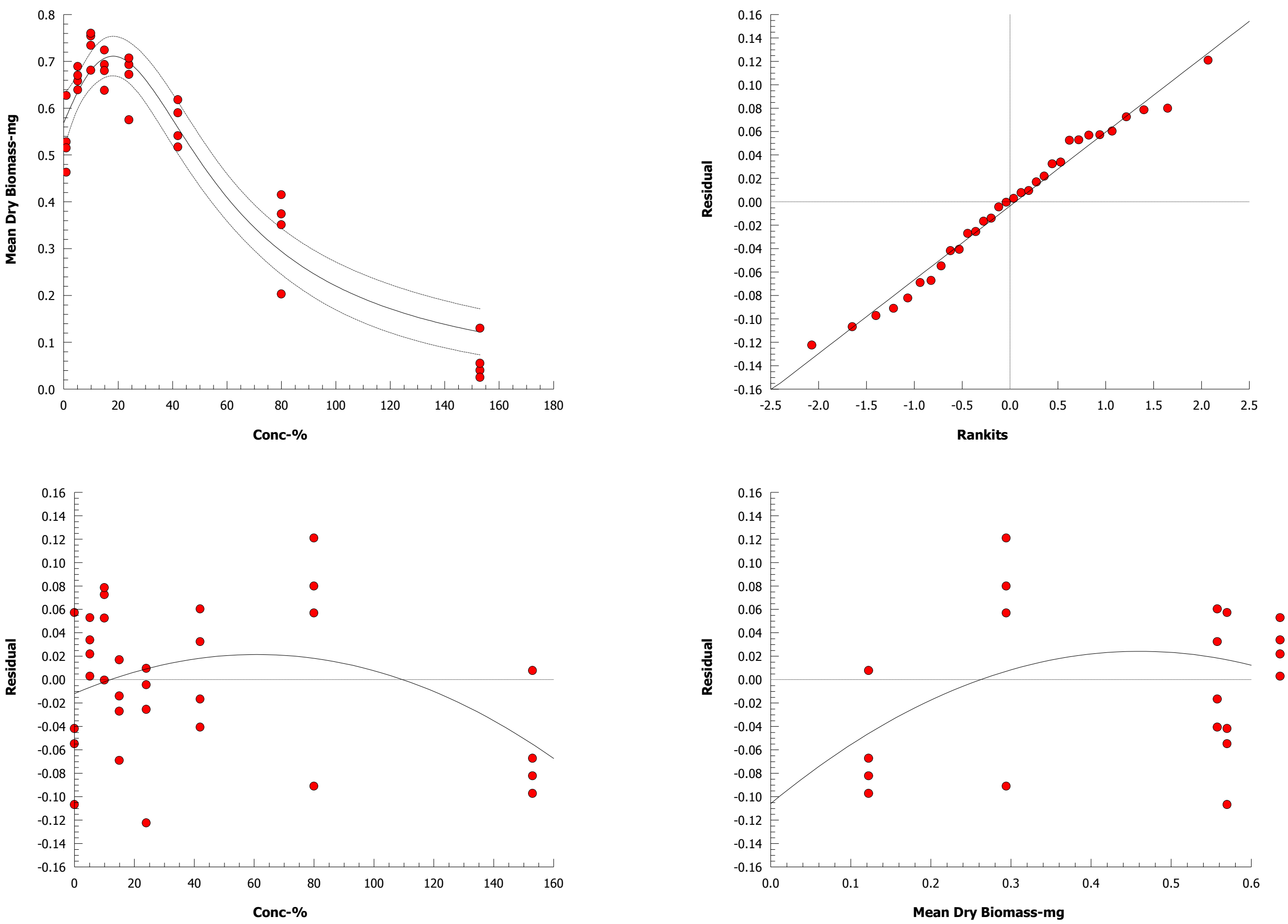
28-d Mean Dry Biomass-mg Summary

Conc-%	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
			Calculated Variate						
0	N	4	0.5332	0.463	0.627	0.03426	0.06852	12.85%	0.00%
5.2		4	0.664	0.639	0.689	0.0105	0.02099	3.16%	-24.52%
10		4	0.7323	0.681	0.76	0.01796	0.03593	4.91%	-37.32%
15		4	0.6837	0.638	0.724	0.01782	0.03565	5.21%	-28.22%
24		4	0.6617	0.575	0.707	0.0298	0.0596	9.01%	-24.10%
42		4	0.5665	0.517	0.618	0.02292	0.04584	8.09%	-6.24%
80		4	0.3358	0.203	0.415	0.04619	0.09237	27.51%	37.04%
153		4	0.0625	0.025	0.13	0.02332	0.04664	74.62%	88.28%

28-d Mean Dry Biomass-mg Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.463	0.627	0.528	0.515
5.2		0.658	0.639	0.67	0.689
10		0.681	0.754	0.734	0.76
15		0.638	0.724	0.693	0.68
24		0.693	0.707	0.672	0.575
42		0.59	0.618	0.541	0.517
80		0.374	0.351	0.415	0.203
153		0.04	0.055	0.025	0.13

Graphics Model: 4P Log-Logistic+Hormesis: μ=α[1+ε·x]/[1+[2ε·δ+1]·[x/δ]^γ] Distribution: Normal [ω=1]



CETIS Analytical Report

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	16-8442-1134	**Endpoint:**	**28-d** Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:27	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Untransformed	C > T	n/a	n/a	n/a	42	80	57.97	2.381	18.0%

Dunnett Multiple Comparison Test

Control vs	Conc-%	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	5.2	-3.372	2.482	0.096	6	CDF	1.0000	Non-Significant Effect
	10	-5.132	2.482	0.096	6	CDF	1.0000	Non-Significant Effect
	15	-3.881	2.482	0.096	6	CDF	1.0000	Non-Significant Effect
	24	-3.314	2.482	0.096	6	CDF	1.0000	Non-Significant Effect
	42	-0.8575	2.482	0.096	6	CDF	0.9850	Non-Significant Effect
	80*	5.093	2.482	0.096	6	CDF	1.0E-04	Significant Effect
	153*	12.14	2.482	0.096	6	CDF	7.6E-07	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.751	2.938	0.1093	No Outliers Detected

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	1.42996	0.20428	7	67.93	<1.0E-37	Significant Effect
Error	0.072176	0.003007	24			
Total	1.50214		31			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	7.081	18.48	0.4205	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9811	0.9081	0.8298	Normal Distribution

28-d Mean Dry Biomass-mg Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	0.5332	0.4242	0.6423	0.5215	0.463	0.627	0.03426	12.85%	0.00%
5.2		4	0.664	0.6306	0.6974	0.664	0.639	0.689	0.0105	3.16%	-24.52%
10		4	0.7323	0.6751	0.7894	0.744	0.681	0.76	0.01796	4.91%	-37.32%
15		4	0.6837	0.627	0.7405	0.6865	0.638	0.724	0.01782	5.21%	-28.22%
24		4	0.6617	0.5669	0.7566	0.6825	0.575	0.707	0.0298	9.01%	-24.10%
42		4	0.5665	0.4936	0.6394	0.5655	0.517	0.618	0.02292	8.09%	-6.24%
80		4	0.3358	0.1888	0.4827	0.3625	0.203	0.415	0.04619	27.51%	37.04%
153		4	0.0625	-0.01171	0.1367	0.0475	0.025	0.13	0.02332	74.62%	88.28%

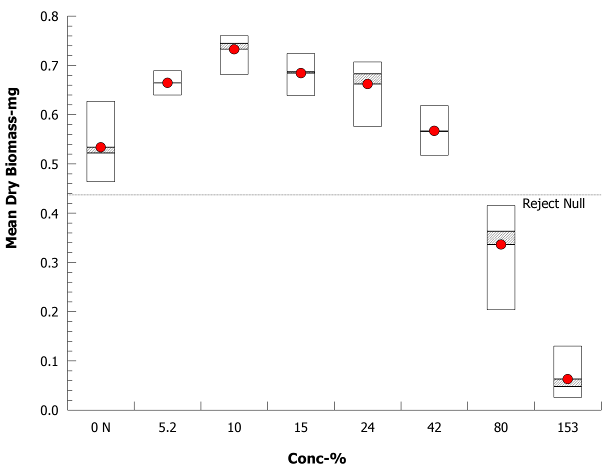
Hyalella azteca **42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

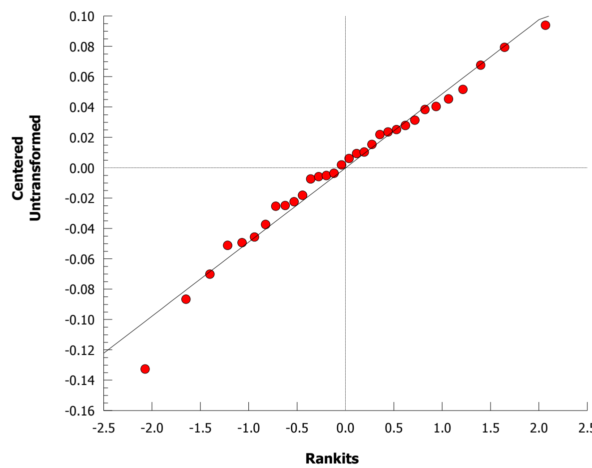
Analysis ID:	16-8442-1134	**Endpoint:**	**28-d** Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:27	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

28-d Mean Dry Biomass-mg Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.463	0.627	0.528	0.515
5.2		0.658	0.639	0.67	0.689
10		0.681	0.754	0.734	0.76
15		0.638	0.724	0.693	0.68
24		0.693	0.707	0.672	0.575
42		0.59	0.618	0.541	0.517
80		0.374	0.351	0.415	0.203
153		0.04	0.055	0.025	0.13

Graphics





CETIS Analytical Report

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	12-3158-9277	**Endpoint:**	42-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:32	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Linear Regression Options

Model Name	Link Function	Threshold Option	Thresh	Optimized	Pooled	Het Corr	Weighted
Log-Normal (Probit)	η=inv Φ[π]	Control Threshold	0.05	Yes	No	No	Yes

Regression Summary

Iters	LL	AICc	BIC	Mu	Sigma	Adj R2	F Stat	Critical	P-Value	Decision(α:5%)
14	-83.02	172.4	178.5	2.105	0.1945	0.9059	1.565	2.38	0.1849	Non-Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	61.01	41.52	74.66	1.639	1.339	2.408
LC10	71.78	52.77	84.83	1.393	1.179	1.895
LC15	80.11	61.91	92.66	1.248	1.079	1.615
LC20	87.42	70.14	99.58	1.144	1.004	1.426
LC25	94.21	77.91	106.2	1.061	0.942	1.284
LC40	113.8	99.93	126.7	0.879	0.7891	1.001
LC50	127.4	114	143.5	0.7848	0.697	0.877

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
Threshold	0.06242	0.01145	0.03998	0.08487	5.45	9.6E-07	Significant Parameter
Slope	5.142	0.8872	3.403	6.881	5.796	2.6E-07	Significant Parameter
Intercept	-10.83	1.855	-14.46	-7.19	-5.836	2.2E-07	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	851.2	425.6	2	304.3	<1.0E-37	Significant
Lack of Fit	10.46	2.092	5	1.565	0.1849	Non-Significant
Pure Error	74.85	1.337	56			
Residual	85.31	1.398	61			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Goodness-of-Fit	Collapsed Chi-Sq GOF Test	21.54	22.36	0.0629	Non-Significant Heterogeneity
	Likelihood Ratio GOF Test	86.78	80.23	0.0167	Significant Heterogeneity
Extreme Value	Grubbs Extreme Value Test	3.792	3.224	0.0036	Outlier Detected
Variances	Mod Levene Equality of Variance	0.5024	2.178	0.8288	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.8612	0.9626	3.7E-06	Non-Normal Distribution
	Anderson-Darling A2 Normality Te	3.552	2.492	<1.0E-37	Non-Normal Distribution

Hyalella azteca **42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	12-3158-9277	**Endpoint:**	42-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:32	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

42-d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-%	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	N	8	0.9500	0.8000	1.0000	0.0327	0.0926	9.75%	0.00%	76	80
5.1		8	0.8625	0.6000	1.0000	0.0498	0.1408	16.32%	9.21%	69	80
10		8	0.9500	0.9000	1.0000	0.0189	0.0535	5.63%	0.00%	76	80
15		8	0.9625	0.8000	1.0000	0.0263	0.0744	7.73%	-1.32%	77	80
24		8	0.9375	0.8000	1.0000	0.0263	0.0744	7.94%	1.32%	75	80
44		8	0.9625	0.9000	1.0000	0.0183	0.0518	5.38%	-1.32%	77	80
83		8	0.7625	0.5000	1.0000	0.0596	0.1685	22.10%	19.74%	61	80
156		8	0.3125	0.1000	0.6000	0.0611	0.1727	55.26%	67.11%	25	80

42-d Survival Rate Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	1.0000	1.0000	0.8000	1.0000	1.0000	1.0000	1.0000	0.8000
5.1		0.6000	0.7000	0.9000	0.9000	0.9000	0.9000	1.0000	1.0000
10		0.9000	0.9000	0.9000	1.0000	1.0000	1.0000	0.9000	1.0000
15		1.0000	0.8000	1.0000	1.0000	1.0000	0.9000	1.0000	1.0000
24		0.9000	1.0000	0.8000	1.0000	1.0000	0.9000	1.0000	0.9000
44		0.9000	1.0000	1.0000	1.0000	1.0000	0.9000	1.0000	0.9000
83		0.7000	1.0000	0.7000	0.7000	0.5000	0.7000	0.8000	1.0000
156		0.1000	0.2000	0.5000	0.2000	0.6000	0.2000	0.3000	0.4000

42-d Survival Rate

Binomials Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	10/10	10/10	8/10	10/10	10/10	10/10	10/10	8/10
5.1		6/10	7/10	9/10	9/10	9/10	9/10	10/10	10/10
10		9/10	9/10	9/10	10/10	10/10	10/10	9/10	10/10
15		10/10	8/10	10/10	10/10	10/10	9/10	10/10	10/10
24		9/10	10/10	8/10	10/10	10/10	9/10	10/10	9/10
44		9/10	10/10	10/10	10/10	10/10	9/10	10/10	9/10
83		7/10	10/10	7/10	7/10	5/10	7/10	8/10	10/10
156		1/10	2/10	5/10	2/10	6/10	2/10	3/10	4/10

Hyalella azteca **42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	12-3158-9277	**Endpoint:**	42-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:32	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

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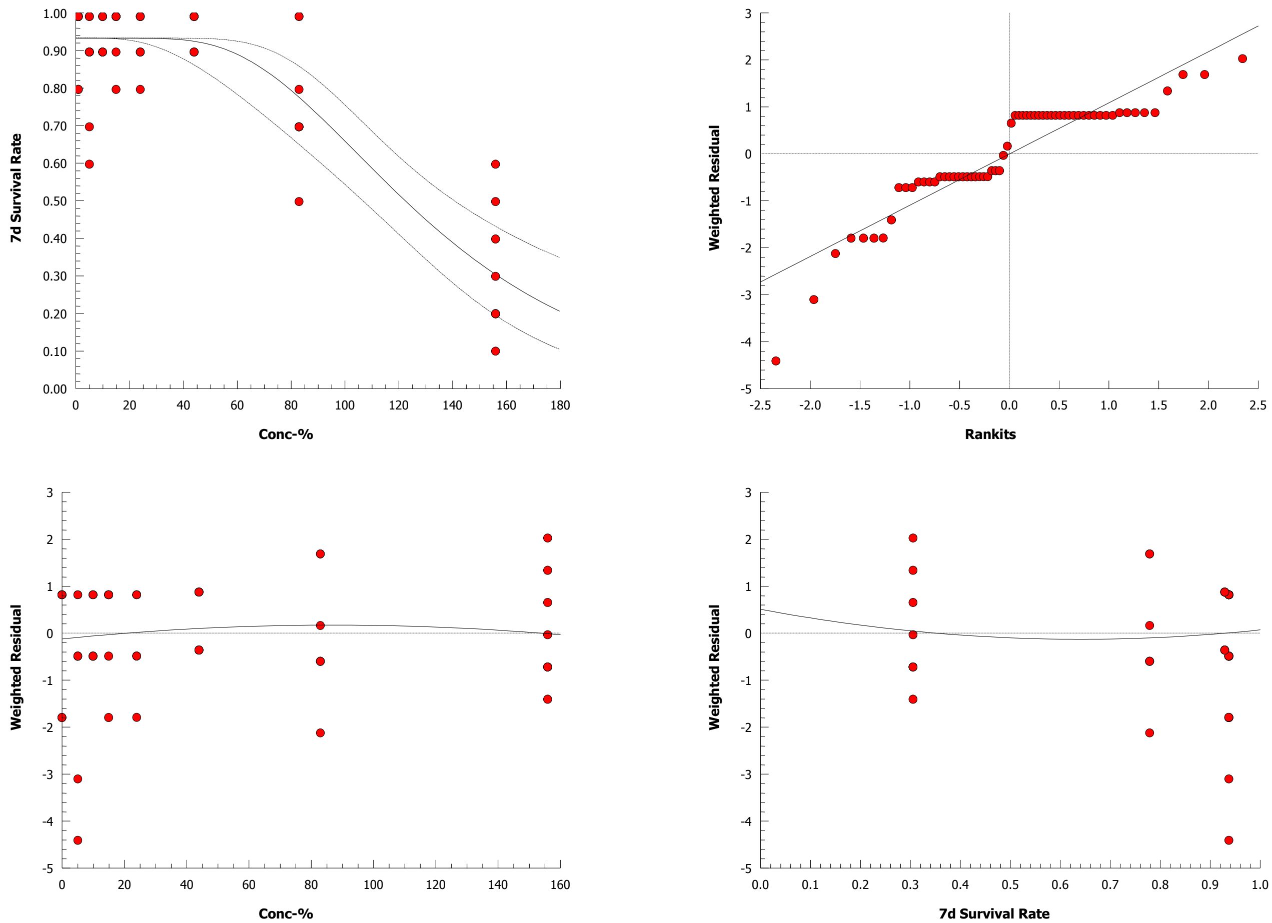


CETIS Analytical Report

Report Date:	03 Dec-15 11:35 (p 1 of 3)
Test Code:	SP15-013 - HA 4 | 06-9943-0659

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	19-3403-1166	**Endpoint:**	42-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:34	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Angular (Corrected)	C > T	n/a	n/a	n/a	44	83	60.43	2.273	11.9%

Dunnett Multiple Comparison Test

Control vs	Conc-%	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	5.1	1.647	2.399	0.180	14	CDF	0.2091	Non-Significant Effect
	10	0.07018	2.399	0.180	14	CDF	0.8566	Non-Significant Effect
	15	-0.2363	2.399	0.180	14	CDF	0.9248	Non-Significant Effect
	24	0.3065	2.399	0.180	14	CDF	0.7817	Non-Significant Effect
	44	-0.2012	2.399	0.180	14	CDF	0.9185	Non-Significant Effect
	83*	3.339	2.399	0.180	14	CDF	0.0045	Significant Effect
	156*	10.05	2.399	0.180	14	CDF	6.2E-07	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.309	3.224	1.0000	No Outliers Detected

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	3.92627	0.560896	7	24.88	<1.0E-37	Significant Effect
Error	1.26233	0.022542	56			
Total	5.18861		63			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	11.69	18.48	0.1112	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9452	0.9488	0.0067	Non-Normal Distribution

42-d Survival Rate Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	8	0.9500	0.8726	1.0000	1.0000	0.8000	1.0000	0.0327	9.75%	0.00%
5.1		8	0.8625	0.7448	0.9802	0.9000	0.6000	1.0000	0.0498	16.32%	9.21%
10		8	0.9500	0.9053	0.9947	0.9500	0.9000	1.0000	0.0189	5.63%	0.00%
15		8	0.9625	0.9003	1.0000	1.0000	0.8000	1.0000	0.0263	7.73%	-1.32%
24		8	0.9375	0.8753	0.9997	0.9500	0.8000	1.0000	0.0263	7.94%	1.32%
44		8	0.9625	0.9192	1.0000	1.0000	0.9000	1.0000	0.0183	5.38%	-1.32%
83		8	0.7625	0.6216	0.9034	0.7000	0.5000	1.0000	0.0596	22.10%	19.74%
156		8	0.3125	0.1681	0.4569	0.2500	0.1000	0.6000	0.0611	55.26%	67.11%

Hyalella azteca **42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	19-3403-1166	**Endpoint:**	42-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:34	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Angular (Corrected) Transformed Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	8	1.336	1.218	1.454	1.412	1.107	1.412	0.0499	10.56%	0.00%
5.1		8	1.212	1.057	1.367	1.249	0.8861	1.412	0.06553	15.29%	9.25%
10		8	1.331	1.258	1.403	1.331	1.249	1.412	0.0308	6.55%	0.39%
15		8	1.354	1.258	1.449	1.412	1.107	1.412	0.04056	8.48%	-1.33%
24		8	1.313	1.216	1.41	1.331	1.107	1.412	0.04094	8.82%	1.72%
44		8	1.351	1.28	1.421	1.412	1.249	1.412	0.02982	6.24%	-1.13%
83		8	1.085	0.9011	1.269	0.9912	0.7854	1.412	0.07785	20.29%	18.76%
156		8	0.5811	0.4218	0.7404	0.5216	0.3218	0.8861	0.06737	32.79%	56.50%

42-d Survival Rate Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	1.0000	1.0000	0.8000	1.0000	1.0000	1.0000	1.0000	0.8000
5.1		0.6000	0.7000	0.9000	0.9000	0.9000	0.9000	1.0000	1.0000
10		0.9000	0.9000	0.9000	1.0000	1.0000	1.0000	0.9000	1.0000
15		1.0000	0.8000	1.0000	1.0000	1.0000	0.9000	1.0000	1.0000
24		0.9000	1.0000	0.8000	1.0000	1.0000	0.9000	1.0000	0.9000
44		0.9000	1.0000	1.0000	1.0000	1.0000	0.9000	1.0000	0.9000
83		0.7000	1.0000	0.7000	0.7000	0.5000	0.7000	0.8000	1.0000
156		0.1000	0.2000	0.5000	0.2000	0.6000	0.2000	0.3000	0.4000

Angular (Corrected) Transformed Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	1.412	1.412	1.107	1.412	1.412	1.412	1.412	1.107
5.1		0.8861	0.9912	1.249	1.249	1.249	1.249	1.412	1.412
10		1.249	1.249	1.249	1.412	1.412	1.412	1.249	1.412
15		1.412	1.107	1.412	1.412	1.412	1.249	1.412	1.412
24		1.249	1.412	1.107	1.412	1.412	1.249	1.412	1.249
44		1.249	1.412	1.412	1.412	1.412	1.249	1.412	1.249
83		0.9912	1.412	0.9912	0.9912	0.7854	0.9912	1.107	1.412
156		0.3218	0.4636	0.7854	0.4636	0.8861	0.4636	0.5796	0.6847

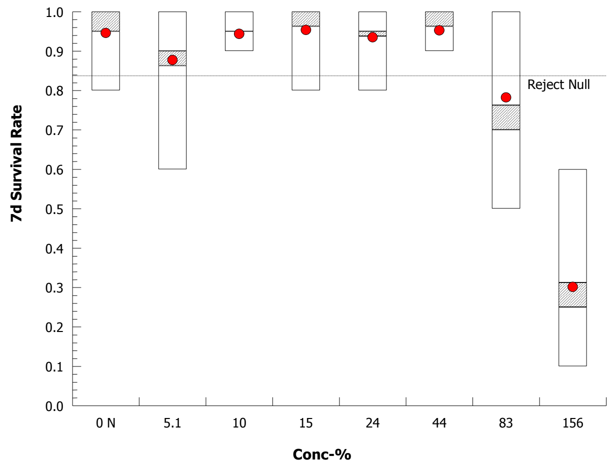
42-d Survival Rate Binomials

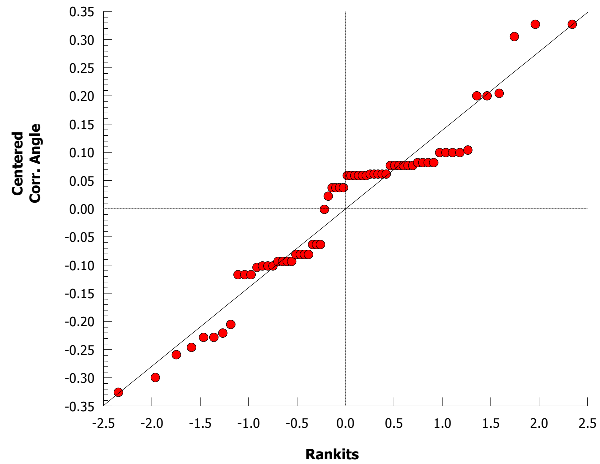
Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	10/10	10/10	8/10	10/10	10/10	10/10	10/10	8/10
5.1		6/10	7/10	9/10	9/10	9/10	9/10	10/10	10/10
10		9/10	9/10	9/10	10/10	10/10	10/10	9/10	10/10
15		10/10	8/10	10/10	10/10	10/10	9/10	10/10	10/10
24		9/10	10/10	8/10	10/10	10/10	9/10	10/10	9/10
44		9/10	10/10	10/10	10/10	10/10	9/10	10/10	9/10
83		7/10	10/10	7/10	7/10	5/10	7/10	8/10	10/10
156		1/10	2/10	5/10	2/10	6/10	2/10	3/10	4/10

Hyalella azteca **42-d Survival, Growth and Reproduction Test** | **HydroQual Laboratories, Ltd**

Analysis ID:	19-3403-1166	**Endpoint:**	42-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:34	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Graphics





CETIS Analytical Report

Hyalella azteca **42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	03-8857-8067	**Endpoint:**	**42-d** Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 12:05	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Gompertz: μ=α·exp[log[0.5]·[x/δ]^γ]	Normal: ω=1	Off: μ*=μ	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
5	134.8	-263.1	-257	0.8143	Yes	1.276	2.38	0.2871	Non-Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	24.91	8.158	34.29	4.015	2.917	12.26
IC10	35.19	23.09	44.39	2.842	2.253	4.331
IC15	43.33	31.87	52.84	2.308	1.893	3.137
IC20	50.45	39.4	60.15	1.982	1.663	2.538
IC25	57	46.33	66.75	1.755	1.498	2.158
IC40	75.09	65.23	84.91	1.332	1.178	1.533
IC50	86.94	76.89	97.42	1.15	1.026	1.301

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	0.8517	0.02257	0.8066	0.8968	37.74	<1.0E-37	Significant Parameter
γ	2.083	0.3367	1.41	2.756	6.186	<1.0E-37	Significant Parameter
δ	86.94	5.638	75.66	98.21	15.42	<1.0E-37	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	34.03	11.34	3	740.4	<1.0E-37	Significant
Lack of Fit	0.09558	0.01912	5	1.276	0.2871	Non-Significant
Pure Error	0.8389	0.01498	56			
Residual	0.9344	0.01532	61			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.334	3.224	0.0314	Outlier Detected
Variances	Mod Levene Equality of Variance	0.6124	2.178	0.7433	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9514	0.9626	0.0135	Non-Normal Distribution
	Anderson-Darling A2 Normality Te	1.253	2.492	0.0026	Non-Normal Distribution

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	03-8857-8067	**Endpoint:**	**42-d** Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 12:05	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

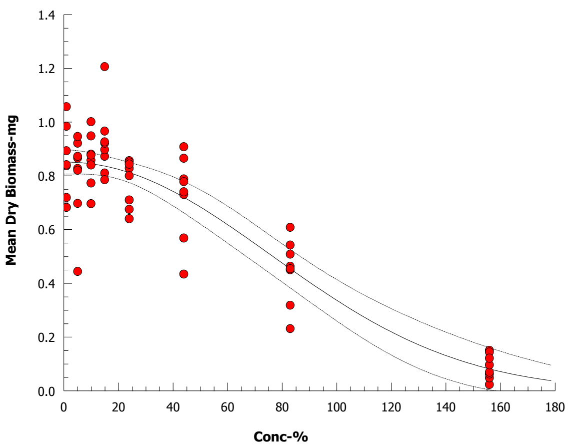
42-d Mean Dry Biomass-mg Summary

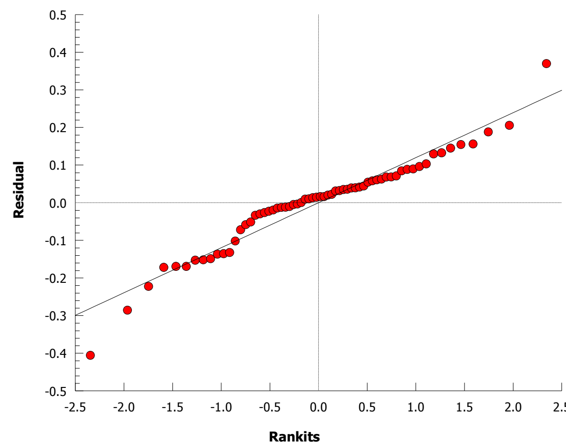
			Calculated Variate						
Conc-%	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	N	8	0.8369	0.682	1.057	0.04912	0.1389	16.60%	0.00%
5.1		8	0.7991	0.444	0.946	0.05732	0.1621	20.29%	4.51%
10		8	0.8591	0.696	1.001	0.03359	0.095	11.06%	-2.66%
15		8	0.9229	0.785	1.206	0.04572	0.1293	14.01%	-10.28%
24		8	0.7754	0.64	0.856	0.03072	0.08689	11.21%	7.35%
44		8	0.7264	0.434	0.908	0.05501	0.1556	21.42%	13.20%
83		8	0.4467	0.231	0.608	0.04274	0.1209	27.06%	46.62%
156		8	0.08913	0.023	0.15	0.01636	0.04627	51.91%	89.35%

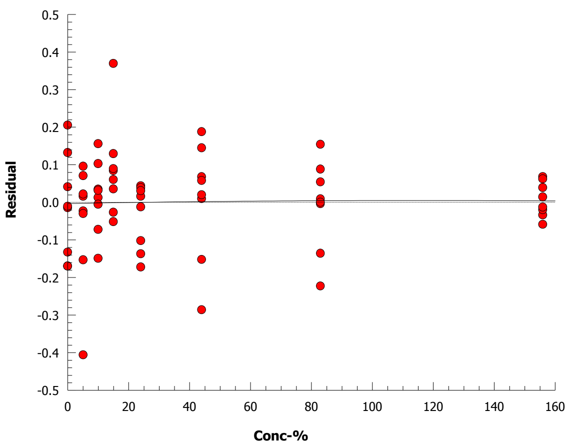
42-d Mean Dry Biomass-mg Detail

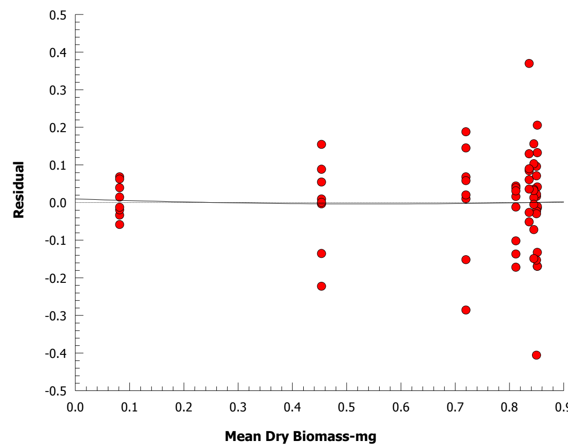
Conc-%	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 6**	**Rep 7**	**Rep 8**
0	N	0.837	0.719	0.682	0.841	0.893	0.984	1.057	0.682
5.1		0.444	0.697	0.827	0.866	0.82	0.921	0.872	0.946
10		0.773	0.696	0.858	1.001	0.88	0.877	0.84	0.948
15		1.206	0.81	0.872	0.785	0.966	0.897	0.921	0.926
24		0.856	0.71	0.64	0.675	0.828	0.8	0.851	0.843
44		0.568	0.73	0.788	0.865	0.74	0.778	0.908	0.434
83		0.45	0.508	0.542	0.463	0.231	0.318	0.454	0.608
156		0.023	0.048	0.062	0.069	0.15	0.096	0.144	0.121

Graphics Model: 3P Log-Gompertz: μ=α·exp[log[0.5]·[x/δ]^γ] Distribution: Normal [ω=1]









CETIS Analytical Report

Report Date:	03 Dec-15 12:07 (p 1 of 2)
Test Code:	SP15-013 - HA w | 18-9742-3368

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	03-7645-5882	**Endpoint:**	**42-d** Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 12:06	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Untransformed	C > T	n/a	n/a	n/a	44	83	60.43	2.273	17.5%

Dunnett Multiple Comparison Test

Control vs	Conc-%	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	5.1	0.6169	2.399	0.147	14	CDF	0.6563	Non-Significant Effect
	10	-0.3636	2.399	0.147	14	CDF	0.9444	Non-Significant Effect
	15	-1.405	2.399	0.147	14	CDF	0.9977	Non-Significant Effect
	24	1.005	2.399	0.147	14	CDF	0.4755	Non-Significant Effect
	44	1.806	2.399	0.147	14	CDF	0.1611	Non-Significant Effect
	83*	6.375	2.399	0.147	14	CDF	7.4E-07	Significant Effect
	156*	12.22	2.399	0.147	14	CDF	6.2E-07	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.078	3.224	0.0902	No Outliers Detected

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	4.35704	0.622434	7	41.55	<1.0E-37	Significant Effect
Error	0.838856	0.01498	56			
Total	5.1959		63			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	11.67	18.48	0.1119	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9715	0.9488	0.1453	Normal Distribution

42-d Mean Dry Biomass-mg Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	8	0.8369	0.7207	0.953	0.839	0.682	1.057	0.04912	16.60%	0.00%
5.1		8	0.7991	0.6636	0.9347	0.8465	0.444	0.946	0.05732	20.29%	4.51%
10		8	0.8591	0.7797	0.9385	0.8675	0.696	1.001	0.03359	11.06%	-2.66%
15		8	0.9229	0.8148	1.031	0.909	0.785	1.206	0.04572	14.01%	-10.28%
24		8	0.7754	0.7027	0.848	0.814	0.64	0.856	0.03072	11.21%	7.35%
44		8	0.7264	0.5963	0.8564	0.759	0.434	0.908	0.05501	21.42%	13.20%
83		8	0.4467	0.3457	0.5478	0.4585	0.231	0.608	0.04274	27.06%	46.62%
156		8	0.08913	0.05044	0.1278	0.0825	0.023	0.15	0.01636	51.91%	89.35%

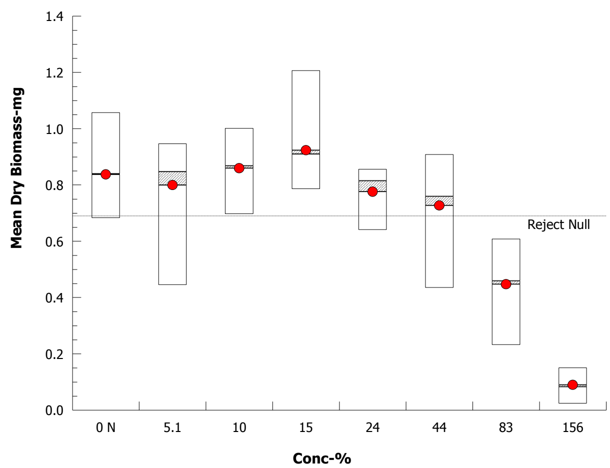
***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

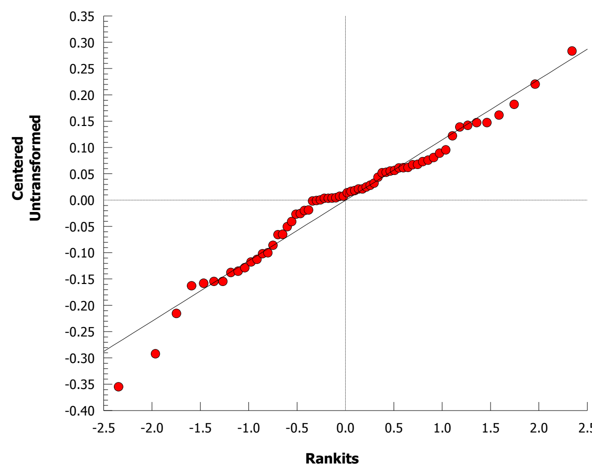
Analysis ID: 03-7645-5882	**Endpoint:** **42-d** Mean Dry Biomass-mg	**CETIS Version:** CETISv1.9.0
Analyzed: 03 Dec-15 12:06	**Analysis:** Parametric-Control vs Treatments	**Official Results:** Yes

42-d Mean Dry Biomass-mg Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	0.837	0.719	0.682	0.841	0.893	0.984	1.057	0.682
5.1		0.444	0.697	0.827	0.866	0.82	0.921	0.872	0.946
10		0.773	0.696	0.858	1.001	0.88	0.877	0.84	0.948
15		1.206	0.81	0.872	0.785	0.966	0.897	0.921	0.926
24		0.856	0.71	0.64	0.675	0.828	0.8	0.851	0.843
44		0.568	0.73	0.788	0.865	0.74	0.778	0.908	0.434
83		0.45	0.508	0.542	0.463	0.231	0.318	0.454	0.608
156		0.023	0.048	0.062	0.069	0.15	0.096	0.144	0.121

Graphics





CETIS Analytical Report

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	00-0428-6993	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:39	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Logistic: μ=α/[1+[x/δ]^γ]	Normal: ω=1	Off: μ*=μ	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
23	-62.88	132.2	138.2	0.3274	Yes	0.7741	2.38	0.5725	Non-Significant Lack of Fit

Point Estimates

Level	%	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	7.518	n/a	19.29	13.3	5.183	n/a
IC10	11.44	n/a	22.43	8.739	4.459	n/a
IC15	14.84	n/a	26.94	6.737	3.713	n/a
IC20	18.05	n/a	31.68	5.539	3.156	n/a
IC25	21.22	6.008	36.45	4.712	2.743	16.65
IC40	31.34	16.71	51.97	3.191	1.924	5.983
IC50	39.36	23.2	66.8	2.54	1.497	4.311

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	5.686	0.7131	4.26	7.112	7.974	<1.0E-37	Significant Parameter
γ	1.779	0.8125	0.1539	3.403	2.189	0.0324	Significant Parameter
δ	39.36	12.32	14.74	63.99	3.196	0.0022	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	1104	367.9	3	49.93	<1.0E-37	Significant
Lack of Fit	29.06	5.811	5	0.7741	0.5725	Non-Significant
Pure Error	420.4	7.507	56			
Residual	449.4	7.368	61			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.284	3.224	0.0389	Outlier Detected
Variances	Bartlett Equality of Variance Test	39.39	14.07	1.7E-06	Unequal Variances
	Mod Levene Equality of Variance	5.47	2.178	8.0E-05	Unequal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9664	0.9626	0.0784	Normal Distribution
	Anderson-Darling A2 Normality Te	0.6273	2.492	0.1029	Normal Distribution

Hyalella azteca **42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	00-0428-6993	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:39	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

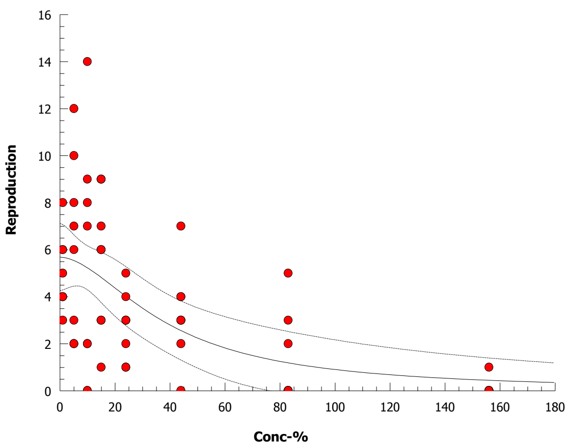
Reproduction Summary

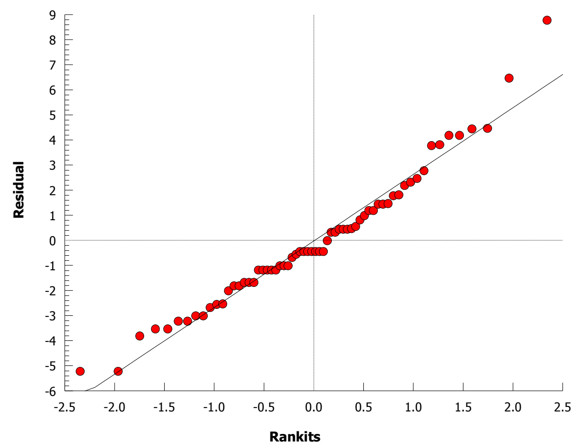
			Calculated Variate						
Conc-%	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	N	8	5	3	8	0.5669	1.604	32.07%	0.00%
5.1		8	6.25	2	12	1.319	3.732	59.71%	-25.00%
10		8	5.25	0	14	1.78	5.036	95.92%	-5.00%
15		8	5.5	1	9	1.035	2.928	53.23%	-10.00%
24		8	2.75	1	5	0.491	1.389	50.50%	45.00%
44		8	3.25	0	7	0.7008	1.982	60.99%	35.00%
83		8	1.25	0	5	0.6748	1.909	152.69%	75.00%
156		8	0.125	0	1	0.125	0.3536	282.84%	97.50%

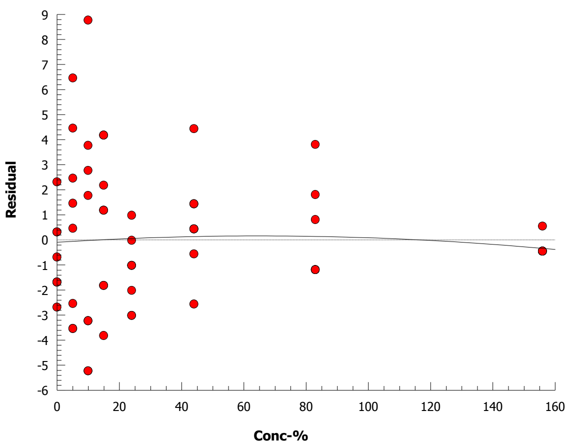
Reproduction Detail

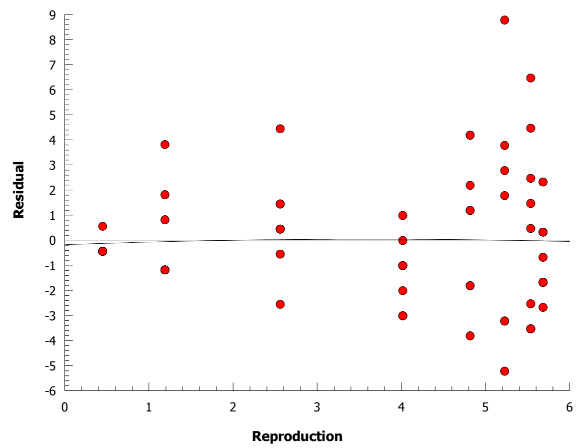
Conc-%	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 6**	**Rep 7**	**Rep 8**
0	N	6	4	4	3	6	4	8	5
5.1		2	8	2	10	3	6	12	7
10		0	2	0	2	14	7	9	8
15		6	9	1	7	3	9	3	6
24		1	3	3	2	4	1	5	3
44		0	4	3	3	4	7	3	2
83		3	0	0	5	0	0	0	2
156		0	0	0	0	0	0	1	0

Graphics Model: 3P Log-Logistic: μ=α/[1+[x/δ]^γ] Distribution: Normal [ω=1]









CETIS Analytical Report

Report Date:	03 Dec-15 11:57 (p 1 of 2)
Test Code:	SP15-013 - HA 4 | 06-9943-0659

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	10-8459-0579	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:57	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Total copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Data Transform	Alt Hyp	Trials	Seed	TST b	NOEL	LOEL	TOEL	TU	PMSD
Untransformed	C > T	n/a	n/a	n/a	44	83	60.43	2.273	65.7%

Dunnett Multiple Comparison Test

Control vs	Conc-%	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	5.1	-0.9125	2.399	3.287	14	CDF	0.9880	Non-Significant Effect
	10	-0.1825	2.399	3.287	14	CDF	0.9150	Non-Significant Effect
	15	-0.365	2.399	3.287	14	CDF	0.9446	Non-Significant Effect
	24	1.642	2.399	3.287	14	CDF	0.2105	Non-Significant Effect
	44	1.277	2.399	3.287	14	CDF	0.3511	Non-Significant Effect
	83*	2.737	2.399	3.287	14	CDF	0.0226	Significant Effect
	156*	3.559	2.399	3.287	14	CDF	0.0024	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.387	3.224	0.0249	Outlier Detected

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	269.734	38.5335	7	5.133	1.5E-04	Significant Effect
Error	420.375	7.5067	56			
Total	690.109		63			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	39.39	18.48	1.7E-06	Unequal Variances
Distribution	Shapiro-Wilk W Normality Test	0.966	0.9488	0.0747	Normal Distribution

Reproduction Summary

Conc-%	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	8	5	3.659	6.341	4.5	3	8	0.5669	32.07%	0.00%
5.1		8	6.25	3.13	9.37	6.5	2	12	1.319	59.71%	-25.00%
10		8	5.25	1.04	9.46	4.5	0	14	1.78	95.92%	-5.00%
15		8	5.5	3.052	7.948	6	1	9	1.035	53.23%	-10.00%
24		8	2.75	1.589	3.911	3	1	5	0.491	50.50%	45.00%
44		8	3.25	1.593	4.907	3	0	7	0.7008	60.99%	35.00%
83		8	1.25	-0.3457	2.846	0	0	5	0.6748	152.69%	75.00%
156		8	0.125	-0.1706	0.4206	0	0	1	0.125	282.84%	97.50%

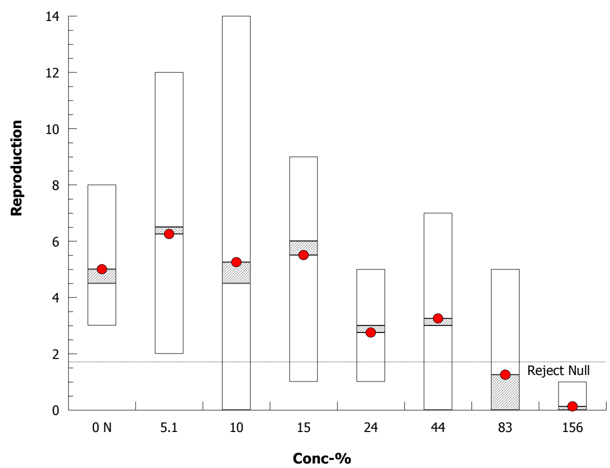
***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

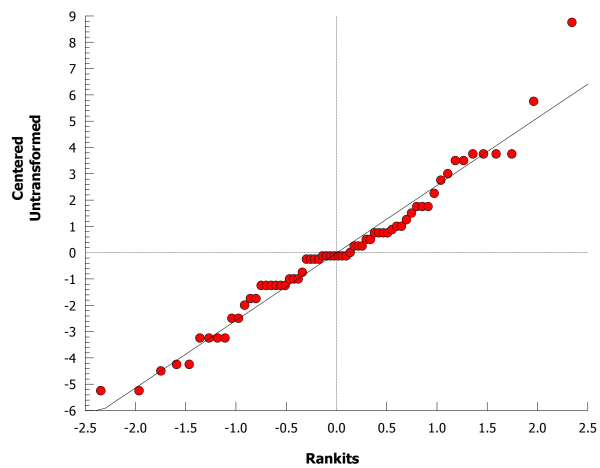
Analysis ID:	10-8459-0579	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	03 Dec-15 11:57	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Reproduction Detail

Conc-%	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	6	4	4	3	6	4	8	5
5.1		2	8	2	10	3	6	12	7
10		0	2	0	2	14	7	9	8
15		6	9	1	7	3	9	3	6
24		1	3	3	2	4	1	5	3
44		0	4	3	3	4	7	3	2
83		3	0	0	5	0	0	0	2
156		0	0	0	0	0	0	1	0

Graphics





CETIS Analytical Report

Report Date:	15 Apr-16 11:05 (p 1 of 2)
Test Code:	SP15-013 HA 28 | 19-0182-7550

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	19-1738-6315	**Endpoint:**	28-d Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 11:03	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
4P Log-Logistic+Hormesis: μ=α[1+ε·x]/[1+[2ε·δ+1]·[x/δ]^γ]	Normal: ω=1	Off: μ*=μ	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
17	89.07	-168.7	-164.3	0.9127	Yes	3.848	2.776	0.0149	Significant Lack of Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	40.03	34.49	45.77	2.498	2.185	2.899
IC10	42.9	37.4	48.79	2.331	2.049	2.674
IC15	45.88	40.34	51.95	2.18	1.925	2.479
IC20	49	43.36	55.32	2.041	1.808	2.306
IC25	52.32	46.5	58.98	1.911	1.696	2.151
IC40	64.08	56.94	72.76	1.56	1.374	1.756
IC50	74.36	65.27	86.12	1.345	1.161	1.532

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	0.5664	0.02925	0.5065	0.6263	19.36	<1.0E-37	Significant Parameter
γ	2.323	0.2074	1.898	2.748	11.2	<1.0E-37	Significant Parameter
δ	74.36	5.757	62.57	86.15	12.92	<1.0E-37	Significant Parameter
ε	0.02695	0.009862	0.006749	0.04715	2.733	0.0108	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Lack of Fit	0.04629	0.01157	4	3.848	0.0149	Significant
Model	10.37	2.593	4	612.9	<1.0E-37	Significant
Pure Error	0.07218	0.003007	24			
Residual	0.1185	0.004231	28			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.04	2.938	1.0000	No Outliers Detected
Variances	Bartlett Equality of Variance Test	7.081	14.07	0.4205	Equal Variances
	Mod Levene Equality of Variance	0.4835	2.423	0.8370	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.982	0.9338	0.8560	Normal Distribution
	Anderson-Darling A2 Normality Te	0.2043	2.492	0.9160	Normal Distribution

Analysis ID: 19-1738-6315 **Endpoint:** 28-d Mean Dry Biomass-mg **CETIS Version:** CETISv1.9.0
Analyzed: 15 Apr-16 11:03 **Analysis:** Nonlinear Regression (NLR) **Official Results:** Yes

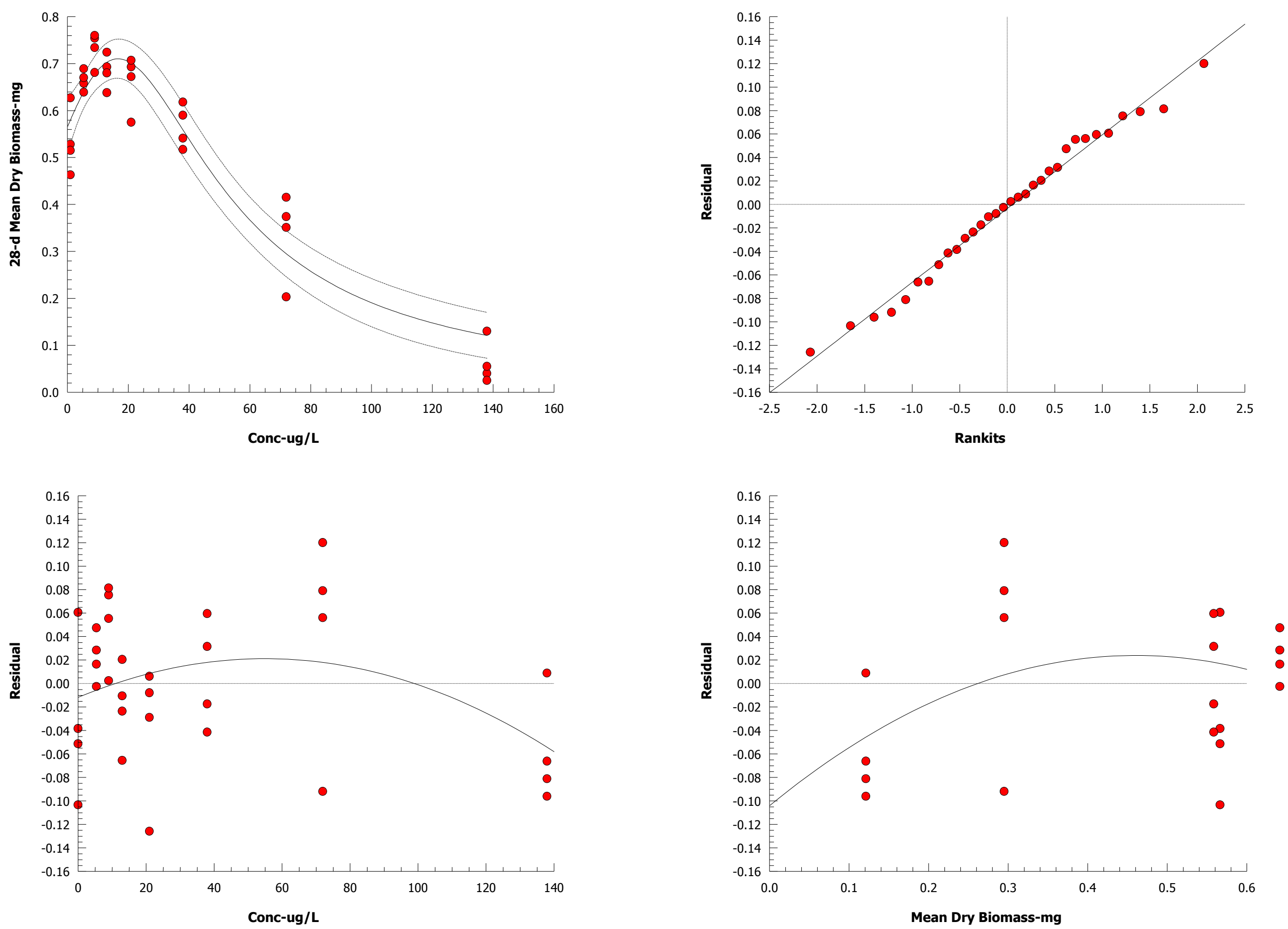
28-d Mean Dry Biomass-mg Summary

			Calculated Variate						
Conc-ug/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	N	4	0.5332	0.463	0.627	0.03426	0.06852	12.85%	0.00%
5.4		4	0.664	0.639	0.689	0.0105	0.02099	3.16%	-24.52%
9		4	0.7323	0.681	0.76	0.01796	0.03593	4.91%	-37.32%
13		4	0.6837	0.638	0.724	0.01782	0.03565	5.21%	-28.22%
21		4	0.6617	0.575	0.707	0.0298	0.0596	9.01%	-24.10%
38		4	0.5665	0.517	0.618	0.02292	0.04584	8.09%	-6.24%
72		4	0.3358	0.203	0.415	0.04619	0.09237	27.51%	37.04%
138		4	0.0625	0.025	0.13	0.02332	0.04664	74.62%	88.28%

28-d Mean Dry Biomass-mg Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.463	0.627	0.528	0.515
5.4		0.658	0.639	0.67	0.689
9		0.681	0.754	0.734	0.76
13		0.638	0.724	0.693	0.68
21		0.693	0.707	0.672	0.575
38		0.59	0.618	0.541	0.517
72		0.374	0.351	0.415	0.203
138		0.04	0.055	0.025	0.13

Graphics Model: 4P Log-Logistic+Hormesis: μ=α[1+ε·x]/[1+[2ε·δ+1]·[x/δ]^γ] Distribution: Normal [ω=1]



***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	11-1588-9215	**Endpoint:**	28-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 10:41	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Linear Regression Options

Model Name	Link Function	Threshold Option	Thresh	Optimized	Pooled	Het Corr	Weighted
Log-Logit	η=log[π/(1-π)]	Control Threshold	0.025	Yes	No	No	Yes

Regression Summary

Iters	LL	AICc	BIC	Mu	Sigma	Adj R2	F Stat	Critical	P-Value	Decision(α:5%)
6	-25.1	57.05	60.59	2.079	0.1881	0.9842	0.7892	2.621	0.5678	Non-Significant Lack of Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	59.31	32.62	75.45	1.686	1.325	3.066
LC10	70.9	44.9	86.07	1.41	1.162	2.227
LC15	79.18	54.54	93.7	1.263	1.067	1.833
LC20	86.05	62.95	100.2	1.162	0.998	1.589
LC25	92.17	70.63	106.2	1.085	0.9413	1.416
LC40	108.8	91.22	125	0.9195	0.7998	1.096
LC50	119.8	103.5	140.7	0.8346	0.7106	0.9658

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
Threshold	0.01953	0.009454	0.001	0.03806	2.066	0.0479	Significant Parameter
Slope	9.642	2.25	5.232	14.05	4.285	1.8E-04	Significant Parameter
Intercept	-20.04	4.648	-29.15	-10.93	-4.312	1.7E-04	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	1722	861	2	964.2	<1.0E-37	Significant
Lack of Fit	3.656	0.7312	5	0.7892	0.5678	Non-Significant
Pure Error	22.24	0.9266	24			
Residual	25.89	0.8929	29			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Goodness-of-Fit	Pearson Chi-Sq GOF Test	25.89	42.56	0.6311	Non-Significant Heterogeneity
	Likelihood Ratio GOF Test	23.58	42.56	0.7492	Non-Significant Heterogeneity
Extreme Value	Grubbs Extreme Value Test	2.012	2.938	1.0000	No Outliers Detected
Variances	Mod Levene Equality of Variance	0.9854	2.423	0.4647	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.7919	0.9338	2.9E-05	Non-Normal Distribution
	Anderson-Darling A2 Normality Te	3.715	2.492	<1.0E-37	Non-Normal Distribution

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	11-1588-9215	**Endpoint:**	28-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 10:41	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

28-d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-ug/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	N	4	0.9750	0.9000	1.0000	0.0250	0.0500	5.13%	0.00%	39	40
5.4		4	0.9500	0.9000	1.0000	0.0289	0.0577	6.08%	2.56%	38	40
9		4	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-2.56%	40	40
13		4	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-2.56%	40	40
21		4	0.9750	0.9000	1.0000	0.0250	0.0500	5.13%	0.00%	39	40
38		4	0.9750	0.9000	1.0000	0.0250	0.0500	5.13%	0.00%	39	40
72		4	0.8750	0.8000	1.0000	0.0479	0.0957	10.94%	10.26%	35	40
138		4	0.3500	0.2000	0.6000	0.0866	0.1732	49.49%	64.10%	14	40

28-d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	0.9000	1.0000	1.0000	1.0000
5.4		1.0000	1.0000	0.9000	0.9000
9		1.0000	1.0000	1.0000	1.0000
13		1.0000	1.0000	1.0000	1.0000
21		0.9000	1.0000	1.0000	1.0000
38		0.9000	1.0000	1.0000	1.0000
72		0.8000	0.9000	1.0000	0.8000
138		0.2000	0.3000	0.3000	0.6000

28-d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	9/10	10/10	10/10	10/10
5.4		10/10	10/10	9/10	9/10
9		10/10	10/10	10/10	10/10
13		10/10	10/10	10/10	10/10
21		9/10	10/10	10/10	10/10
38		9/10	10/10	10/10	10/10
72		8/10	9/10	10/10	8/10
138		2/10	3/10	3/10	6/10

Hyalella azteca **42-d Survival, Growth and Reproduction Test** | **HydroQual Laboratories, Ltd**

Analysis ID:	11-1588-9215	**Endpoint:**	28-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 10:41	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

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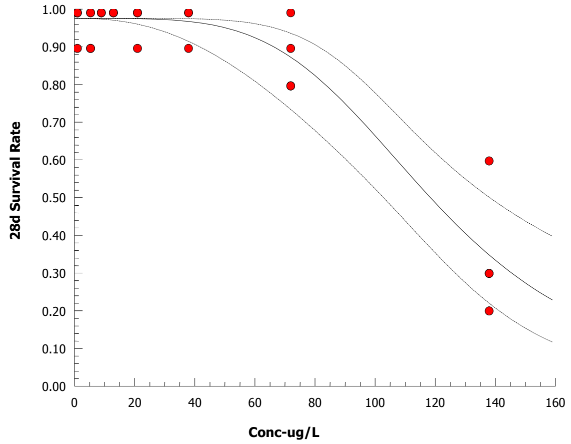
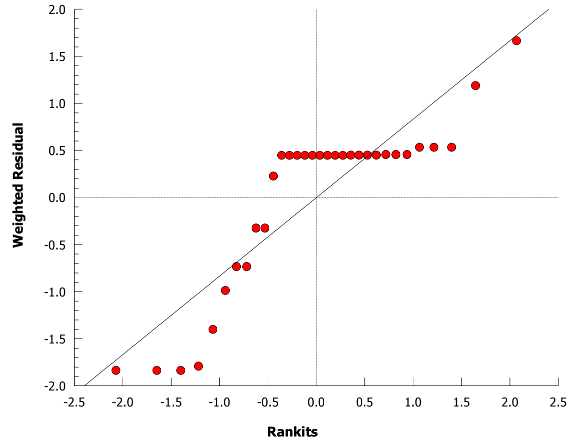
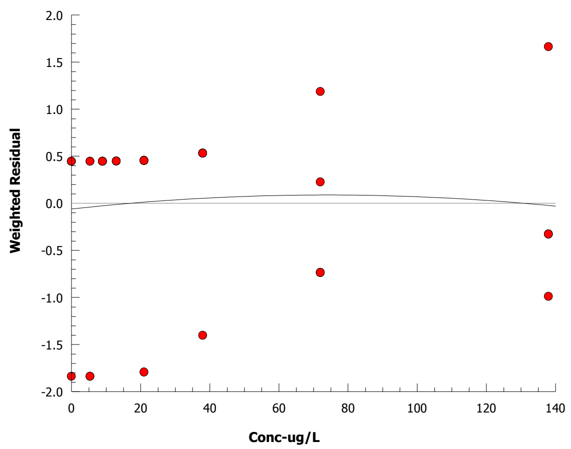
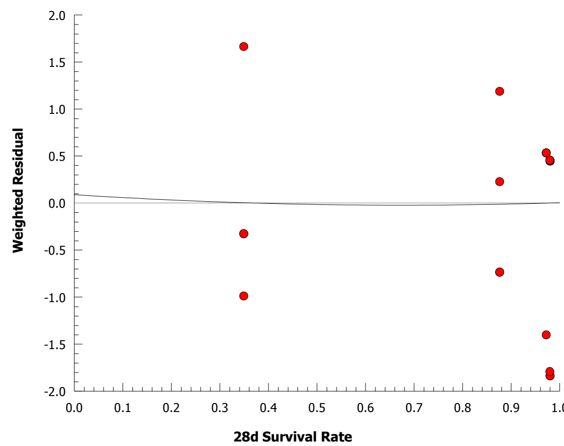








CETIS Analytical Report

Hyalella azteca **42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	05-0978-4677	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.0
Analyzed:	19 Apr-16 11:05	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Cumulative Log-Normal: μ=α·[1- Φ[log[x/δ]/γ]]	Normal: ω=1	Off: μ*=μ	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
21	-62.58	131.6	137.6	0.3352	Yes	0.6957	2.38	0.6289	Non-Significant Lack of Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	8.215	n/a	18.5	12.17	5.407	n/a
IC10	11.58	n/a	22.07	8.636	4.531	n/a
IC15	14.6	n/a	26.46	6.851	3.779	n/a
IC20	17.55	n/a	30.9	5.699	3.236	n/a
IC25	20.55	7.462	35.32	4.866	2.831	13.4
IC40	30.59	17.24	50.01	3.269	2	5.799
IC50	38.87	23.49	64.32	2.573	1.555	4.258

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	5.719	0.7111	4.297	7.141	8.043	<1.0E-37	Significant Parameter
γ	0.9449	0.3965	0.1521	1.738	2.383	0.0203	Significant Parameter
δ	38.87	12.02	14.84	62.9	3.235	0.0020	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	1117	372.2	3	50.99	<1.0E-37	Significant
Lack of Fit	26.04	5.208	5	0.6957	0.6289	Non-Significant
Pure Error	419.2	7.487	56			
Residual	445.3	7.3	61			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.277	3.224	0.0401	Outlier Detected
Variances	Bartlett Equality of Variance Test	39.67	14.07	1.5E-06	Unequal Variances
	Mod Levene Equality of Variance	5.564	2.178	6.7E-05	Unequal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9684	0.9626	0.1000	Normal Distribution
	Anderson-Darling A2 Normality Te	0.5956	2.492	0.1236	Normal Distribution

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** | **HydroQual Laboratories, Ltd**

Analysis ID: 05-0978-4677 **Endpoint:** Reproduction **CETIS Version:** CETISv1.9.0
Analyzed: 19 Apr-16 11:05 **Analysis:** Nonlinear Regression (NLR) **Official Results:** Yes

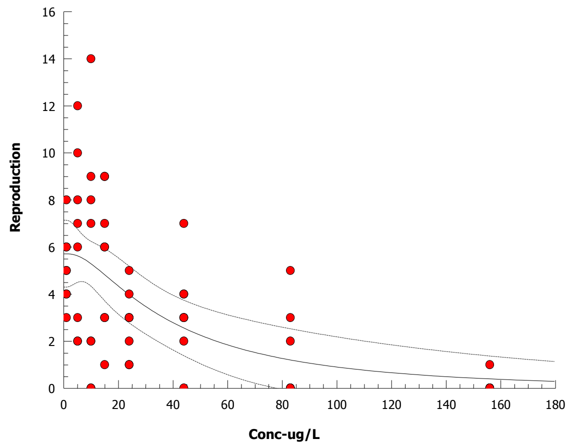
Reproduction Summary

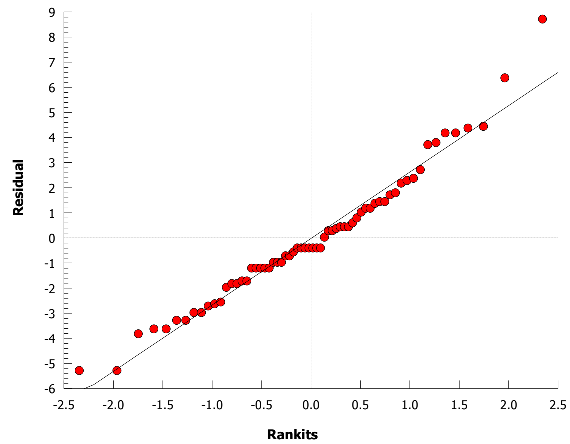
			Calculated Variate						
Conc-ug/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	N	8	5.125	3	8	0.5489	1.553	30.30%	0.00%
5.1		8	6.25	2	12	1.319	3.732	59.71%	-21.95%
10		8	5.25	0	14	1.78	5.036	95.92%	-2.44%
15		8	5.5	1	9	1.035	2.928	53.23%	-7.32%
24		8	2.75	1	5	0.491	1.389	50.50%	46.34%
44		8	3.25	0	7	0.7008	1.982	60.99%	36.59%
83		8	1.25	0	5	0.6748	1.909	152.69%	75.61%
156		8	0.125	0	1	0.125	0.3536	282.84%	97.56%

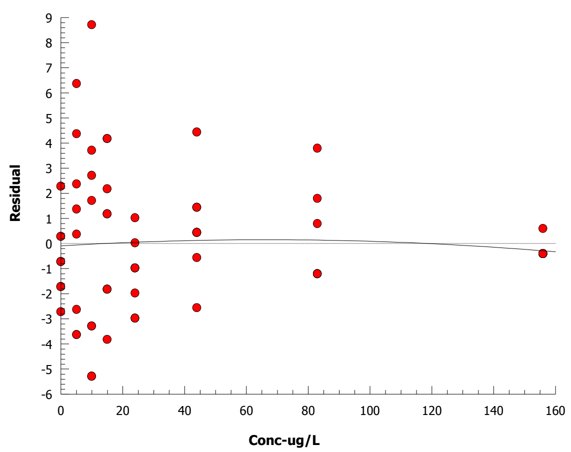
Reproduction Detail

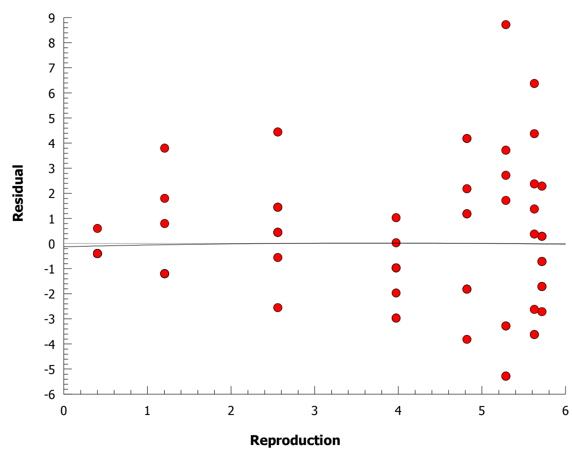
Conc-ug/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 6**	**Rep 7**	**Rep 8**
0	N	6	4	4	3	6	5	8	5
5.1		2	8	2	10	3	6	12	7
10		0	2	0	2	14	7	9	8
15		6	9	1	7	3	9	3	6
24		1	3	3	2	4	1	5	3
44		0	4	3	3	4	7	3	2
83		3	0	0	5	0	0	0	2
156		0	0	0	0	0	0	1	0

Graphics Model: 3P Cumulative Log-Normal: μ=α·[1- Φ[log[x/δ]/γ]] Distribution: Normal [ω=1]









CETIS Analytical Report

Report Date:	15 Apr-16 12:59 (p 1 of 2)	**Test Code:**	SP15-013 HA 42d | 06-6550-9859

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	01-5143-2083	**Endpoint:**	42-d Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 12:58	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Gompertz: $\mu=\alpha\cdot\exp[\log[0.5]\cdot[x/\delta]^\gamma]$	Normal: $\omega=1$	Off: $\mu^*=\mu$	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
5	134.9	-263.3	-257.3	0.8150	Yes	1.23	2.38	0.3074	Non-Significant Lack of Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	21.4	7.122	29.62	4.674	3.376	14.04
IC10	30.5	19.95	38.63	3.278	2.589	5.013
IC15	37.76	27.66	46.22	2.648	2.163	3.616
IC20	44.15	34.32	52.83	2.265	1.893	2.914
IC25	50.03	40.49	58.81	1.999	1.7	2.47
IC40	66.39	57.49	75.3	1.506	1.328	1.739
IC50	77.17	68.08	86.68	1.296	1.154	1.469

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	0.8529	0.02287	0.8072	0.8986	37.29	<1.0E-37	Significant Parameter
γ	2.03	0.3274	1.375	2.684	6.2	<1.0E-37	Significant Parameter
δ	77.17	5.132	66.9	87.43	15.04	<1.0E-37	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	34.03	11.34	3	743.2	<1.0E-37	Significant
Lack of Fit	0.09211	0.01842	5	1.23	0.3074	Non-Significant
Pure Error	0.8389	0.01498	56			
Residual	0.931	0.01526	61			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	3.342	3.224	0.0303	Outlier Detected
Variances	Mod Levene Equality of Variance	0.6124	2.178	0.7433	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9511	0.9626	0.0130	Non-Normal Distribution
	Anderson-Darling A2 Normality Te	1.245	2.492	0.0028	Non-Normal Distribution

***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	01-5143-2083	**Endpoint:**	42-d Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 12:58	**Analysis:**	Nonlinear Regression (NLR)	**Official Results:**	Yes

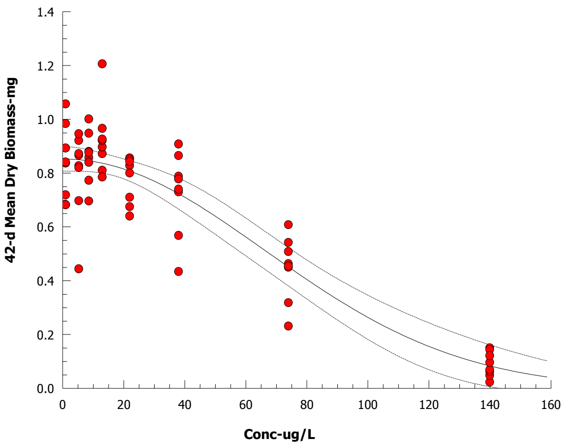
42-d Mean Dry Biomass-mg Summary

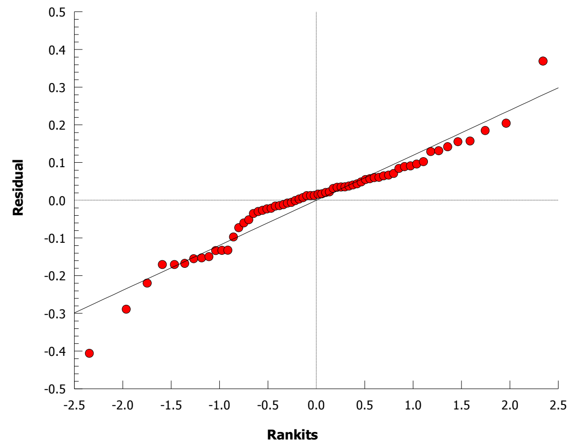
			Calculated Variate						
Conc-ug/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	N	8	0.8369	0.682	1.057	0.04912	0.1389	16.60%	0.00%
5.3		8	0.7991	0.444	0.946	0.05732	0.1621	20.29%	4.51%
8.6		8	0.8591	0.696	1.001	0.03359	0.095	11.06%	-2.66%
13		8	0.9229	0.785	1.206	0.04572	0.1293	14.01%	-10.28%
22		8	0.7754	0.64	0.856	0.03072	0.08689	11.21%	7.35%
38		8	0.7264	0.434	0.908	0.05501	0.1556	21.42%	13.20%
74		8	0.4467	0.231	0.608	0.04274	0.1209	27.06%	46.62%
140		8	0.08913	0.023	0.15	0.01636	0.04627	51.91%	89.35%

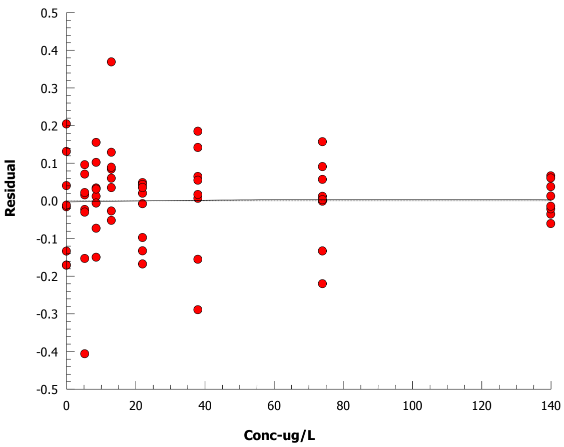
42-d Mean Dry Biomass-mg Detail

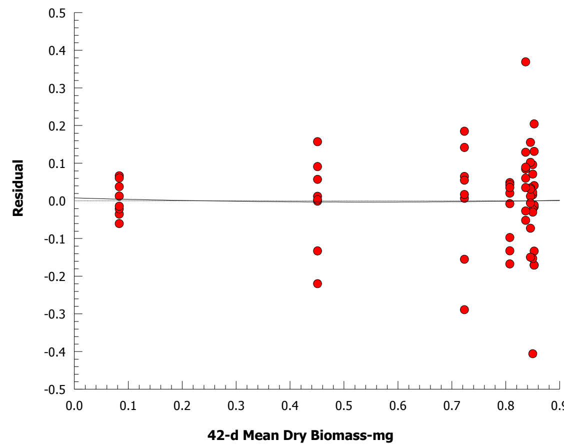
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	0.837	0.719	0.682	0.841	0.893	0.984	1.057	0.682
5.3		0.444	0.697	0.827	0.866	0.82	0.921	0.872	0.946
8.6		0.773	0.696	0.858	1.001	0.88	0.877	0.84	0.948
13		1.206	0.81	0.872	0.785	0.966	0.897	0.921	0.926
22		0.856	0.71	0.64	0.675	0.828	0.8	0.851	0.843
38		0.568	0.73	0.788	0.865	0.74	0.778	0.908	0.434
74		0.45	0.508	0.542	0.463	0.231	0.318	0.454	0.608
140		0.023	0.048	0.062	0.069	0.15	0.096	0.144	0.121

Graphics Model: 3P Log-Gompertz: μ=α·exp[log[0.5]·[x/δ]^γ] Distribution: Normal [ω=1]









***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** — **HydroQual Laboratories, Ltd**

Analysis ID:	06-7581-3840	**Endpoint:**	42-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 12:34	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

Batch ID:		**Test Type:**		**Analyst:**	
Start Date:		**Protocol:**		**Diluent:**	
Ending Date:		**Species:**	Hyalella azteca	**Brine:**	
Duration:		**Source:**		**Age:**	

Sample ID:		**Code:**		**Client:**	
Sample Date:		**Material:**	Dissolved copper	**Project:**	
Receipt Date:		**Source:**			
Sample Age:		**Station:**			

Linear Regression Options

Model Name	Link Function	Threshold Option	Thresh	Optimized	Pooled	Het Corr	Weighted
Log-Normal (Probit)	η=inv Φ[π]	Control Threshold	0.05	Yes	No	No	Yes

Regression Summary

Iters	LL	AICc	BIC	Mu	Sigma	Adj R2	F Stat	Critical	P-Value	Decision(α:5%)
14	-82.97	172.3	178.4	2.057	0.1976	0.9064	1.554	2.38	0.1882	Non-Significant Lack of Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL	TU	95% LCL	95% UCL
LC5	53.97	36.34	66.32	1.853	1.508	2.751
LC10	63.67	46.42	75.49	1.571	1.325	2.154
LC15	71.18	54.63	82.55	1.405	1.211	1.83
LC20	77.78	62.06	88.81	1.286	1.126	1.611
LC25	83.92	69.09	94.76	1.192	1.055	1.447
LC40	101.6	89.07	113.4	0.9838	0.8818	1.123
LC50	114.1	101.9	128.7	0.8767	0.7772	0.9814

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
Threshold	0.06242	0.01142	0.04003	0.08481	5.463	9.2E-07	Significant Parameter
Slope	5.061	0.8803	3.335	6.786	5.749	3.1E-07	Significant Parameter
Intercept	-10.41	1.798	-13.94	-6.886	-5.789	2.7E-07	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	854.4	427.2	2	305.9	<1.0E-37	Significant
Lack of Fit	10.38	2.076	5	1.554	0.1882	Non-Significant
Pure Error	74.82	1.336	56			
Residual	85.2	1.397	61			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Goodness-of-Fit	Collapsed Chi-Sq GOF Test	21.45	22.36	0.0645	Non-Significant Heterogeneity
	Likelihood Ratio GOF Test	86.68	80.23	0.0170	Significant Heterogeneity
Extreme Value	Grubbs Extreme Value Test	3.795	3.224	0.0035	Outlier Detected
Variances	Mod Levene Equality of Variance	0.4996	2.178	0.8309	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.8603	0.9626	3.4E-06	Non-Normal Distribution
	Anderson-Darling A2 Normality Te	3.582	2.492	<1.0E-37	Non-Normal Distribution

Analysis ID:	06-7581-3840	**Endpoint:**	42-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 12:34	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

42-d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-ug/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	N	8	0.9500	0.8000	1.0000	0.0327	0.0926	9.75%	0.00%	76	80
5.3		8	0.8625	0.6000	1.0000	0.0498	0.1408	16.32%	9.21%	69	80
8.6		8	0.9500	0.9000	1.0000	0.0189	0.0535	5.63%	0.00%	76	80
13		8	0.9625	0.8000	1.0000	0.0263	0.0744	7.73%	-1.32%	77	80
22		8	0.9375	0.8000	1.0000	0.0263	0.0744	7.94%	1.32%	75	80
38		8	0.9625	0.9000	1.0000	0.0183	0.0518	5.38%	-1.32%	77	80
74		8	0.7625	0.5000	1.0000	0.0596	0.1685	22.10%	19.74%	61	80
140		8	0.3125	0.1000	0.6000	0.0611	0.1727	55.26%	67.11%	25	80

42-d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	1.0000	1.0000	0.8000	1.0000	1.0000	1.0000	1.0000	0.8000
5.3		0.6000	0.7000	0.9000	0.9000	0.9000	0.9000	1.0000	1.0000
8.6		0.9000	0.9000	0.9000	1.0000	1.0000	1.0000	0.9000	1.0000
13		1.0000	0.8000	1.0000	1.0000	1.0000	0.9000	1.0000	1.0000
22		0.9000	1.0000	0.8000	1.0000	1.0000	0.9000	1.0000	0.9000
38		0.9000	1.0000	1.0000	1.0000	1.0000	0.9000	1.0000	0.9000
74		0.7000	1.0000	0.7000	0.7000	0.5000	0.7000	0.8000	1.0000
140		0.1000	0.2000	0.5000	0.2000	0.6000	0.2000	0.3000	0.4000

42-d Survival Rate Binomials

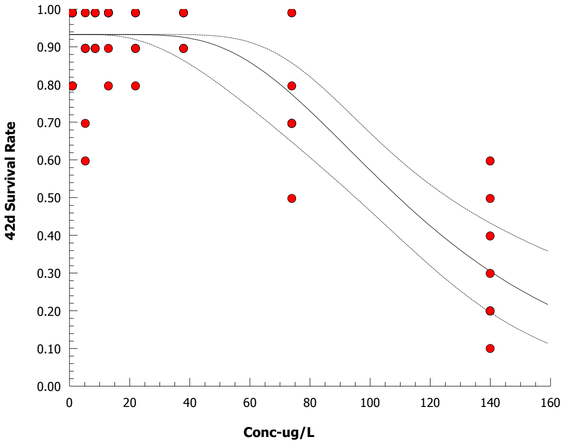
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	10/10	10/10	8/10	10/10	10/10	10/10	10/10	8/10
5.3		6/10	7/10	9/10	9/10	9/10	9/10	10/10	10/10
8.6		9/10	9/10	9/10	10/10	10/10	10/10	9/10	10/10
13		10/10	8/10	10/10	10/10	10/10	9/10	10/10	10/10
22		9/10	10/10	8/10	10/10	10/10	9/10	10/10	9/10
38		9/10	10/10	10/10	10/10	10/10	9/10	10/10	9/10
74		7/10	10/10	7/10	7/10	5/10	7/10	8/10	10/10
140		1/10	2/10	5/10	2/10	6/10	2/10	3/10	4/10

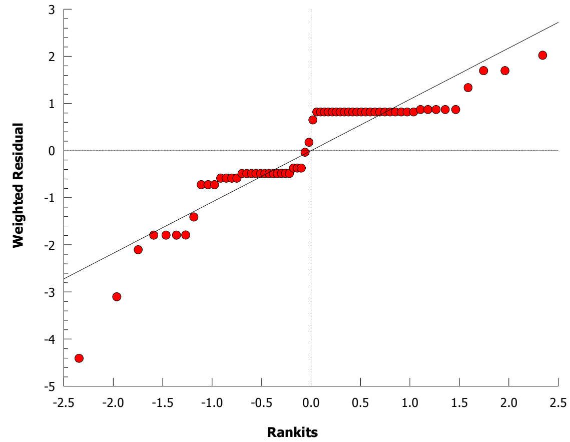
***Hyalella azteca* 42-d Survival, Growth and Reproduction Test** | **HydroQual Laboratories, Ltd**

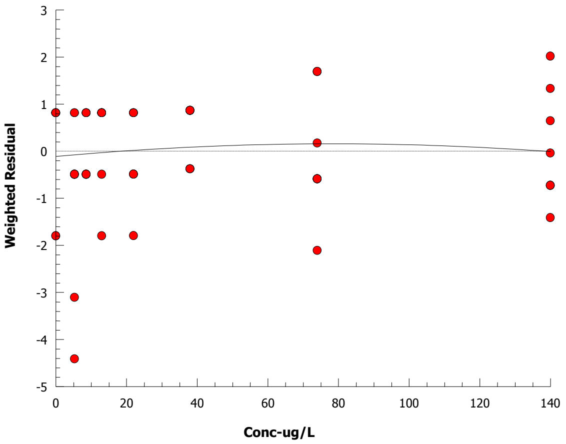
Analysis ID:	06-7581-3840	**Endpoint:**	42-d Survival Rate	**CETIS Version:**	CETISv1.9.0
Analyzed:	15 Apr-16 12:34	**Analysis:**	Linear Regression (GLM)	**Official Results:**	Yes

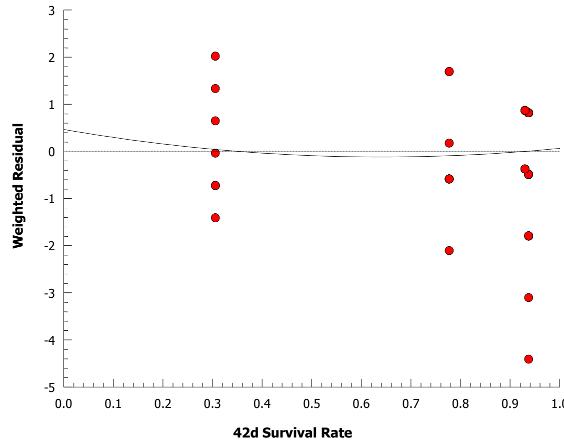
Graphics

Log-Normal: inv Φ[π]=α+β·log[x]









APPENDIX E – Analytical Chemistry Data

NAUTILUS ENVIRONMENTAL
ATTN: Bonnie Lo
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 13-OCT-15
Report Date: 22-OCT-15 10:29 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L1687022
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers: 1419
Legal Site Desc:

Jamie Lo, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1687022-1	L1687022-2	L1687022-3	L1687022-4	L1687022-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	13-OCT-15	13-OCT-15	13-OCT-15	13-OCT-15	13-OCT-15
	Sampled Time					
	Client ID	ROTIFER CTRL T+D	5 T+D	10 T+D	20 T+D	40 T+D
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)					
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)					
	Chloride (Cl) (mg/L)					
	Sulfate (SO4) (mg/L)					
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)					
Total Metals	Aluminum (Al)-Total (mg/L)					
	Antimony (Sb)-Total (mg/L)					
	Arsenic (As)-Total (mg/L)					
	Barium (Ba)-Total (mg/L)					
	Beryllium (Be)-Total (mg/L)					
	Bismuth (Bi)-Total (mg/L)					
	Boron (B)-Total (mg/L)					
	Cadmium (Cd)-Total (mg/L)					
	Calcium (Ca)-Total (mg/L)					
	Chromium (Cr)-Total (mg/L)					
	Cobalt (Co)-Total (mg/L)					
	Copper (Cu)-Total (mg/L)	0.00075	0.0115	0.0173	0.0277	0.0501
	Iron (Fe)-Total (mg/L)					
	Lead (Pb)-Total (mg/L)					
	Lithium (Li)-Total (mg/L)					
	Magnesium (Mg)-Total (mg/L)					
	Manganese (Mn)-Total (mg/L)					
	Molybdenum (Mo)-Total (mg/L)					
	Nickel (Ni)-Total (mg/L)					
	Phosphorus (P)-Total (mg/L)					
	Potassium (K)-Total (mg/L)					
	Selenium (Se)-Total (mg/L)					
	Silicon (Si)-Total (mg/L)					
	Silver (Ag)-Total (mg/L)					
	Sodium (Na)-Total (mg/L)					
	Strontium (Sr)-Total (mg/L)					
	Thallium (Tl)-Total (mg/L)					
	Tin (Sn)-Total (mg/L)					
	Titanium (Ti)-Total (mg/L)					
	Uranium (U)-Total (mg/L)					
	Vanadium (V)-Total (mg/L)					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1687022-6	L1687022-7	L1687022-8	L1687022-9	
	Description	Water	Water	Water	Water	
	Sampled Date	13-OCT-15	13-OCT-15	13-OCT-15	13-OCT-15	
	Sampled Time					
	Client ID	80 T+D	160 T+D	RATIO WATER	ROTIFER SITE T+D	
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)			174		
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)			159		
	Chloride (Cl) (mg/L)			3.64		
	Sulfate (SO4) (mg/L)			25.5		
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)			9.64		
Total Metals	Aluminum (Al)-Total (mg/L)			0.0256		
	Antimony (Sb)-Total (mg/L)			<0.00010		
	Arsenic (As)-Total (mg/L)			0.00050		
	Barium (Ba)-Total (mg/L)			0.0608		
	Beryllium (Be)-Total (mg/L)			<0.00010		
	Bismuth (Bi)-Total (mg/L)			<0.000050		
	Boron (B)-Total (mg/L)			0.028		
	Cadmium (Cd)-Total (mg/L)			0.0000061		
	Calcium (Ca)-Total (mg/L)			45.9		
	Chromium (Cr)-Total (mg/L)			0.00041		
	Cobalt (Co)-Total (mg/L)			<0.00010		
	Copper (Cu)-Total (mg/L)	0.0987	0.174	0.00700	0.00691	
	Iron (Fe)-Total (mg/L)			0.110		
	Lead (Pb)-Total (mg/L)			0.000191		
	Lithium (Li)-Total (mg/L)			<0.0050		
	Magnesium (Mg)-Total (mg/L)			14.5		
	Manganese (Mn)-Total (mg/L)			0.0715		
	Molybdenum (Mo)-Total (mg/L)			0.00241		
	Nickel (Ni)-Total (mg/L)			0.00097		
	Phosphorus (P)-Total (mg/L)			<0.30		
	Potassium (K)-Total (mg/L)			2.1		
	Selenium (Se)-Total (mg/L)			0.000231		
	Silicon (Si)-Total (mg/L)			4.48		
	Silver (Ag)-Total (mg/L)			<0.000010		
	Sodium (Na)-Total (mg/L)			11.9		
	Strontium (Sr)-Total (mg/L)			0.469		
	Thallium (Tl)-Total (mg/L)			<0.00010		
	Tin (Sn)-Total (mg/L)			<0.00010		
	Titanium (Ti)-Total (mg/L)			<0.010		
	Uranium (U)-Total (mg/L)			0.00140		
	Vanadium (V)-Total (mg/L)			0.00061		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1687022-1	L1687022-2	L1687022-3	L1687022-4	L1687022-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	13-OCT-15	13-OCT-15	13-OCT-15	13-OCT-15	13-OCT-15
	Sampled Time					
	Client ID	ROTIFER CTRL T+D	5 T+D	10 T+D	20 T+D	40 T+D
Grouping	**Analyte**					
WATER						
Total Metals	Zinc (Zn)-Total (mg/L)					
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Copper (Cu)-Dissolved (mg/L)	0.00045	0.00827	0.0121	0.0162	0.0317

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1687022-6	L1687022-7	L1687022-8	L1687022-9	
	Description	Water	Water	Water	Water	
	Sampled Date	13-OCT-15	13-OCT-15	13-OCT-15	13-OCT-15	
	Sampled Time					
	Client ID	80 T+D	160 T+D	RATIO WATER	ROTIFER SITE T+D	
Grouping	**Analyte**					
WATER						
Total Metals	Zinc (Zn)-Total (mg/L)			0.0066		
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB		LAB	
	Copper (Cu)-Dissolved (mg/L)	0.0657	0.132		0.00499	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Number	Client Sample ID	Qualifier	Description
L1687022-8	RATIO WATER	LPMB	Lab-Preserved for Total Metals. Sample received with pH > 2 and preserved at the lab. Total Metals results may be biased low.

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Chloride (Cl)	DLDS	L1687022-8
Matrix Spike	Calcium (Ca)-Total	MS-B	L1687022-8
Matrix Spike	Iron (Fe)-Total	MS-B	L1687022-8
Matrix Spike	Silicon (Si)-Total	MS-B	L1687022-8
Matrix Spike	Sodium (Na)-Total	MS-B	L1687022-8
Matrix Spike	Aluminum (Al)-Total	MS-B	L1687022-8
Matrix Spike	Barium (Ba)-Total	MS-B	L1687022-8
Matrix Spike	Manganese (Mn)-Total	MS-B	L1687022-8
Matrix Spike	Strontium (Sr)-Total	MS-B	L1687022-8
Matrix Spike	Dissolved Organic Carbon	MS-B	L1687022-8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Reference Information

Laboratory Definition Code	Laboratory Location

Chain of Custody Numbers:

1419

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Nautilus Environmental

BRITISH COLUMBIA
8664 Commerce Court
Burnaby British Columbia Canada V5A 4N7
Phone 604.420.8773
Fax 604.357.1361

Chain of Custody

1419

Date Oct 13/15 Page 1 of 1

Sample Collection by:

Report to:
Company Nautilus Environmental
Address (1)
City ______ Prov. ______ PC ______
Contact bonnie@nautilusenvironmental.ca
Phone No. emma@nautilusenvironmental.ca

Invoice to:
Company same as report to.
Address
City ______ Prov. ______ PC ______
Contact
Phone No.

ANALYSIS REQUIRED

SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NUMBER OF CONTAINERS	COMMENTS	low level Cu Total	low level Cu Dissolved	Low level metals	alkalinity	Sulphate	chloride	DOC					RECEIPT TEMPERATURE (°C)
Rotifer Ctrl T+D	Oct 13/15	–	water	125 mL plastic	1	Day 0 - Rotifer Initiation	X	X										
5 T+D	↓	–		↓	↓		X	X										
10 T+D		–					X	X										
20 T+D		–					X	X										
40 T+D		–					X	X										
80 T+D		–					X	X										
160 T+D		–					X	X										
Ratio Water	↓	–		1-L plastic	↓				X	X	X	X	X					

L1687022-COFC

Short Holding Time

Rush Processing

SAMPLE RECEIPT

OF CONTAINERS

REC'D GOOD CONDITION

SHIPPED VIA:

RELINQUISHED BY (CLIENT)
(Signature) (Time) Oct 13/15
(Printed Name) Emma Marus @ 1630h (Date)
(Company) (1)

RELINQUISHED BY (COURIER)
(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (COURIER)
(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (LABORATORY)
YC Oct 13 17:00 7.6°C
(Signature) (Time)
(Printed Name) (Date)

SPECIAL INSTRUCTIONS/COMMENTS:
* Copper ~ 5 µg/L → please run low levels
* not filtered or preserved

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

NAUTILUS ENVIRONMENTAL
ATTN: Bonnie Lo
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 15-OCT-15
Report Date: 23-OCT-15 12:09 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L1688646

Project P.O. #: NOT SUBMITTED

Job Reference:

C of C Numbers: 1418

Legal Site Desc:

Jamie Lo, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1688646-1	L1688646-2	L1688646-3	L1688646-4	L1688646-5
	Sample ID	L1688646-1	L1688646-2	L1688646-3	L1688646-4	L1688646-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	15-OCT-15	15-OCT-15	15-OCT-15	15-OCT-15	15-OCT-15
	Sampled Time					
	Client ID	ROTIFER CTRL T+D	ROTIFER SITE T+D	ROTIFER 5 T+D	ROTIFER 10 T+D	ROTIFER 20 T+D
Grouping	**Analyte**					
WATER						
Total Metals	Copper (Cu)-Total (mg/L)	0.00230	0.00771	0.0166	0.0169	0.0246
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Copper (Cu)-Dissolved (mg/L)	0.00170	0.00585	0.00920	0.0132	0.0192

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1688646-6	L1688646-7	L1688646-8		
	Description	Water	Water	Water		
	Sampled Date	15-OCT-15	15-OCT-15	15-OCT-15		
	Sampled Time					
	Client ID	ROTIFER 40 T+D	ROTIFER 80 T+D	ROTIFER 160 T+D		
Grouping	**Analyte**					
WATER						
Total Metals	Copper (Cu)-Total (mg/L)	0.0425	0.0788	0.162		
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB		
	Copper (Cu)-Dissolved (mg/L)	0.0328	0.0641	0.119		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
LPML	Lab-Preserved for Total Metals. Sample received with pH > 2 and preserved at the lab. Total Metals results may be biased low.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location

Chain of Custody Numbers:

1418

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Nautilus Environmental

(1) BRITISH COLUMBIA
8664 Commerce Court
Burnaby British Columbia Canada V5A 4N7
Phone 604.420.8773
Fax 604.357.1361

Chain of Custody

1418

Date Oct 15/15 Page 1 of 1

Sample Collection by:

Report to:
Company Nautilus Environmental
Address (1)
City Prov. PC
Contact bonnie@nautilusenvironmental.com
Phone No. emma@nautilusenvironmental.com

Invoice to:
Company same as report to
Address
City Prov. PC
Contact
Phone No.

SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NUMBER OF CONTAINERS	COMMENTS	low level Cu Total	low level Cu Dissolved	ANALYSIS REQUIRED									RECEIPT TEMPERATURE (°C)
Rotifer Ctrl T+D	Oct 15/15	—	water	125mL plastic	1	termination	X	X										
Rotifer Site T+D	↓	↓	↓	↓	↓	↓	X	X										
Rotifer 5 T+D							X	X										
Rotifer 10 T+D							X	X										
Rotifer 20 T+D							X	X										
Rotifer 40 T+D							X	X										
Rotifer 80 T+D							X	X										
Rotifer 160 T+D							X	X										

L1688646-COFC

PROJECT INFORMATION	SAMPLE RECEIPT	
CLIENT	TOTAL NO. OF CONTAINERS	
P.O. NO.	REC'D GOOD CONDITION	
SHIPPED VIA:		

SPECIAL INSTRUCTIONS/COMMENTS:
~5 µg/L Cu - low levels
not filtered or preserved

RELINQUISHED BY (CLIENT)
(Signature) [signature] (Time) Oct 15/15
(Printed Name) Emma Marus @1700 (Date)
(Company) Nautilus Environmental

RECEIVED BY (COURIER)
(Signature) (Time)
(Printed Name) (Date)
(Company)

RELINQUISHED BY (COURIER)
(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (LABORATORY)
(Signature) Paul Barry (Time)
(Printed Name) PAUL BARRY (Date)
OCT 15 @ 18:30 19.8°C

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

Nautilus Environmental
ATTN: Leila Oosterbroek
#4, 6125 - 12 Street SE
Calgary AB T2H 2K1

Date Received: 08-OCT-15
Report Date: 07-APR-16 19:52 (MT)
Version: FINAL REV. 2

Client Phone: 403-253-7121

Certificate of Analysis

Lab Work Order #: L1685361
Project P.O. #: PO 2016-046
Job Reference:
C of C Numbers:
Legal Site Desc:

Comments: 7-APR-16
Revised report: diss. Cu results with lower LORs

Jesse Eagle, B.Sc.
Business Development Representative

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1685361-1 SP15-013; LAB CONTROL DA - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Calcium (Ca)-Dissolved	33.1		0.10	mg/L		15-OCT-15	R3290069
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		15-OCT-15	R3290069
Magnesium (Mg)-Dissolved	0.90		0.10	mg/L		15-OCT-15	R3290069
Potassium (K)-Dissolved	<0.50		0.50	mg/L		15-OCT-15	R3290069
Sodium (Na)-Dissolved	2.4		1.0	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00061		0.00050	mg/L		15-OCT-15	R3290011
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	4.39		0.50	mg/L		10-OCT-15	R3290692
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		10-OCT-15	R3290692
Ion Balance Calculation							
Ion Balance	90.2			%		16-OCT-15	
TDS (Calculated)	104			mg/L		16-OCT-15	
Hardness (as CaCO3)	86.4			mg/L		16-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	0.433		0.020	mg/L		10-OCT-15	R3290692
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.433		0.050	mg/L		16-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		10-OCT-15	R3290692
Sulfate in Water by IC							
Sulfate (SO4)	6.54		0.30	mg/L		10-OCT-15	R3290692
pH, Conductivity and Total Alkalinity							
pH	8.46		0.10	pH		14-OCT-15	R3290128
Conductivity (EC)	200		3.0	uS/cm		14-OCT-15	R3290128
Bicarbonate (HCO3)	106		5.0	mg/L		14-OCT-15	R3290128
Carbonate (CO3)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Hydroxide (OH)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Alkalinity, Total (as CaCO3)	91.9		5.0	mg/L		14-OCT-15	R3290128
L1685361-2 SP15-013; LAB CONTROL FM - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Calcium (Ca)-Dissolved	20.2		0.10	mg/L		15-OCT-15	R3290069
Copper (Cu)-Dissolved	<0.005		0.0050	mg/L		15-OCT-15	R3290069
Magnesium (Mg)-Dissolved	17.4		0.10	mg/L		15-OCT-15	R3290069
Potassium (K)-Dissolved	3.31		0.50	mg/L		15-OCT-15	R3290069
Sodium (Na)-Dissolved	42.5		1.0	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00110		0.00050	mg/L		15-OCT-15	R3290011
Routine Water Analysis							
Chloride in Water by IC							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1685361-2 SP15-013; LAB CONTROL FM - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Chloride in Water by IC							
Chloride (Cl)	2.82		0.50	mg/L		10-OCT-15	R3290692
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		10-OCT-15	R3290692
Ion Balance Calculation							
Ion Balance	92.9			%		16-OCT-15	
TDS (Calculated)	273			mg/L		16-OCT-15	
Hardness (as CaCO3)	122			mg/L		16-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	<0.020		0.020	mg/L		10-OCT-15	R3290692
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		16-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		10-OCT-15	R3290692
Sulfate in Water by IC							
Sulfate (SO4)	127		0.30	mg/L		10-OCT-15	R3290692
pH, Conductivity and Total Alkalinity							
pH	7.90		0.10	pH		14-OCT-15	R3290128
Conductivity (EC)	440		3.0	uS/cm		14-OCT-15	R3290128
Bicarbonate (HCO3)	121		5.0	mg/L		14-OCT-15	R3290128
Carbonate (CO3)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Hydroxide (OH)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Alkalinity, Total (as CaCO3)	99.5		5.0	mg/L		14-OCT-15	R3290128
L1685361-3 SP15-013; LAB CONTROL HA - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Calcium (Ca)-Dissolved	39.6		0.10	mg/L		15-OCT-15	R3290069
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		15-OCT-15	R3290069
Magnesium (Mg)-Dissolved	5.68		0.10	mg/L		15-OCT-15	R3290069
Potassium (K)-Dissolved	2.06		0.50	mg/L		15-OCT-15	R3290069
Sodium (Na)-Dissolved	24.5		1.0	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.00050		0.00050	mg/L		15-OCT-15	R3290011
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	74.3		0.50	mg/L		10-OCT-15	R3290692
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		10-OCT-15	R3290692
Ion Balance Calculation							
Ion Balance	94.8			%		16-OCT-15	
TDS (Calculated)	205			mg/L		16-OCT-15	
Hardness (as CaCO3)	122			mg/L		16-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	<0.020		0.020	mg/L		10-OCT-15	R3290692
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		16-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		10-OCT-15	R3290692

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1685361-3 SP15-013; LAB CONTROL HA - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Sulfate in Water by IC							
Sulfate (SO4)	24.3		0.30	mg/L		10-OCT-15	R3290692
pH, Conductivity and Total Alkalinity							
pH	7.55		0.10	pH		14-OCT-15	R3290128
Conductivity (EC)	400		3.0	uS/cm		14-OCT-15	R3290128
Bicarbonate (HCO3)	70.5		5.0	mg/L		14-OCT-15	R3290128
Carbonate (CO3)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Hydroxide (OH)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Alkalinity, Total (as CaCO3)	57.8		5.0	mg/L		14-OCT-15	R3290128
L1685361-4 SP15-013; SITE CONTROL DA,FM - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Calcium (Ca)-Dissolved	44.9		0.10	mg/L		15-OCT-15	R3290069
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		15-OCT-15	R3290069
Magnesium (Mg)-Dissolved	14.1		0.10	mg/L		15-OCT-15	R3290069
Potassium (K)-Dissolved	1.80		0.50	mg/L		15-OCT-15	R3290069
Sodium (Na)-Dissolved	11.7		1.0	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00523		0.00050	mg/L		15-OCT-15	R3290011
Miscellaneous Parameters							
Dissolved Organic Carbon	9.5		1.0	mg/L		17-OCT-15	R3291790
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	2.96		0.50	mg/L		10-OCT-15	R3290692
Fluoride in Water by IC							
Fluoride (F)	0.286		0.020	mg/L		10-OCT-15	R3290692
Ion Balance Calculation							
Ion Balance	103			%		16-OCT-15	
TDS (Calculated)	199			mg/L		16-OCT-15	
Hardness (as CaCO3)	170			mg/L		16-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	0.308		0.020	mg/L		10-OCT-15	R3290692
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.308		0.050	mg/L		16-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		10-OCT-15	R3290692
Sulfate in Water by IC							
Sulfate (SO4)	24.9		0.30	mg/L		10-OCT-15	R3290692
pH, Conductivity and Total Alkalinity							
pH	8.05		0.10	pH		14-OCT-15	R3290128
Conductivity (EC)	350		3.0	uS/cm		14-OCT-15	R3290128
Bicarbonate (HCO3)	196		5.0	mg/L		14-OCT-15	R3290128
Carbonate (CO3)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Hydroxide (OH)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Alkalinity, Total (as CaCO3)	161		5.0	mg/L		14-OCT-15	R3290128
L1685361-5 SP15-013; SITE CONTROL HA - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1685361-5 SP15-013; SITE CONTROL HA - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Miscellaneous Parameters							
Dissolved Organic Carbon	9.2		1.0	mg/L		17-OCT-15	R3291790
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	28.8		0.50	mg/L		10-OCT-15	R3290692
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Calcium (Ca)-Dissolved	44.1		0.10	mg/L		15-OCT-15	R3290069
Magnesium (Mg)-Dissolved	13.8		0.10	mg/L		15-OCT-15	R3290069
Potassium (K)-Dissolved	1.76		0.50	mg/L		15-OCT-15	R3290069
Sodium (Na)-Dissolved	28.6		1.0	mg/L		15-OCT-15	R3290069
Fluoride in Water by IC							
Fluoride (F)	0.288		0.020	mg/L		10-OCT-15	R3290692
Ion Balance Calculation							
Ion Balance	95.9			%		16-OCT-15	
TDS (Calculated)	247			mg/L		16-OCT-15	
Hardness (as CaCO3)	167			mg/L		16-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	0.306		0.020	mg/L		10-OCT-15	R3290692
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.306		0.050	mg/L		16-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		10-OCT-15	R3290692
Sulfate in Water by IC							
Sulfate (SO4)	24.8		0.30	mg/L		10-OCT-15	R3290692
pH, Conductivity and Total Alkalinity							
pH	8.05		0.10	pH		14-OCT-15	R3290128
Conductivity (EC)	420		3.0	uS/cm		14-OCT-15	R3290128
Bicarbonate (HCO3)	211		5.0	mg/L		14-OCT-15	R3290128
Carbonate (CO3)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Hydroxide (OH)	<5.0		5.0	mg/L		14-OCT-15	R3290128
Alkalinity, Total (as CaCO3)	173		5.0	mg/L		14-OCT-15	R3290128
L1685361-6 SP15-013; 5 UG/L CU - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Copper (Cu)-Dissolved	0.0099		0.0050	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0103		0.00050	mg/L		15-OCT-15	R3290011
L1685361-7 SP15-013; 10 UG/L CU - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Copper (Cu)-Dissolved	0.013		0.010	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1685361-7 SP15-013; 10 UG/L CU - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0145		0.00050	mg/L		15-OCT-15	R3290011
L1685361-8 SP15-013; 20 UG/L CU - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Copper (Cu)-Dissolved	0.023		0.010	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0244		0.00050	mg/L		15-OCT-15	R3290011
L1685361-9 SP15-013; 40 UG/L CU - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Copper (Cu)-Dissolved	0.038		0.010	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0428		0.00050	mg/L		15-OCT-15	R3290011
L1685361-10 SP15-013; 80 UG/L CU - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Copper (Cu)-Dissolved	0.075		0.010	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0805		0.00050	mg/L		15-OCT-15	R3290011
L1685361-11 SP15-013; 160 UG/L CU - WEEK 1							
Sampled By: CLIENT							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					15-OCT-15	R3290119
Copper (Cu)-Dissolved	0.144		0.010	mg/L		15-OCT-15	R3290069
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.148		0.00050	mg/L		15-OCT-15	R3290011

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-DIS-ORG-CL	Water	Dissolved Organic Carbon	APHA 5310 B-Instrumental
CL-IC-N-CL	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

F-IC-N-CL	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

IONBALANCE-CL	Water	Ion Balance Calculation	APHA 1030E
MET-DIS-ICP-CL	Water	Dissolved Metals by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-CL	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

N2N3-CALC-CL	Water	Nitrate+Nitrite	CALCULATION
NO2-IC-N-CL	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-IC-N-CL	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH/EC/ALK-CL	Water	pH, Conductivity and Total Alkalinity	APHA 4500H,2510,2320

All samples analyzed by this method for pH will have exceeded the 15 minute recommended hold time from time of sampling (field analysis is recommended for pH where highly accurate results are needed)
pH measurement is determined from the activity of the hydrogen ions using a hydrogen electrode and a reference electrode.
Alkalinity measurement is based on the sample's capacity to neutralize acid
Conductivity measurement is based on the sample's capacity to convey an electric current

SO4-IC-N-CL	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
CL	ALS ENVIRONMENTAL - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1685361-COFC

COC Number: 14 -

Page ___ of ___

Report To	
Company:	HydroQual Laboratories
Contact:	Leila Oosterbroek
Address:	#4, 6125 12 St SE Calgary, AB T2H 2K1
Phone:	403-253-7121

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ Yes ☐ No

☐ Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax leila@nautilusenvironmental.com

Email 2 bryon@nautilusenvironmental.com

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To

Same as Report To ☑ Yes ☐ No

Copy of Invoice with Report ☑ Yes ☐ No

Company:

Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax

Email 2

Project Information

ALS Quote #: Q52926

Job #:

PO / AFE: PO 2016-046

LSD:

Oil and Gas Required Fields (client use)

Approver ID: | Cost Center:

GL Account: | Routing Code:

Activity Code:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact: Jesse Eagle | Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-DIS-ORG-CL (dissolved organic carbon)	ROU-CL (Ca, Mg, Na, SO4, Cl, alk)	CL-CU-TOT-MS (total copper in water) - (P)	CL-CU-DIS-ICP (dissolved copper in water)	FILTER-CL (lab filtered and preserved)	Number of Containers
1	SP15-013; Lab Control DA - Week 1			water		R	R	R	R	
2	SP15-013; Lab Control FM - Week 1			water		R	R	R	R	
3	SP15-013; Lab Control HA - Week 1			water		R	R	R	R	
4	SP15-013; Site Control DA,FM - Week 1			water	R	R	R	R	R	
5	SP15-013; Site Control HA - Week 1			water	R	R			R	
6	SP15-013; 5 ug/L Cu - Week 1			water			R	R	R	
7	SP15-013; 10 ug/L Cu - Week 1			water			R	R	R	
8	SP15-013; 20 ug/L Cu - Week 1			water			R	R	R	
9	SP15-013; 40 ug/L Cu - Week 1			water			R	R	R	
10	SP15-013; 80 ug/L Cu - Week 1			water			R	R	R	
11	SP15-013; 160 ug/L Cu - Wekk 1			water			R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

****Samples have not been filtered****

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☒

Ice packs Yes ☒ No ☐ Custody seal intact Yes ☐ No ☒

Cooling Initiated ☒

INITIAL COOLER TEMPERATURES °C: 5°C

FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: [signature]	Date: 2015/10/08	Time: 1030	Received by:	Date:	Time:	Received by: AC	Date: Oct-15	Time: 12:20 pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA-FM-0326e v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Nautilus Environmental
ATTN: Leila Oosterbroek
#4, 6125 - 12 Street SE
Calgary AB T2H 2K1

Date Received: 14-OCT-15
Report Date: 11-APR-16 15:05 (MT)
Version: FINAL REV. 2

Client Phone: 403-253-7121

Certificate of Analysis

Lab Work Order #: L1687583
Project P.O. #: PO 2016-052
Job Reference:
C of C Numbers:
Legal Site Desc:

Comments: 7-APR-16
Revised report: diss. Cu results with lower LORs

Jesse Eagle, B.Sc.
Business Development Representative

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1687583-1 SP15-013; LAB CONTROL DA - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Calcium (Ca)-Dissolved	31.3		0.10	mg/L		20-OCT-15	R3292853
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		20-OCT-15	R3292853
Magnesium (Mg)-Dissolved	0.83		0.10	mg/L		20-OCT-15	R3292853
Potassium (K)-Dissolved	<0.50		0.50	mg/L		20-OCT-15	R3292853
Sodium (Na)-Dissolved	2.1		1.0	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00053		0.00050	mg/L		20-OCT-15	R3292211
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	4.48		0.50	mg/L		15-OCT-15	R3293568
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		15-OCT-15	R3293568
Ion Balance Calculation							
Ion Balance	84.8	BL:INT		%		21-OCT-15	
TDS (Calculated)	99.4			mg/L		21-OCT-15	
Hardness (as CaCO3)	81.6			mg/L		21-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	0.415		0.020	mg/L		15-OCT-15	R3293568
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.415		0.050	mg/L		21-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		15-OCT-15	R3293568
Sulfate in Water by IC							
Sulfate (SO4)	6.54		0.30	mg/L		15-OCT-15	R3293568
pH, Conductivity and Total Alkalinity							
pH	7.71		0.10	pH		17-OCT-15	R3292525
Conductivity (EC)	194		3.0	uS/cm		17-OCT-15	R3292525
Bicarbonate (HCO3)	106		5.0	mg/L		17-OCT-15	R3292525
Carbonate (CO3)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Hydroxide (OH)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Alkalinity, Total (as CaCO3)	87.2		5.0	mg/L		17-OCT-15	R3292525
L1687583-2 SP15-013; LAB CONTROL FM - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Calcium (Ca)-Dissolved	19.6		0.10	mg/L		20-OCT-15	R3292853
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		20-OCT-15	R3292853
Magnesium (Mg)-Dissolved	16.5		0.10	mg/L		20-OCT-15	R3292853
Potassium (K)-Dissolved	3.05		0.50	mg/L		20-OCT-15	R3292853
Sodium (Na)-Dissolved	40.2		1.0	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00066		0.00050	mg/L		20-OCT-15	R3292211
Routine Water Analysis							
Chloride in Water by IC							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1687583-2 SP15-013; LAB CONTROL FM - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Chloride in Water by IC							
Chloride (Cl)	2.94		0.50	mg/L		15-OCT-15	R3293568
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		15-OCT-15	R3293568
Ion Balance Calculation							
Ion Balance	85.5	BL:INT		%		21-OCT-15	
TDS (Calculated)	276			mg/L		21-OCT-15	
Hardness (as CaCO3)	117			mg/L		21-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	<0.020		0.020	mg/L		15-OCT-15	R3293568
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		21-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		15-OCT-15	R3293568
Sulfate in Water by IC							
Sulfate (SO4)	133		0.30	mg/L		15-OCT-15	R3293568
pH, Conductivity and Total Alkalinity							
pH	7.83		0.10	pH		17-OCT-15	R3292525
Conductivity (EC)	440		3.0	uS/cm		17-OCT-15	R3292525
Bicarbonate (HCO3)	123		5.0	mg/L		17-OCT-15	R3292525
Carbonate (CO3)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Hydroxide (OH)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Alkalinity, Total (as CaCO3)	101		5.0	mg/L		17-OCT-15	R3292525
L1687583-3 SP15-013; LAB CONTROL HA - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Calcium (Ca)-Dissolved	38.1		0.10	mg/L		20-OCT-15	R3292853
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		20-OCT-15	R3292853
Magnesium (Mg)-Dissolved	5.44		0.10	mg/L		20-OCT-15	R3292853
Potassium (K)-Dissolved	1.93		0.50	mg/L		20-OCT-15	R3292853
Sodium (Na)-Dissolved	23.5		1.0	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.00050		0.00050	mg/L		20-OCT-15	R3292211
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	77.9		0.50	mg/L		15-OCT-15	R3293568
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		15-OCT-15	R3293568
Ion Balance Calculation							
Ion Balance	87.8	BL:INT		%		21-OCT-15	
TDS (Calculated)	207			mg/L		21-OCT-15	
Hardness (as CaCO3)	118			mg/L		21-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	0.036		0.020	mg/L		15-OCT-15	R3293568
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		21-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		15-OCT-15	R3293568

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1687583-3 SP15-013; LAB CONTROL HA - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Sulfate in Water by IC							
Sulfate (SO4)	25.3		0.30	mg/L		15-OCT-15	R3293568
pH, Conductivity and Total Alkalinity							
pH	7.46		0.10	pH		17-OCT-15	R3292525
Conductivity (EC)	401		3.0	uS/cm		17-OCT-15	R3292525
Bicarbonate (HCO3)	71.3		5.0	mg/L		17-OCT-15	R3292525
Carbonate (CO3)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Hydroxide (OH)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Alkalinity, Total (as CaCO3)	58.4		5.0	mg/L		17-OCT-15	R3292525
L1687583-4 SP15-013; SITE CONTROL DA, FM - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Calcium (Ca)-Dissolved	41.9		0.10	mg/L		20-OCT-15	R3292853
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		20-OCT-15	R3292853
Magnesium (Mg)-Dissolved	12.9		0.10	mg/L		20-OCT-15	R3292853
Potassium (K)-Dissolved	1.66		0.50	mg/L		20-OCT-15	R3292853
Sodium (Na)-Dissolved	10.8		1.0	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00457		0.00050	mg/L		20-OCT-15	R3292211
Miscellaneous Parameters							
Dissolved Organic Carbon	9.7		1.0	mg/L		21-OCT-15	R3295481
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	2.95		0.50	mg/L		15-OCT-15	R3293568
Fluoride in Water by IC							
Fluoride (F)	0.307		0.020	mg/L		15-OCT-15	R3293568
Ion Balance Calculation							
Ion Balance	90.2			%		21-OCT-15	
TDS (Calculated)	199			mg/L		21-OCT-15	
Hardness (as CaCO3)	158			mg/L		21-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	0.309		0.020	mg/L		15-OCT-15	R3293568
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.309		0.050	mg/L		21-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		15-OCT-15	R3293568
Sulfate in Water by IC							
Sulfate (SO4)	24.7		0.30	mg/L		15-OCT-15	R3293568
pH, Conductivity and Total Alkalinity							
pH	7.94		0.10	pH		17-OCT-15	R3292525
Conductivity (EC)	343		3.0	uS/cm		17-OCT-15	R3292525
Bicarbonate (HCO3)	209		5.0	mg/L		17-OCT-15	R3292525
Carbonate (CO3)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Hydroxide (OH)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Alkalinity, Total (as CaCO3)	171		5.0	mg/L		17-OCT-15	R3292525
L1687583-5 SP15-013; SITE CONTROL HA - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1687583-5 SP15-013; SITE CONTROL HA - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Miscellaneous Parameters							
Dissolved Organic Carbon	10.5		1.0	mg/L		21-OCT-15	R3295481
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	20.9		0.50	mg/L		15-OCT-15	R3293568
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					21-OCT-15	R3292832
Calcium (Ca)-Dissolved	39.9	DLDS	0.10	mg/L		21-OCT-15	R3292853
Magnesium (Mg)-Dissolved	13.1	DLDS	0.10	mg/L		21-OCT-15	R3292853
Potassium (K)-Dissolved	2.02	DLDS	0.50	mg/L		21-OCT-15	R3292853
Sodium (Na)-Dissolved	21.2	DLDS	1.0	mg/L		21-OCT-15	R3292853
Fluoride in Water by IC							
Fluoride (F)	0.306		0.020	mg/L		15-OCT-15	R3293568
Nitrate in Water by IC							
Nitrate (as N)	0.305		0.020	mg/L		15-OCT-15	R3293568
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.305		0.050	mg/L		21-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		15-OCT-15	R3293568
Sulfate in Water by IC							
Sulfate (SO4)	24.8		0.30	mg/L		15-OCT-15	R3293568
pH, Conductivity and Total Alkalinity							
pH	7.89		0.10	pH		17-OCT-15	R3292525
Conductivity (EC)	397		3.0	uS/cm		17-OCT-15	R3292525
Bicarbonate (HCO3)	212		5.0	mg/L		17-OCT-15	R3292525
Carbonate (CO3)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Hydroxide (OH)	<5.0		5.0	mg/L		17-OCT-15	R3292525
Alkalinity, Total (as CaCO3)	174		5.0	mg/L		17-OCT-15	R3292525
L1687583-6 SP15-013; 5 UG/L CU - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Copper (Cu)-Dissolved	0.0092		0.0050	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00955		0.00050	mg/L		20-OCT-15	R3292211
L1687583-7 SP15-013; 10 UG/L CU - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Copper (Cu)-Dissolved	0.014		0.010	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0150		0.00050	mg/L		20-OCT-15	R3292211

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1687583-8 SP15-013; 20 UG/L CU - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Copper (Cu)-Dissolved	0.021		0.010	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0242		0.00050	mg/L		20-OCT-15	R3292211
L1687583-9 SP15-013; 40 UG/L CU - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Copper (Cu)-Dissolved	0.039		0.010	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0443		0.00050	mg/L		20-OCT-15	R3292211
L1687583-10 SP15-013; 80 UG/L CU - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Copper (Cu)-Dissolved	0.071		0.010	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0814		0.00050	mg/L		20-OCT-15	R3292211
L1687583-11 SP15-013; 160 UG/L CU - WEEK 2							
Sampled By: CLIENT on 13-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					20-OCT-15	R3292832
Copper (Cu)-Dissolved	0.130		0.010	mg/L		20-OCT-15	R3292853
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.139		0.00050	mg/L		20-OCT-15	R3292211

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Numbe	Client ID	Qualifier	Description
L1687583-4	SP15-013; SITE CONTROL I	SFPL	DOC - Sample was Filtered and Preserved at the laboratory
L1687583-5	SP15-013; SITE CONTROL I	SFPL	DOC - Sample was Filtered and Preserved at the laboratory

Sample Parameter Qualifier Key:

Qualifier	Description
BL:INT	Balance Reviewed: Interference Or Non-Measured Component
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-DIS-ORG-CL	Water	Dissolved Organic Carbon	APHA 5310 B-Instrumental
CL-IC-N-CL	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
F-IC-N-CL	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
IONBALANCE-CL	Water	Ion Balance Calculation	APHA 1030E
MET-DIS-ICP-CL	Water	Dissolved Metals by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-CL	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
N2N3-CALC-CL	Water	Nitrate+Nitrite	CALCULATION
NO2-IC-N-CL	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
NO3-IC-N-CL	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
PH/EC/ALK-CL	Water	pH, Conductivity and Total Alkalinity	APHA 4500H,2510,2320

All samples analyzed by this method for pH will have exceeded the 15 minute recommended hold time from time of sampling (field analysis is recommended for pH where highly accurate results are needed)
pH measurement is determined from the activity of the hydrogen ions using a hydrogen electrode and a reference electrode.
Alkalinity measurement is based on the sample's capacity to neutralize acid
Conductivity measurement is based on the sample's capacity to convey an electric current

ALS Test Code	Matrix	Test Description	Method Reference**
SO4-IC-N-CL	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
CL	ALS ENVIRONMENTAL - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
L1687583-COFC

Report To	
Company:	HydroQual Laboratories
Contact:	Leila Oosterbroek
Address:	#4, 6125 12 St SE Calgary, AB T2H 2K1
Phone:	403-253-7121

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ Yes ☐ No
☐ Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax leila@nautilusenvironmental.com
Email 2 bryon@nautilusenvironmental.com

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

R ☑ Regular (Standard TAT if received by 3 pm - business days)
P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Specify Date Required for E2,E or P:

Invoice To
Same as Report To ☑ Yes ☐ No
Copy of Invoice with Report ☑ Yes ☐ No
Company:
Contact:

Invoice Distribution
Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax
Email 2

Project Information

ALS Quote #:	Q52926
Job #:	
PO / AFE:	PO 2016-052
LSD:	

Oil and Gas Required Fields (client use)

Approver ID:	Cost Center:
GL Account:	Routing Code:
Activity Code:	
Location:	

ALS Lab Work Order # (lab use only)

ALS Contact: Jesse Eagle
Sampler:

Analysis Request
Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-DIS-ORG-CL (dissolved organic carbon)	ROU-CL (Ca, Mg, Na, SO4, Cl, alk)	CL-CU-TOT-MS (total copper in water) - (P)	CL-CU-DIS-ICP (dissolved copper in water)	FILTER-CL (lab filtered and preserved)	Number of Containers
1	SP15-013; Lab Control DA - Week 2	2015/10/13		water		R	R	R	R	
2	SP15-013; Lab Control FM - Week 2	↓		water		R	R	R	R	
3	SP15-013; Lab Control HA - Week 2	↓		water		R	R	R	R	
4	SP15-013; Site Control DA,FM - Week 2	↓		water	R	R	R	R	R	
5	SP15-013; Site Control HA - Week 2	↓		water	R	R			R	
6	SP15-013; 5 ug/L Cu - Week 2	↓		water			R	R	R	
7	SP15-013; 10 ug/L Cu - Week 2	↓		water			R	R	R	
8	SP15-013; 20 ug/L Cu - Week 2	↓		water			R	R	R	
9	SP15-013; 40 ug/L Cu - Week 2	↓		water			R	R	R	
10	SP15-013; 80 ug/L Cu - Week 2	↓		water			R	R	R	
11	SP15-013; 160 ug/L Cu - Week 2	↓		water			R	R	R	

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System? ☐ Yes ☐ No
Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)
****Samples have not been filtered****

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen ☐ SIF Observations Yes ☒ No ☒
Ice packs Yes ☑ No ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 3
FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: [signature]	Date: 2015/10/14	Time:	Received by: [signature]	Date: Oct 14	Time: 9:55	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY

Nautilus Environmental
ATTN: Leila Oosterbroek
#4, 6125 - 12 Street SE
Calgary AB T2H 2K1

Date Received: 21-OCT-15
Report Date: 11-APR-16 15:07 (MT)
Version: FINAL REV. 2

Client Phone: 403-253-7121

Certificate of Analysis

Lab Work Order #: L1691629
Project P.O. #: PO 2016-063
Job Reference:
C of C Numbers:
Legal Site Desc:

Comments: 7-APR-16
Revised report: diss. Cu results with lower LORs

Nelson Kwan, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1691629-1 SP15-013; LAB CONTROL DA - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.00050		0.00050	mg/L		31-OCT-15	R3300795
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	4.62		0.50	mg/L		22-OCT-15	R3297770
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Calcium (Ca)-Dissolved	34.8		0.10	mg/L		28-OCT-15	R3298331
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		28-OCT-15	R3298331
Magnesium (Mg)-Dissolved	0.98		0.10	mg/L		28-OCT-15	R3298331
Potassium (K)-Dissolved	<0.50		0.50	mg/L		28-OCT-15	R3298331
Sodium (Na)-Dissolved	2.5		1.0	mg/L		28-OCT-15	R3298331
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		22-OCT-15	R3297770
Ion Balance Calculation							
Ion Balance	91.5			%		01-NOV-15	
TDS (Calculated)	106			mg/L		01-NOV-15	
Hardness (as CaCO3)	90.9			mg/L		01-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	0.426		0.020	mg/L		22-OCT-15	R3297770
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.445		0.050	mg/L		27-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	0.019		0.010	mg/L		22-OCT-15	R3297770
Sulfate in Water by IC							
Sulfate (SO4)	6.77		0.30	mg/L		22-OCT-15	R3297770
pH, Conductivity and Total Alkalinity							
pH	7.80		0.10	pH		27-OCT-15	R3298636
Conductivity (EC)	185		3.0	uS/cm		27-OCT-15	R3298636
Bicarbonate (HCO3)	110		5.0	mg/L		27-OCT-15	R3298636
Carbonate (CO3)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Hydroxide (OH)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Alkalinity, Total (as CaCO3)	89.8		5.0	mg/L		27-OCT-15	R3298636
L1691629-2 SP15-013; LAB CONTROL FM - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00053		0.00050	mg/L		31-OCT-15	R3300795
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	2.92		0.50	mg/L		22-OCT-15	R3297770
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Calcium (Ca)-Dissolved	19.9		0.10	mg/L		28-OCT-15	R3298331
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		28-OCT-15	R3298331
Magnesium (Mg)-Dissolved	16.8		0.10	mg/L		28-OCT-15	R3298331
Potassium (K)-Dissolved	3.11		0.50	mg/L		28-OCT-15	R3298331
Sodium (Na)-Dissolved	41.8		1.0	mg/L		28-OCT-15	R3298331
Fluoride in Water by IC							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1691629-2 SP15-013; LAB CONTROL FM - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		22-OCT-15	R3297770
Ion Balance Calculation							
Ion Balance	86.7	BL:INT		%		01-NOV-15	
TDS (Calculated)	281			mg/L		01-NOV-15	
Hardness (as CaCO3)	119			mg/L		01-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	0.022		0.020	mg/L		22-OCT-15	R3297770
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		27-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		22-OCT-15	R3297770
Sulfate in Water by IC							
Sulfate (SO4)	135		0.30	mg/L		22-OCT-15	R3297770
pH, Conductivity and Total Alkalinity							
pH	7.72		0.10	pH		27-OCT-15	R3298636
Conductivity (EC)	432		3.0	uS/cm		27-OCT-15	R3298636
Bicarbonate (HCO3)	124		5.0	mg/L		27-OCT-15	R3298636
Carbonate (CO3)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Hydroxide (OH)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Alkalinity, Total (as CaCO3)	102		5.0	mg/L		27-OCT-15	R3298636
L1691629-3 SP15-013; LAB CONTROL HA- WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00064		0.00050	mg/L		31-OCT-15	R3300795
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	74.0		0.50	mg/L		22-OCT-15	R3297770
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Calcium (Ca)-Dissolved	39.4		0.10	mg/L		28-OCT-15	R3298331
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		28-OCT-15	R3298331
Magnesium (Mg)-Dissolved	5.30		0.10	mg/L		28-OCT-15	R3298331
Potassium (K)-Dissolved	2.02		0.50	mg/L		28-OCT-15	R3298331
Sodium (Na)-Dissolved	23.6		1.0	mg/L		28-OCT-15	R3298331
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		22-OCT-15	R3297770
Ion Balance Calculation							
Ion Balance	93.4			%		01-NOV-15	
TDS (Calculated)	202			mg/L		01-NOV-15	
Hardness (as CaCO3)	120			mg/L		01-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	<0.020		0.020	mg/L		22-OCT-15	R3297770
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		27-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		22-OCT-15	R3297770
Sulfate in Water by IC							
Sulfate (SO4)	23.9		0.30	mg/L		22-OCT-15	R3297770
pH, Conductivity and Total Alkalinity							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1691629-3 SP15-013; LAB CONTROL HA- WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
pH, Conductivity and Total Alkalinity							
pH	7.31		0.10	pH		27-OCT-15	R3298636
Conductivity (EC)	383		3.0	uS/cm		27-OCT-15	R3298636
Bicarbonate (HCO3)	69.7		5.0	mg/L		27-OCT-15	R3298636
Carbonate (CO3)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Hydroxide (OH)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Alkalinity, Total (as CaCO3)	57.1		5.0	mg/L		27-OCT-15	R3298636
L1691629-4 SP15-013; SITE CONTROL DA,FM - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.00503		0.00050	mg/L		31-OCT-15	R3300795
Miscellaneous Parameters							
Dissolved Organic Carbon	8.9		1.0	mg/L		29-OCT-15	R3299718
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	2.94		0.50	mg/L		22-OCT-15	R3297770
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Calcium (Ca)-Dissolved	42.3		0.10	mg/L		28-OCT-15	R3298331
Copper (Cu)-Dissolved	0.0066		0.0050	mg/L		28-OCT-15	R3298331
Magnesium (Mg)-Dissolved	12.5		0.10	mg/L		28-OCT-15	R3298331
Potassium (K)-Dissolved	1.64		0.50	mg/L		28-OCT-15	R3298331
Sodium (Na)-Dissolved	10.8		1.0	mg/L		28-OCT-15	R3298331
Fluoride in Water by IC							
Fluoride (F)	0.285		0.020	mg/L		22-OCT-15	R3297770
Ion Balance Calculation							
Ion Balance	88.4	BL:INT		%		01-NOV-15	
TDS (Calculated)	202			mg/L		01-NOV-15	
Hardness (as CaCO3)	157			mg/L		01-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	0.298		0.020	mg/L		22-OCT-15	R3297770
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.298		0.050	mg/L		27-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		22-OCT-15	R3297770
Sulfate in Water by IC							
Sulfate (SO4)	24.9		0.30	mg/L		22-OCT-15	R3297770
pH, Conductivity and Total Alkalinity							
pH	7.77		0.10	pH		27-OCT-15	R3298636
Conductivity (EC)	340		3.0	uS/cm		27-OCT-15	R3298636
Bicarbonate (HCO3)	213		5.0	mg/L		27-OCT-15	R3298636
Carbonate (CO3)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Hydroxide (OH)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Alkalinity, Total (as CaCO3)	175		5.0	mg/L		27-OCT-15	R3298636
L1691629-5 SP15-013; SITE CONTROL HA - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Miscellaneous Parameters							
Dissolved Organic Carbon	9.2		1.0	mg/L		29-OCT-15	R3299718
Routine Water Analysis							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1691629-5 SP15-013; SITE CONTROL HA - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Chloride in Water by IC							
Chloride (Cl)	28.0		0.50	mg/L		22-OCT-15	R3297770
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Calcium (Ca)-Dissolved	41.2		0.10	mg/L		29-OCT-15	R3298331
Magnesium (Mg)-Dissolved	12.7		0.10	mg/L		29-OCT-15	R3298331
Potassium (K)-Dissolved	1.70		0.50	mg/L		29-OCT-15	R3298331
Sodium (Na)-Dissolved	25.6		1.0	mg/L		29-OCT-15	R3298331
Fluoride in Water by IC							
Fluoride (F)	0.290		0.020	mg/L		22-OCT-15	R3297770
Ion Balance Calculation							
Ion Balance	88.6	BL:INT		%		29-OCT-15	
TDS (Calculated)	240			mg/L		29-OCT-15	
Hardness (as CaCO3)	155			mg/L		29-OCT-15	
Nitrate in Water by IC							
Nitrate (as N)	0.312		0.020	mg/L		22-OCT-15	R3297770
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.312		0.050	mg/L		27-OCT-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		22-OCT-15	R3297770
Sulfate in Water by IC							
Sulfate (SO4)	24.9		0.30	mg/L		22-OCT-15	R3297770
pH, Conductivity and Total Alkalinity							
pH	7.76		0.10	pH		27-OCT-15	R3298636
Conductivity (EC)	413		3.0	uS/cm		27-OCT-15	R3298636
Bicarbonate (HCO3)	211		5.0	mg/L		27-OCT-15	R3298636
Carbonate (CO3)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Hydroxide (OH)	<5.0		5.0	mg/L		27-OCT-15	R3298636
Alkalinity, Total (as CaCO3)	173		5.0	mg/L		27-OCT-15	R3298636
L1691629-6 SP15-013; 5 UG/L CU - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Copper (Cu)-Dissolved	0.0096		0.0050	mg/L		28-OCT-15	R3298331
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0103		0.00050	mg/L		31-OCT-15	R3300795
L1691629-7 SP15-013; 10 UG/L CU - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Copper (Cu)-Dissolved	0.012		0.010	mg/L		28-OCT-15	R3298331
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0147		0.00050	mg/L		31-OCT-15	R3300795

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1691629-8 SP15-013; 20 UG/L CU - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Copper (Cu)-Dissolved	0.018		0.010	mg/L		28-OCT-15	R3298331
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0236		0.00050	mg/L		31-OCT-15	R3300795
L1691629-9 SP15-013; 40 UG/L CU - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Copper (Cu)-Dissolved	0.035		0.010	mg/L		28-OCT-15	R3298331
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0418		0.00050	mg/L		31-OCT-15	R3300795
L1691629-10 SP15-013; 80 UG/L CU - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Copper (Cu)-Dissolved	0.068		0.010	mg/L		28-OCT-15	R3298331
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0787		0.00050	mg/L		31-OCT-15	R3300795
L1691629-11 SP15-013; 160 UG/L CU - WEEK 3							
Sampled By: CLIENT on 20-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					28-OCT-15	R3298212
Copper (Cu)-Dissolved	0.134		0.010	mg/L		28-OCT-15	R3298331
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.159		0.00050	mg/L		31-OCT-15	R3300795

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
SPL	TOT-MET FOR -1 TO -11 (EXC. -5) - Sample was Preserved at the laboratory
SFPL	DISS-MET FOR -1 TO -11 (EXC. -5), DOC FOR-4-5 - Sample was Filtered and Preserved at the laboratory

Sample Parameter Qualifier Key:

Qualifier	Description
BL:INT	Balance Reviewed: Interference Or Non-Measured Component
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-DIS-ORG-CL	Water	Dissolved Organic Carbon	APHA 5310 B-Instrumental
CL-IC-N-CL	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
F-IC-N-CL	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
IONBALANCE-CL	Water	Ion Balance Calculation	APHA 1030E
MET-DIS-ICP-CL	Water	Dissolved Metals by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-CL	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
N2N3-CALC-CL	Water	Nitrate+Nitrite	CALCULATION
NO2-IC-N-CL	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
NO3-IC-N-CL	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
PH/EC/ALK-CL	Water	pH, Conductivity and Total Alkalinity	APHA 4500H,2510,2320

All samples analyzed by this method for pH will have exceeded the 15 minute recommended hold time from time of sampling (field analysis is recommended for pH where highly accurate results are needed)
pH measurement is determined from the activity of the hydrogen ions using a hydrogen electrode and a reference electrode.
Alkalinity measurement is based on the sample’s capacity to neutralize acid
Conductivity measurement is based on the sample’s capacity to convey an electric current

ALS Test Code	Matrix	Test Description	Method Reference**
SO4-IC-N-CL	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
CL	ALS ENVIRONMENTAL - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1691629-COFC

COC Number: 14 -

Page ____ of ____

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	HydroQual Laboratories	Select Report Format:	☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Leila Oosterbroek	Quality Control (QC) Report with Report	☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	#4, 6125 12 St SE	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Calgary, AB T2H 2K1	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	403-253-7121	Email 1 or Fax	leila@nautilusenvironmental.com	Specify Date Required for E2,E or P:
		Email 2	bryon@nautilusenvironmental.com	

Invoice To		Invoice Distribution	
Same as Report To	☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Copy of Invoice with Report	☑ Yes ☐ No	Email 1 or Fax	
Company:		Email 2	
Contact:			

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q52926	Approver ID:	Cost Center:
Job #:		GL Account:	Routing Code:
PO / AFE:	PO 2016-063	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact: Jesse Eagle	Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-DIS-ORG-CL (dissolved organic carbon)	ROU-CL (Ca, Mg, Na, S)4, Cl, alk)	MET-T-CCMS-1-CL (total copper in water) -	CL-CU-DIS-ICP (dissolved copper in water)	FILTER-CL (lab filtered and preserved)	Number of Containers
1	SP15-013; Lab Control DA - Week 3	2015/10/20		water		R	R	R	R	
2	SP15-013; Lab Control FM - Week 3			water		R	R	R	R	
3	SP15-013; Lab Control HA - Week 3			water		R	R	R	R	
4	SP15-013; Site Control DA,FM - Week 3			water	R	R	R	R	R	
5	SP15-013; Site Control HA - Week 3			water	R	R			R	
6	SP15-013; 5 ug/L Cu - Week 3			water			R	R	R	
7	SP15-013; 10 ug/L Cu - Week 3			water			R	R	R	
8	SP15-013; 20 ug/L Cu - Week 3			water			R	R	R	
9	SP15-013; 40 ug/L Cu - Week 3			water			R	R	R	
10	SP15-013; 80 ug/L Cu - Week 3			water			R	R	R	
11	SP15-013; 160 ug/L Cu - Week 3			water			R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

****Samples have not been filtered****

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☑ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 4, 5 | FINAL COOLER TEMPERATURES °C:

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: [signature]	Date: 2015/10/21	Time:	Received by: [signature]	Date: Oct 21	Time: 1:08	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Nautilus Environmental
ATTN: Leila Oosterbroek
#4, 6125 - 12 Street SE
Calgary AB T2H 2K1

Date Received: 28-OCT-15
Report Date: 07-APR-16 19:53 (MT)
Version: FINAL REV. 2

Client Phone: 403-253-7121

Certificate of Analysis

Lab Work Order #: L1695403
Project P.O. #: 2016-076
Job Reference:
C of C Numbers:
Legal Site Desc:

Comments: 7-APR-16
Revised report: diss. Cu results with lower LORs

Nelson Kwan, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1695403-1 SP15-013; LAB CONTROL FM - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.0050	DLDS	0.0050	mg/L		04-NOV-15	R3305410
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	3.18		0.50	mg/L		30-OCT-15	R3305091
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Calcium (Ca)-Dissolved	22.8		0.10	mg/L		03-NOV-15	R3304852
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		03-NOV-15	R3304852
Magnesium (Mg)-Dissolved	19.8		0.10	mg/L		03-NOV-15	R3304852
Potassium (K)-Dissolved	3.87		0.50	mg/L		03-NOV-15	R3304852
Sodium (Na)-Dissolved	47.6		1.0	mg/L		03-NOV-15	R3304852
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		30-OCT-15	R3305091
Ion Balance Calculation							
Ion Balance	91.3			%		04-NOV-15	
TDS (Calculated)	312			mg/L		04-NOV-15	
Hardness (as CaCO3)	138			mg/L		04-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	<0.020		0.020	mg/L		30-OCT-15	R3305091
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		04-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	0.014		0.010	mg/L		30-OCT-15	R3305091
Sulfate in Water by IC							
Sulfate (SO4)	146		0.30	mg/L		30-OCT-15	R3305091
pH, Conductivity and Total Alkalinity							
pH	7.55		0.10	pH		04-NOV-15	R3305347
Conductivity (EC)	457		3.0	uS/cm		04-NOV-15	R3305347
Bicarbonate (HCO3)	139		5.0	mg/L		04-NOV-15	R3305347
Carbonate (CO3)	<5.0		5.0	mg/L		04-NOV-15	R3305347
Hydroxide (OH)	<5.0		5.0	mg/L		04-NOV-15	R3305347
Alkalinity, Total (as CaCO3)	114		5.0	mg/L		04-NOV-15	R3305347
L1695403-2 SP15-013; LAB CONTROL HA - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.0050	DLDS	0.0050	mg/L		04-NOV-15	R3305410
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	77.2		0.50	mg/L		30-OCT-15	R3305091
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Calcium (Ca)-Dissolved	40.3		0.10	mg/L		03-NOV-15	R3304852
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		03-NOV-15	R3304852
Magnesium (Mg)-Dissolved	5.68		0.10	mg/L		03-NOV-15	R3304852
Potassium (K)-Dissolved	2.21		0.50	mg/L		03-NOV-15	R3304852
Sodium (Na)-Dissolved	24.3		1.0	mg/L		03-NOV-15	R3304852
Fluoride in Water by IC							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1695403-2 SP15-013; LAB CONTROL HA - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		30-OCT-15	R3305091
Ion Balance Calculation							
Ion Balance	91.8			%		04-NOV-15	
TDS (Calculated)	211			mg/L		04-NOV-15	
Hardness (as CaCO3)	124			mg/L		04-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	<0.020		0.020	mg/L		30-OCT-15	R3305091
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		04-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		30-OCT-15	R3305091
Sulfate in Water by IC							
Sulfate (SO4)	25.1		0.30	mg/L		30-OCT-15	R3305091
pH, Conductivity and Total Alkalinity							
pH	7.32		0.10	pH		04-NOV-15	R3305347
Conductivity (EC)	384		3.0	uS/cm		04-NOV-15	R3305347
Bicarbonate (HCO3)	74.1		5.0	mg/L		04-NOV-15	R3305347
Carbonate (CO3)	<5.0		5.0	mg/L		04-NOV-15	R3305347
Hydroxide (OH)	<5.0		5.0	mg/L		04-NOV-15	R3305347
Alkalinity, Total (as CaCO3)	60.7		5.0	mg/L		04-NOV-15	R3305347
L1695403-3 SP15-013; SITE CONTROL DA, FM - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0059	DLDS	0.0050	mg/L		04-NOV-15	R3305410
Miscellaneous Parameters							
Dissolved Organic Carbon	8.7		1.0	mg/L		02-NOV-15	R3305331
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	2.93		0.50	mg/L		30-OCT-15	R3305091
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Calcium (Ca)-Dissolved	44.7		0.10	mg/L		03-NOV-15	R3304852
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		03-NOV-15	R3304852
Magnesium (Mg)-Dissolved	13.7		0.10	mg/L		03-NOV-15	R3304852
Potassium (K)-Dissolved	1.99		0.50	mg/L		03-NOV-15	R3304852
Sodium (Na)-Dissolved	11.6		1.0	mg/L		03-NOV-15	R3304852
Fluoride in Water by IC							
Fluoride (F)	0.280		0.020	mg/L		30-OCT-15	R3305091
Ion Balance Calculation							
Ion Balance	92.6			%		04-NOV-15	
TDS (Calculated)	209			mg/L		04-NOV-15	
Hardness (as CaCO3)	168			mg/L		04-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	0.313		0.020	mg/L		30-OCT-15	R3305091
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.313		0.050	mg/L		04-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		30-OCT-15	R3305091
Sulfate in Water by IC							
Sulfate (SO4)	24.8		0.30	mg/L		30-OCT-15	R3305091

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1695403-3 SP15-013; SITE CONTROL DA, FM - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
pH, Conductivity and Total Alkalinity							
pH	7.78		0.10	pH		04-NOV-15	R3305347
Conductivity (EC)	328		3.0	uS/cm		04-NOV-15	R3305347
Bicarbonate (HCO3)	219		5.0	mg/L		04-NOV-15	R3305347
Carbonate (CO3)	<5.0		5.0	mg/L		04-NOV-15	R3305347
Hydroxide (OH)	<5.0		5.0	mg/L		04-NOV-15	R3305347
Alkalinity, Total (as CaCO3)	180		5.0	mg/L		04-NOV-15	R3305347
L1695403-4 SP15-013; SITE CONTROL HA - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Miscellaneous Parameters							
Dissolved Organic Carbon	8.8		1.0	mg/L		02-NOV-15	R3305331
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	17.7		0.50	mg/L		30-OCT-15	R3305091
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Calcium (Ca)-Dissolved	43.4		0.10	mg/L		03-NOV-15	R3304852
Magnesium (Mg)-Dissolved	13.4		0.10	mg/L		03-NOV-15	R3304852
Potassium (K)-Dissolved	1.88		0.50	mg/L		03-NOV-15	R3304852
Sodium (Na)-Dissolved	18.0		1.0	mg/L		03-NOV-15	R3304852
Fluoride in Water by IC							
Fluoride (F)	0.277		0.020	mg/L		30-OCT-15	R3305091
Ion Balance Calculation							
Ion Balance	77.4	BL:INT		%		04-NOV-15	
TDS (Calculated)	260			mg/L		04-NOV-15	
Hardness (as CaCO3)	164			mg/L		04-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	0.729		0.020	mg/L		30-OCT-15	R3305091
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.862		0.050	mg/L		04-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	0.133		0.010	mg/L		30-OCT-15	R3305091
Sulfate in Water by IC							
Sulfate (SO4)	54.3		0.30	mg/L		30-OCT-15	R3305091
pH, Conductivity and Total Alkalinity							
pH	7.76		0.10	pH		04-NOV-15	R3305347
Conductivity (EC)	357		3.0	uS/cm		04-NOV-15	R3305347
Bicarbonate (HCO3)	219		5.0	mg/L		04-NOV-15	R3305347
Carbonate (CO3)	<5.0		5.0	mg/L		04-NOV-15	R3305347
Hydroxide (OH)	<5.0		5.0	mg/L		04-NOV-15	R3305347
Alkalinity, Total (as CaCO3)	179		5.0	mg/L		04-NOV-15	R3305347
L1695403-5 SP15-013; 5 UG/L CU - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Copper (Cu)-Dissolved	0.0073		0.0050	mg/L		03-NOV-15	R3304852
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0088	DLDS	0.0050	mg/L		04-NOV-15	R3305410

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1695403-5 SP15-013; 5 UG/L CU - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
L1695403-6 SP15-013; 10 UG/L CU - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Copper (Cu)-Dissolved	0.012		0.010	mg/L		03-NOV-15	R3304852
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0155	DLDS	0.0050	mg/L		04-NOV-15	R3305410
L1695403-7 SP15-013; 20 UG/L CU - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Copper (Cu)-Dissolved	0.022		0.010	mg/L		03-NOV-15	R3304852
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0252	DLDS	0.0050	mg/L		04-NOV-15	R3305410
L1695403-8 SP15-013; 40 UG/L CU - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Copper (Cu)-Dissolved	0.038		0.010	mg/L		03-NOV-15	R3304852
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0403	DLDS	0.0050	mg/L		04-NOV-15	R3305410
L1695403-9 SP15-013; 80 UG/L CU - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Copper (Cu)-Dissolved	0.074		0.010	mg/L		03-NOV-15	R3304852
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0803	DLDS	0.0050	mg/L		04-NOV-15	R3305410
L1695403-10 SP15-013; 160 UG/L CU - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					03-NOV-15	R3304823
Copper (Cu)-Dissolved	0.144		0.010	mg/L		03-NOV-15	R3304852

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1695403-10 SP15-013; 160 UG/L CU - WEEK 4							
Sampled By: CLIENT on 27-OCT-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.166	DLDS	0.0050	mg/L		04-NOV-15	R3305410

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Numbe	Client ID	Qualifier	Description
L1695403-3	SP15-013; SITE CONTROL I	SFPL	DOC - Sample was Filtered and Preserved at the laboratory
L1695403-4	SP15-013; SITE CONTROL I	SFPL	DOC - Sample was Filtered and Preserved at the laboratory

Sample Parameter Qualifier Key:

Qualifier	Description
BL:INT	Balance Reviewed: Interference Or Non-Measured Component
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-DIS-ORG-CL	Water	Dissolved Organic Carbon	APHA 5310 B-Instrumental
CL-IC-N-CL	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
F-IC-N-CL	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
IONBALANCE-CL	Water	Ion Balance Calculation	APHA 1030E
MET-DIS-ICP-CL	Water	Dissolved Metals by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-CL	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
N2N3-CALC-CL	Water	Nitrate+Nitrite	CALCULATION
NO2-IC-N-CL	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
NO3-IC-N-CL	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
PH/EC/ALK-CL	Water	pH, Conductivity and Total Alkalinity	APHA 4500H,2510,2320

All samples analyzed by this method for pH will have exceeded the 15 minute recommended hold time from time of sampling (field analysis is recommended for pH where highly accurate results are needed)
pH measurement is determined from the activity of the hydrogen ions using a hydrogen electrode and a reference electrode.
Alkalinity measurement is based on the sample's capacity to neutralize acid
Conductivity measurement is based on the sample's capacity to convey an electric current

ALS Test Code	Matrix	Test Description	Method Reference**
SO4-IC-N-CL	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
CL	ALS ENVIRONMENTAL - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1695403-COFC

COC Number: 14 -

Page ___ of ___

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	HydroQual Laboratories	Select Report Format:	☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Leila Oosterbroek	Quality Control (QC) Report with Report	☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	#4, 6125 12 St SE	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Calgary, AB T2H 2K1	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	403-253-7121	Email 1 or Fax	leila@nautilusenvironmental.com	Specify Date Required for E2,E or P:
		Email 2	bryon@nautilusenvironmental.com	

Invoice To		Invoice Distribution	
Same as Report To	☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Copy of Invoice with Report	☑ Yes ☐ No	Email 1 or Fax	
Company:		Email 2	
Contact:			

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q52926	Approver ID:	Cost Center:
Job #:		GL Account:	Routing Code:
PO / AFE:	PO 2016-076	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact: Jesse Eagle	Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-DIS-ORG-CL (dissolved organic carbon)	ROU-CL (Ca, Mg, Na, S)4, Cl, alk)	MET-T-CCMS-1-CL (total copper in water) -	CL-CU-DIS-ICP (dissolved copper in water)	FILTER-CL (lab filtered and preserved)	Number of Containers
	~~SP15-013; Lab Control DA - Week 4~~	2015/10/27		~~water~~		~~R~~	~~R~~	~~R~~	~~R~~	LO
1	SP15-013; Lab Control FM - Week 4	↓		water		R	R	R	R	
2	SP15-013; Lab Control HA - Week 4			water		R	R	R	R	
3	SP15-013; Site Control DA,FM - Week 4			water	R	R	R	R	R	
4	SP15-013; Site Control HA - Week 4			water	R	R			R	
5	SP15-013; 5 ug/L Cu - Week 4			water			R	R	R	
6	SP15-013; 10 ug/L Cu - Week 4			water			R	R	R	
7	SP15-013; 20 ug/L Cu - Week 4			water			R	R	R	
8	SP15-013; 40 ug/L Cu - Week 4			water			R	R	R	
9	SP15-013; 80 ug/L Cu - Week 4			water			R	R	R	
10	SP15-013; 160 ug/L Cu - Week 4			water			R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

****Samples have not been filtered****

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐		SIF Observations	Yes ☑ No ☐
Ice packs	Yes ☐ No ☑	Custody seal intact	Yes ☐ No ☑
Cooling Initiated ☐			
INITIAL COOLER TEMPERATURES °C		FINAL COOLER TEMPERATURES °C	6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: [signature]	Date: 2015/10/28	Time:	Received by:	Date:	Time:	Received by: MM	Date: 28 Oct 15	Time: 11:10

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA-FM-0326a v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Nautilus Environmental
ATTN: Leila Oosterbroek
#4, 6125 - 12 Street SE
Calgary AB T2H 2K1

Date Received: 04-NOV-15
Report Date: 07-APR-16 19:54 (MT)
Version: FINAL REV. 2

Client Phone: 403-253-7121

Certificate of Analysis

Lab Work Order #: L1698387

Project P.O. #: PO 2016-086

Job Reference:

C of C Numbers:

Legal Site Desc:

Comments: 7-APR-16
Revised report: diss. Cu results with lower LORs

Nelson Kwan, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1698387-1 SP15-013; LAB CONTROL FM - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.0025		0.0025	mg/L		12-NOV-15	R3310094
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	2.77		0.50	mg/L		05-NOV-15	R3310405
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Calcium (Ca)-Dissolved	18.8		0.10	mg/L		12-NOV-15	R3310134
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		12-NOV-15	R3310134
Magnesium (Mg)-Dissolved	15.9		0.10	mg/L		12-NOV-15	R3310134
Potassium (K)-Dissolved	2.97		0.50	mg/L		12-NOV-15	R3310134
Sodium (Na)-Dissolved	39.0		1.0	mg/L		12-NOV-15	R3310134
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		05-NOV-15	R3310405
Ion Balance Calculation							
Ion Balance	83.5	BL:INT		%		12-NOV-15	
TDS (Calculated)	269			mg/L		12-NOV-15	
Hardness (as CaCO3)	112			mg/L		12-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	<0.020		0.020	mg/L		05-NOV-15	R3310405
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		12-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		05-NOV-15	R3310405
Sulfate in Water by IC							
Sulfate (SO4)	126		0.30	mg/L		05-NOV-15	R3310405
pH, Conductivity and Total Alkalinity							
pH	7.90		0.10	pH		09-NOV-15	R3309194
Conductivity (EC)	434		3.0	uS/cm		09-NOV-15	R3309194
Bicarbonate (HCO3)	129		5.0	mg/L		09-NOV-15	R3309194
Carbonate (CO3)	<5.0		5.0	mg/L		09-NOV-15	R3309194
Hydroxide (OH)	<5.0		5.0	mg/L		09-NOV-15	R3309194
Alkalinity, Total (as CaCO3)	106		5.0	mg/L		09-NOV-15	R3309194
L1698387-2 SP15-013; LAB CONTROL HA - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.0025		0.0025	mg/L		12-NOV-15	R3310094
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	77.4		0.50	mg/L		05-NOV-15	R3310405
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Calcium (Ca)-Dissolved	39.4		0.10	mg/L		12-NOV-15	R3310134
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		12-NOV-15	R3310134
Magnesium (Mg)-Dissolved	5.58		0.10	mg/L		12-NOV-15	R3310134
Potassium (K)-Dissolved	2.17		0.50	mg/L		12-NOV-15	R3310134
Sodium (Na)-Dissolved	24.1		1.0	mg/L		12-NOV-15	R3310134
Fluoride in Water by IC							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1698387-2 SP15-013; LAB CONTROL HA - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		05-NOV-15	R3310405
Ion Balance Calculation							
Ion Balance	88.7	BL:INT		%		12-NOV-15	
TDS (Calculated)	212			mg/L		12-NOV-15	
Hardness (as CaCO3)	121			mg/L		12-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	<0.020		0.020	mg/L		05-NOV-15	R3310405
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		12-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		05-NOV-15	R3310405
Sulfate in Water by IC							
Sulfate (SO4)	25.0		0.30	mg/L		05-NOV-15	R3310405
pH, Conductivity and Total Alkalinity							
pH	7.54		0.10	pH		09-NOV-15	R3309194
Conductivity (EC)	402		3.0	uS/cm		09-NOV-15	R3309194
Bicarbonate (HCO3)	77.9		5.0	mg/L		09-NOV-15	R3309194
Carbonate (CO3)	<5.0		5.0	mg/L		09-NOV-15	R3309194
Hydroxide (OH)	<5.0		5.0	mg/L		09-NOV-15	R3309194
Alkalinity, Total (as CaCO3)	63.8		5.0	mg/L		09-NOV-15	R3309194
L1698387-3 SP15-013; SITE CONTROL DA,FM - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0049		0.0025	mg/L		12-NOV-15	R3310094
Miscellaneous Parameters							
Dissolved Organic Carbon	8.8		1.0	mg/L		12-NOV-15	R3310859
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	2.94		0.50	mg/L		05-NOV-15	R3310405
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Calcium (Ca)-Dissolved	40.9		0.10	mg/L		12-NOV-15	R3310134
Copper (Cu)-Dissolved	0.0052		0.0050	mg/L		12-NOV-15	R3310134
Magnesium (Mg)-Dissolved	12.6		0.10	mg/L		12-NOV-15	R3310134
Potassium (K)-Dissolved	1.78		0.50	mg/L		12-NOV-15	R3310134
Sodium (Na)-Dissolved	10.3		1.0	mg/L		12-NOV-15	R3310134
Fluoride in Water by IC							
Fluoride (F)	0.310		0.020	mg/L		05-NOV-15	R3310405
Ion Balance Calculation							
Ion Balance	84.0	BL:INT		%		13-NOV-15	
TDS (Calculated)	203			mg/L		13-NOV-15	
Hardness (as CaCO3)	154			mg/L		13-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	0.285		0.020	mg/L		05-NOV-15	R3310405
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.285		0.050	mg/L		12-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		05-NOV-15	R3310405
Sulfate in Water by IC							
Sulfate (SO4)	23.8		0.30	mg/L		05-NOV-15	R3310405

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1698387-3 SP15-013; SITE CONTROL DA,FM - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
pH, Conductivity and Total Alkalinity							
pH	8.02		0.10	pH		09-NOV-15	R3309194
Conductivity (EC)	338		3.0	uS/cm		09-NOV-15	R3309194
Bicarbonate (HCO3)	222		5.0	mg/L		09-NOV-15	R3309194
Carbonate (CO3)	<5.0		5.0	mg/L		09-NOV-15	R3309194
Hydroxide (OH)	<5.0		5.0	mg/L		09-NOV-15	R3309194
Alkalinity, Total (as CaCO3)	182		5.0	mg/L		09-NOV-15	R3309194
L1698387-4 SP15-013; SITE CONTROL HA - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Miscellaneous Parameters							
Dissolved Organic Carbon	8.8		1.0	mg/L		12-NOV-15	R3310859
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	8.52		0.50	mg/L		04-NOV-15	R3308788
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Calcium (Ca)-Dissolved	41.0		0.10	mg/L		12-NOV-15	R3310134
Magnesium (Mg)-Dissolved	12.6		0.10	mg/L		12-NOV-15	R3310134
Potassium (K)-Dissolved	1.76		0.50	mg/L		12-NOV-15	R3310134
Sodium (Na)-Dissolved	14.0		1.0	mg/L		12-NOV-15	R3310134
Fluoride in Water by IC							
Fluoride (F)	0.307		0.020	mg/L		04-NOV-15	R3308788
Ion Balance Calculation							
Ion Balance	85.4	BL:INT		%		12-NOV-15	
TDS (Calculated)	211			mg/L		12-NOV-15	
Hardness (as CaCO3)	154			mg/L		12-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	0.290		0.020	mg/L		04-NOV-15	R3308788
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.290		0.050	mg/L		10-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		04-NOV-15	R3308788
Sulfate in Water by IC							
Sulfate (SO4)	23.7		0.30	mg/L		04-NOV-15	R3308788
pH, Conductivity and Total Alkalinity							
pH	7.97		0.10	pH		07-NOV-15	R3307639
Conductivity (EC)	357		3.0	uS/cm		07-NOV-15	R3307639
Bicarbonate (HCO3)	220		5.0	mg/L		07-NOV-15	R3307639
Carbonate (CO3)	<5.0		5.0	mg/L		07-NOV-15	R3307639
Hydroxide (OH)	<5.0		5.0	mg/L		07-NOV-15	R3307639
Alkalinity, Total (as CaCO3)	180		5.0	mg/L		07-NOV-15	R3307639
L1698387-5 SP15-013; 5 UG/L CU - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Copper (Cu)-Dissolved	0.0085		0.0050	mg/L		12-NOV-15	R3310134
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0111		0.0025	mg/L		12-NOV-15	R3310094

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1698387-5 SP15-013; 5 UG/L CU - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
L1698387-6 SP15-013; 10 UG/L CU - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Copper (Cu)-Dissolved	0.014		0.010	mg/L		12-NOV-15	R3310134
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0152		0.0025	mg/L		12-NOV-15	R3310094
L1698387-7 SP15-013; 20 UG/L CU - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Copper (Cu)-Dissolved	0.023		0.010	mg/L		12-NOV-15	R3310134
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0242		0.0025	mg/L		12-NOV-15	R3310094
L1698387-8 SP15-013; 40 UG/L CU - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Copper (Cu)-Dissolved	0.038		0.010	mg/L		12-NOV-15	R3310134
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0457		0.0025	mg/L		12-NOV-15	R3310094
L1698387-9 SP15-013; 80 UG/L CU - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Copper (Cu)-Dissolved	0.079		0.010	mg/L		12-NOV-15	R3310134
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0886		0.0025	mg/L		12-NOV-15	R3310094
L1698387-10 SP15-013; 160 UG/L CU - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					12-NOV-15	R3310085
Copper (Cu)-Dissolved	0.145		0.010	mg/L		12-NOV-15	R3310134

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1698387-10 SP15-013; 160 UG/L CU - WEEK 5							
Sampled By: CLIENT on 03-NOV-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.163		0.0025	mg/L		12-NOV-15	R3310094

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Numbe	Client ID	Qualifier	Description
L1698387-3	SP15-013; SITE CONTROL I	SFPL	DOC - Sample was Filtered and Preserved at the laboratory
L1698387-4	SP15-013; SITE CONTROL I	SFPL	DOC - Sample was Filtered and Preserved at the laboratory

Sample Parameter Qualifier Key:

Qualifier	Description
BL:INT	Balance Reviewed: Interference Or Non-Measured Component
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-DIS-ORG-CL	Water	Dissolved Organic Carbon	APHA 5310 B-Instrumental
CL-IC-N-CL	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
F-IC-N-CL	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
IONBALANCE-CL	Water	Ion Balance Calculation	APHA 1030E
MET-DIS-ICP-CL	Water	Dissolved Metals by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-CL	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
N2N3-CALC-CL	Water	Nitrate+Nitrite	CALCULATION
NO2-IC-N-CL	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
NO3-IC-N-CL	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
PH/EC/ALK-CL	Water	pH, Conductivity and Total Alkalinity	APHA 4500H,2510,2320

All samples analyzed by this method for pH will have exceeded the 15 minute recommended hold time from time of sampling (field analysis is recommended for pH where highly accurate results are needed)
pH measurement is determined from the activity of the hydrogen ions using a hydrogen electrode and a reference electrode.
Alkalinity measurement is based on the sample's capacity to neutralize acid
Conductivity measurement is based on the sample's capacity to convey an electric current

ALS Test Code	Matrix	Test Description	Method Reference**
SO4-IC-N-CL	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
CL	ALS ENVIRONMENTAL - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: Nautilus Environmental
#4, 6125 - 12 Street SE
Calgary AB T2H 2K1
Contact: Leila Oosterbroek

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
C-DIS-ORG-CL	**Water**							
Batch R3310859								
WG2213446-14 LCS								
Dissolved Organic Carbon			105.0		%		80-120	12-NOV-15
WG2213446-18 LCS								
Dissolved Organic Carbon			99.2		%		80-120	12-NOV-15
WG2213446-13 MB								
Dissolved Organic Carbon			<1.0		mg/L		1	12-NOV-15
WG2213446-17 MB								
Dissolved Organic Carbon			<1.0		mg/L		1	12-NOV-15
CL-IC-N-CL	**Water**							
Batch R3308788								
WG2211635-2 LCS								
Chloride (Cl)			98.7		%		90-110	04-NOV-15
WG2211635-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	04-NOV-15
Batch R3310405								
WG2213179-7 DUP		**L1698387-1**						
Chloride (Cl)		2.77	2.77		mg/L	0.2	20	05-NOV-15
WG2213179-2 LCS								
Chloride (Cl)			98.7		%		90-110	05-NOV-15
WG2213179-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	05-NOV-15
WG2213179-8 MS		**L1698387-1**						
Chloride (Cl)			101.8		%		75-125	05-NOV-15
F-IC-N-CL	**Water**							
Batch R3308788								
WG2211635-2 LCS								
Fluoride (F)			98.2		%		90-110	04-NOV-15
WG2211635-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	04-NOV-15
Batch R3310405								
WG2213179-7 DUP		**L1698387-1**						
Fluoride (F)		<0.020	<0.020	RPD-NA	mg/L	N/A	20	05-NOV-15
WG2213179-2 LCS								
Fluoride (F)			98.2		%		90-110	05-NOV-15
WG2213179-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	05-NOV-15
WG2213179-8 MS		**L1698387-1**						
Fluoride (F)			103.2		%		75-125	05-NOV-15

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-DIS-ICP-CL	**Water**							
Batch R3310134								
WG2212897-10 CRM		**TMRM**						
Calcium (Ca)-Dissolved			102.8		%		80-120	12-NOV-15
Copper (Cu)-Dissolved			95.8		%		80-120	12-NOV-15
Magnesium (Mg)-Dissolved			100.0		%		80-120	12-NOV-15
Potassium (K)-Dissolved			99.1		%		80-120	12-NOV-15
Sodium (Na)-Dissolved			102.1		%		80-120	12-NOV-15
WG2212897-2 CRM		**TMRM**						
Calcium (Ca)-Dissolved			101.0		%		80-120	12-NOV-15
Copper (Cu)-Dissolved			97.6		%		80-120	12-NOV-15
Magnesium (Mg)-Dissolved			95.1		%		80-120	12-NOV-15
Potassium (K)-Dissolved			97.8		%		80-120	12-NOV-15
Sodium (Na)-Dissolved			104.0		%		80-120	12-NOV-15
WG2212897-5 CRM		**TMRM**						
Calcium (Ca)-Dissolved			99.7		%		80-120	12-NOV-15
Copper (Cu)-Dissolved			96.5		%		80-120	12-NOV-15
Magnesium (Mg)-Dissolved			98.4		%		80-120	12-NOV-15
Potassium (K)-Dissolved			98.7		%		80-120	12-NOV-15
Sodium (Na)-Dissolved			98.0		%		80-120	12-NOV-15
WG2212897-6 DUP		**L1698387-10**						
Copper (Cu)-Dissolved		0.145	0.147		mg/L	1.0	20	12-NOV-15
WG2212897-1 MB								
Calcium (Ca)-Dissolved			<0.10		mg/L		0.1	12-NOV-15
Copper (Cu)-Dissolved			<0.010		mg/L		0.01	12-NOV-15
Magnesium (Mg)-Dissolved			<0.10		mg/L		0.1	12-NOV-15
Potassium (K)-Dissolved			<0.50		mg/L		0.5	12-NOV-15
Sodium (Na)-Dissolved			<1.0		mg/L		1	12-NOV-15
WG2212897-4 MB								
Calcium (Ca)-Dissolved			<0.10		mg/L		0.1	12-NOV-15
Copper (Cu)-Dissolved			<0.010		mg/L		0.01	12-NOV-15
Magnesium (Mg)-Dissolved			<0.10		mg/L		0.1	12-NOV-15
Potassium (K)-Dissolved			<0.50		mg/L		0.5	12-NOV-15
Sodium (Na)-Dissolved			<1.0		mg/L		1	12-NOV-15
WG2212897-9 MB								
Calcium (Ca)-Dissolved			<0.10		mg/L		0.1	12-NOV-15
Copper (Cu)-Dissolved			<0.010		mg/L		0.01	12-NOV-15
Magnesium (Mg)-Dissolved			<0.10		mg/L		0.1	12-NOV-15

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-DIS-ICP-CL	**Water**							
Batch R3310134								
WG2212897-9 MB								
Potassium (K)-Dissolved			<0.50		mg/L		0.5	12-NOV-15
Sodium (Na)-Dissolved			<1.0		mg/L		1	12-NOV-15
MET-T-CCMS-CL	**Water**							
Batch R3308279								
WG2211228-2 CRM		**TMRM**						
Copper (Cu)-Total			98.1		%		80-120	09-NOV-15
WG2211228-1 MB								
Copper (Cu)-Total			<0.00050		mg/L		0.0005	09-NOV-15
Batch R3309276								
WG2211228-5 CRM		**TMRM**						
Copper (Cu)-Total			97.1		%		80-120	10-NOV-15
WG2211228-4 MB								
Copper (Cu)-Total			<0.00050		mg/L		0.0005	10-NOV-15
Batch R3309972								
WG2211228-8 CRM		**TMRM**						
Copper (Cu)-Total			94.0		%		80-120	11-NOV-15
WG2211228-7 MB								
Copper (Cu)-Total			<0.00050		mg/L		0.0005	11-NOV-15
NO2-IC-N-CL	**Water**							
Batch R3308788								
WG2211635-2 LCS								
Nitrite (as N)			103.8		%		90-110	04-NOV-15
WG2211635-1 MB								
Nitrite (as N)			<0.010		mg/L		0.01	04-NOV-15
Batch R3310405								
WG2213179-7 DUP		**L1698387-1**						
Nitrite (as N)		<0.010	<0.010	RPD-NA	mg/L	N/A	20	05-NOV-15
WG2213179-2 LCS								
Nitrite (as N)			103.8		%		90-110	05-NOV-15
WG2213179-1 MB								
Nitrite (as N)			<0.010		mg/L		0.01	05-NOV-15
WG2213179-8 MS		**L1698387-1**						
Nitrite (as N)			105.6		%		75-125	05-NOV-15
NO3-IC-N-CL	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-N-CL	**Water**							
Batch R3308788								
WG2211635-2 LCS								
Nitrate (as N)			98.5		%		90-110	04-NOV-15
WG2211635-1 MB								
Nitrate (as N)			<0.020		mg/L		0.02	04-NOV-15
Batch R3310405								
WG2213179-7 DUP		**L1698387-1**						
Nitrate (as N)		<0.020	<0.020	RPD-NA	mg/L	N/A	20	05-NOV-15
WG2213179-2 LCS								
Nitrate (as N)			98.5		%		90-110	05-NOV-15
WG2213179-1 MB								
Nitrate (as N)			<0.020		mg/L		0.02	05-NOV-15
WG2213179-8 MS		**L1698387-1**						
Nitrate (as N)			100.0		%		75-125	05-NOV-15
PH/EC/ALK-CL	**Water**							
Batch R3307639								
WG2210373-3 LCS								
pH			7.00		pH		6.9-7.1	07-NOV-15
Conductivity (EC)			95.8		%		90-110	07-NOV-15
Batch R3309194								
WG2211880-3 DUP		**L1698387-1**						
pH		7.90	7.81	J	pH	0.09	0.2	09-NOV-15
Conductivity (EC)		434	437		uS/cm	0.7	10	09-NOV-15
Bicarbonate (HCO3)		129	127		mg/L	2.0	20	09-NOV-15
Carbonate (CO3)		<5.0	<5.0	RPD-NA	mg/L	N/A	20	09-NOV-15
Hydroxide (OH)		<5.0	<5.0	RPD-NA	mg/L	N/A	20	09-NOV-15
Alkalinity, Total (as CaCO3)		106	104		mg/L	2.0	20	09-NOV-15
WG2211880-2 LCS								
pH			7.00		pH		6.9-7.1	09-NOV-15
Conductivity (EC)			99.8		%		90-110	09-NOV-15
Alkalinity, Total (as CaCO3)			100.7		%		85-115	09-NOV-15
WG2211880-1 MB								
Conductivity (EC)			<3.0		uS/cm		3	09-NOV-15
Alkalinity, Total (as CaCO3)			<5.0		mg/L		5	09-NOV-15
SO4-IC-N-CL	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-IC-N-CL	**Water**							
Batch R3308788								
WG2211635-2 LCS								
Sulfate (SO4)			98.8		%		90-110	04-NOV-15
WG2211635-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	04-NOV-15
Batch R3310405								
WG2213179-7 DUP		**L1698387-1**						
Sulfate (SO4)		126	125		mg/L	0.1	20	05-NOV-15
WG2213179-2 LCS								
Sulfate (SO4)			98.9		%		90-110	05-NOV-15
WG2213179-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	05-NOV-15
WG2213179-8 MS		**L1698387-1**						
Sulfate (SO4)			N/A	MS-B	%		-	05-NOV-15

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1698387-COFC

COC Number: 14 -

Page ___ of ___

Report To	
Company:	HydroQual Laboratories
Contact:	Leila Oosterbroek
Address:	#4, 6125 12 St SE Calgary, AB T2H 2K1
Phone:	403-253-7121

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ Yes ☐ No

☐ Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: leila@nautilusenvironmental.com

Email 2: bryon@nautilusenvironmental.com

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To

Same as Report To ☑ Yes ☐ No

Copy of Invoice with Report ☑ Yes ☐ No

Company:

Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax:

Email 2:

Project Information

ALS Quote #: Q52926

Job #:

PO / AFE: PO 7016-086

LSD:

Oil and Gas Required Fields (client use)

Approver ID: | Cost Center:

GL Account: | Routing Code:

Activity Code:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact: Jesse Eagle | Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-DIS-ORG-CL (dissolved organic carbon)	ROU-CL (Ca, Mg, Na, S)4, Cl, alk)	MET-T-CCMS-1-CL (total copper in water) - (F	CL-CU-DIS-ICP (dissolved copper in water)	FILTER-CL (lab filtered and preserved)	Number of Containers
		20/11/15								
1	SP15-013; Lab Control FM - Week 5			water		R	R	R	R	
2	SP15-013; Lab Control HA - Week 5			water		R	R	R	R	
3	SP15-013; Site Control DA,FM - Week 5			water	R	R	R	R	R	
4	SP15-013; Site Control HA - Week 5			water	R	R			R	
5	SP15-013; 5 ug/L Cu - Week 5			water			R	R	R	
6	SP15-013; 10 ug/L Cu - Week 5			water			R	R	R	
7	SP15-013; 20 ug/L Cu - Week 5			water			R	R	R	
8	SP15-013; 40 ug/L Cu - Week 5			water			R	R	R	
9	SP15-013; 80 ug/L Cu - Week 5			water			R	R	R	
10	SP15-013; 160 ug/L Cu - Week 5			water			R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

****Samples have not been filtered****

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ | SIF Observations Yes ☐ No ☒

Ice packs Yes ☐ No ☒ | Custody seal intact Yes ☐ No ☒

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C | FINAL COOLER TEMPERATURES °C: 5°C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: [signature]	Date: 20/11/15	Time:	Received by:	Date:	Time:	Received by: AC	Date: 24 Nov 15	Time: 2:30pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA-FM-0326e v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Nautilus Environmental
ATTN: Leila Oosterbroek
#4, 6125 - 12 Street SE
Calgary AB T2H 2K1

Date Received: 10-NOV-15
Report Date: 07-APR-16 19:54 (MT)
Version: FINAL REV. 2

Client Phone: 403-253-7121

Certificate of Analysis

Lab Work Order #: L1700844
Project P.O. #: PO 2016-093
Job Reference:
C of C Numbers:
Legal Site Desc:

Comments: 7-APR-16
Revised report: diss. Cu results with lower LORs

Nelson Kwan, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1700844-1 SP15-013; LAB CONTROL HA - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	<0.0025	DLDS	0.0025	mg/L		16-NOV-15	R3311079
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	74.3		0.50	mg/L		10-NOV-15	R3313283
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					13-NOV-15	R3310733
Calcium (Ca)-Dissolved	40.1		0.10	mg/L		13-NOV-15	R3310746
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		13-NOV-15	R3310746
Magnesium (Mg)-Dissolved	5.49		0.10	mg/L		13-NOV-15	R3310746
Potassium (K)-Dissolved	2.12		0.50	mg/L		13-NOV-15	R3310746
Sodium (Na)-Dissolved	24.1		1.0	mg/L		13-NOV-15	R3310746
Fluoride in Water by IC							
Fluoride (F)	<0.020		0.020	mg/L		10-NOV-15	R3313283
Ion Balance Calculation							
Ion Balance	92.6			%		18-NOV-15	
TDS (Calculated)	207			mg/L		18-NOV-15	
Hardness (as CaCO3)	123			mg/L		18-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	<0.020		0.020	mg/L		10-NOV-15	R3313283
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	<0.050		0.050	mg/L		18-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		10-NOV-15	R3313283
Sulfate in Water by IC							
Sulfate (SO4)	23.8		0.30	mg/L		10-NOV-15	R3313283
pH, Conductivity and Total Alkalinity							
pH	7.67		0.10	pH		17-NOV-15	R3313664
Conductivity (EC)	425		3.0	uS/cm		17-NOV-15	R3313664
Bicarbonate (HCO3)	76.1		5.0	mg/L		17-NOV-15	R3313664
Carbonate (CO3)	<5.0		5.0	mg/L		17-NOV-15	R3313664
Hydroxide (OH)	<5.0		5.0	mg/L		17-NOV-15	R3313664
Alkalinity, Total (as CaCO3)	62.4		5.0	mg/L		17-NOV-15	R3313664
L1700844-2 SP15-013; SITE CONTROL HA - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0049	DLDS	0.0025	mg/L		16-NOV-15	R3311079
Miscellaneous Parameters							
Dissolved Organic Carbon	8.7		1.0	mg/L		14-NOV-15	R3311543
Routine Water Analysis							
Chloride in Water by IC							
Chloride (Cl)	28.2		0.50	mg/L		10-NOV-15	R3313283
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					13-NOV-15	R3310733
Calcium (Ca)-Dissolved	43.9		0.10	mg/L		13-NOV-15	R3310746
Copper (Cu)-Dissolved	<0.0050		0.0050	mg/L		13-NOV-15	R3310746
Magnesium (Mg)-Dissolved	13.1		0.10	mg/L		13-NOV-15	R3310746
Potassium (K)-Dissolved	1.74		0.50	mg/L		13-NOV-15	R3310746
Sodium (Na)-Dissolved	27.7		1.0	mg/L		13-NOV-15	R3310746

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1700844-2 SP15-013; SITE CONTROL HA - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Fluoride in Water by IC							
Fluoride (F)	0.319		0.020	mg/L		10-NOV-15	R3313283
Ion Balance Calculation							
Ion Balance	89.8	BL:INT		%		18-NOV-15	
TDS (Calculated)	251			mg/L		18-NOV-15	
Hardness (as CaCO3)	164			mg/L		18-NOV-15	
Nitrate in Water by IC							
Nitrate (as N)	0.288		0.020	mg/L		10-NOV-15	R3313283
Nitrate+Nitrite							
Nitrate and Nitrite (as N)	0.288		0.050	mg/L		18-NOV-15	
Nitrite in Water by IC							
Nitrite (as N)	<0.010		0.010	mg/L		10-NOV-15	R3313283
Sulfate in Water by IC							
Sulfate (SO4)	23.9		0.30	mg/L		10-NOV-15	R3313283
pH, Conductivity and Total Alkalinity							
pH	7.94		0.10	pH		17-NOV-15	R3313664
Conductivity (EC)	444		3.0	uS/cm		17-NOV-15	R3313664
Bicarbonate (HCO3)	226		5.0	mg/L		17-NOV-15	R3313664
Carbonate (CO3)	<5.0		5.0	mg/L		17-NOV-15	R3313664
Hydroxide (OH)	<5.0		5.0	mg/L		17-NOV-15	R3313664
Alkalinity, Total (as CaCO3)	185		5.0	mg/L		17-NOV-15	R3313664
L1700844-3 SP15-013; 5 UG/L CU - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					13-NOV-15	R3310733
Copper (Cu)-Dissolved	0.0071		0.0050	mg/L		13-NOV-15	R3310746
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0099	DLDS	0.0025	mg/L		16-NOV-15	R3311079
L1700844-4 SP15-013; 10 UG/L CU - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					13-NOV-15	R3310733
Copper (Cu)-Dissolved	0.012		0.010	mg/L		13-NOV-15	R3310746
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0155	DLDS	0.0025	mg/L		13-NOV-15	R3311079
L1700844-5 SP15-013; 20 UG/L CU - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					13-NOV-15	R3310733
Copper (Cu)-Dissolved	0.023		0.010	mg/L		13-NOV-15	R3310746
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1700844-5 SP15-013; 20 UG/L CU - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0242	DLDS	0.0025	mg/L		13-NOV-15	R3311079
L1700844-6 SP15-013; 40 UG/L CU - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					13-NOV-15	R3310733
Copper (Cu)-Dissolved	0.039		0.010	mg/L		13-NOV-15	R3310746
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0472	DLDS	0.0025	mg/L		13-NOV-15	R3311079
L1700844-7 SP15-013; 80 UG/L CU - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					13-NOV-15	R3310733
Copper (Cu)-Dissolved	0.076		0.010	mg/L		13-NOV-15	R3310746
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.0862	DLDS	0.0025	mg/L		13-NOV-15	R3311079
L1700844-8 SP15-013; 160 UG/L CU - WEEK 6							
Sampled By: LO on 10-NOV-15							
Matrix: WATER							
Individual Dissolved Metal							
Dissolved Metals by ICPOES							
Dissolved Metals Filtration Location	LAB					13-NOV-15	R3310733
Copper (Cu)-Dissolved	0.141		0.010	mg/L		13-NOV-15	R3310746
Individual Total Metal by CCMS							
Total Metals in Water by CRC ICPMS							
Copper (Cu)-Total	0.158	DLDS	0.0025	mg/L		13-NOV-15	R3311079

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Numbe	Client ID	Qualifier	Description
L1700844-2	SP15-013; SITE CONTROL I	SFPL	DOC - Sample was Filtered and Preserved at the laboratory

Sample Parameter Qualifier Key:

Qualifier	Description
BL:INT	Balance Reviewed: Interference Or Non-Measured Component
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-DIS-ORG-CL	Water	Dissolved Organic Carbon	APHA 5310 B-Instrumental
CL-IC-N-CL	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
F-IC-N-CL	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
IONBALANCE-CL	Water	Ion Balance Calculation	APHA 1030E
MET-DIS-ICP-CL	Water	Dissolved Metals by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-CL	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
N2N3-CALC-CL	Water	Nitrate+Nitrite	CALCULATION
NO2-IC-N-CL	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
NO3-IC-N-CL	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

ALS Test Code	Matrix	Test Description	Method Reference**
PH/EC/ALK-CL	Water	pH, Conductivity and Total Alkalinity	APHA 4500H,2510,2320

All samples analyzed by this method for pH will have exceeded the 15 minute recommended hold time from time of sampling (field analysis is recommended for pH where highly accurate results are needed)
pH measurement is determined from the activity of the hydrogen ions using a hydrogen electrode and a reference electrode.
Alkalinity measurement is based on the sample's capacity to neutralize acid
Conductivity measurement is based on the sample's capacity to convey an electric current

ALS Test Code	Matrix	Test Description	Method Reference**
SO4-IC-N-CL	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
CL	ALS ENVIRONMENTAL - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: Nautilus Environmental
#4, 6125 - 12 Street SE
Calgary AB T2H 2K1

Contact: Leila Oosterbroek

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
C-DIS-ORG-CL	**Water**							
Batch R3311543								
WG2214467-15 DUP		**L1700844-2**						
Dissolved Organic Carbon		8.7	9.5		mg/L	8.6	20	14-NOV-15
WG2214467-12 LCS								
Dissolved Organic Carbon			105.0		%		80-120	14-NOV-15
WG2214467-11 MB								
Dissolved Organic Carbon			<1.0		mg/L		1	14-NOV-15
CL-IC-N-CL	**Water**							
Batch R3313283								
WG2216481-2 LCS								
Chloride (Cl)			101.9		%		90-110	10-NOV-15
WG2216481-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	10-NOV-15
F-IC-N-CL	**Water**							
Batch R3313283								
WG2216481-2 LCS								
Fluoride (F)			97.4		%		90-110	10-NOV-15
WG2216481-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	10-NOV-15
MET-DIS-ICP-CL	**Water**							
Batch R3310746								
WG2213635-2 CRM		**TMRM**						
Calcium (Ca)-Dissolved			96.7		%		80-120	13-NOV-15
Copper (Cu)-Dissolved			88.2		%		80-120	13-NOV-15
Magnesium (Mg)-Dissolved			92.5		%		80-120	13-NOV-15
Potassium (K)-Dissolved			92.3		%		80-120	13-NOV-15
Sodium (Na)-Dissolved			101.0		%		80-120	13-NOV-15
WG2213635-7 CRM		**TMRM**						
Calcium (Ca)-Dissolved			100.3		%		80-120	13-NOV-15
Copper (Cu)-Dissolved			92.7		%		80-120	13-NOV-15
Magnesium (Mg)-Dissolved			95.4		%		80-120	13-NOV-15
Potassium (K)-Dissolved			96.9		%		80-120	13-NOV-15
Sodium (Na)-Dissolved			105.7		%		80-120	13-NOV-15
WG2213635-8 DUP		**L1700844-1**						
Calcium (Ca)-Dissolved		40.1	40.4		mg/L	0.8	20	13-NOV-15
Copper (Cu)-Dissolved		<0.0050	<0.010	RPD-NA	mg/L	N/A	20	13-NOV-15
Magnesium (Mg)-Dissolved		5.49	5.55		mg/L	1.1	20	13-NOV-15
Potassium (K)-Dissolved		2.12	2.15		mg/L	1.5	20	13-NOV-15

ALS Environmental

Quality Control Report

Workorder: L1700844 Report Date: 07-APR-16

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-DIS-ICP-CL	**Water**							
Batch R3310746								
WG2213635-8 DUP		**L1700844-1**						
Sodium (Na)-Dissolved		24.1	24.5		mg/L	1.6	20	13-NOV-15
WG2213635-1 MB								
Calcium (Ca)-Dissolved			<0.10		mg/L		0.1	13-NOV-15
Copper (Cu)-Dissolved			<0.010		mg/L		0.01	13-NOV-15
Magnesium (Mg)-Dissolved			<0.10		mg/L		0.1	13-NOV-15
Potassium (K)-Dissolved			<0.50		mg/L		0.5	13-NOV-15
Sodium (Na)-Dissolved			<1.0		mg/L		1	13-NOV-15
WG2213635-6 MB								
Calcium (Ca)-Dissolved			<0.10		mg/L		0.1	13-NOV-15
Copper (Cu)-Dissolved			<0.010		mg/L		0.01	13-NOV-15
Magnesium (Mg)-Dissolved			<0.10		mg/L		0.1	13-NOV-15
Potassium (K)-Dissolved			<0.50		mg/L		0.5	13-NOV-15
Sodium (Na)-Dissolved			<1.0		mg/L		1	13-NOV-15
MET-T-CCMS-CL	**Water**							
Batch R3311079								
WG2213395-10 CRM		**TMRM**						
Copper (Cu)-Total			98.9		%		80-120	15-NOV-15
WG2213395-2 CRM		**TMRM**						
Copper (Cu)-Total			96.6		%		80-120	13-NOV-15
WG2213395-6 CRM		**TMRM**						
Copper (Cu)-Total			96.6		%		80-120	15-NOV-15
WG2213395-1 MB								
Copper (Cu)-Total			<0.00050		mg/L		0.0005	13-NOV-15
WG2213395-5 MB								
Copper (Cu)-Total			<0.00050		mg/L		0.0005	15-NOV-15
WG2213395-9 MB								
Copper (Cu)-Total			<0.00050		mg/L		0.0005	16-NOV-15
NO2-IC-N-CL	**Water**							
Batch R3313283								
WG2216481-2 LCS								
Nitrite (as N)			105.1		%		90-110	10-NOV-15
WG2216481-1 MB								
Nitrite (as N)			<0.010		mg/L		0.01	10-NOV-15
NO3-IC-N-CL	**Water**							

Quality Control Report

Test		Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-IC-N-CL		**Water**							
Batch	**R3313283**								
WG2216481-2	**LCS**								
Nitrate (as N)				101.4		%		90-110	10-NOV-15
WG2216481-1	**MB**								
Nitrate (as N)				<0.020		mg/L		0.02	10-NOV-15
PH/EC/ALK-CL		**Water**							
Batch	**R3313664**								
WG2216373-2	**LCS**								
pH				6.99		pH		6.9-7.1	17-NOV-15
Conductivity (EC)				90.6		%		90-110	17-NOV-15
Alkalinity, Total (as CaCO3)				106.7		%		85-115	17-NOV-15
WG2216373-1	**MB**								
Conductivity (EC)				<3.0		uS/cm		3	17-NOV-15
Alkalinity, Total (as CaCO3)				<5.0		mg/L		5	17-NOV-15
SO4-IC-N-CL		**Water**							
Batch	**R3313283**								
WG2216481-2	**LCS**								
Sulfate (SO4)				101.7		%		90-110	10-NOV-15
WG2216481-1	**MB**								
Sulfate (SO4)				<0.30		mg/L		0.3	10-NOV-15

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1700844-COFC

COC Number: 14 -

Page ___ of ___

Report To	
Company:	HydroQual Laboratories
Contact:	Leila Oosterbroek
Address:	#4, 6125 12 St SE Calgary, AB T2H 2K1
Phone:	403-253-7121

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ Yes ☐ No

☐ Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax leila@nautilusenvironmental.com

Email 2 bryon@nautilusenvironmental.com

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To

Same as Report To ☑ Yes ☐ No

Copy of Invoice with Report ☑ Yes ☐ No

Company:

Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax

Email 2

Project Information

ALS Quote #: Q52926

Job #:

PO / AFE: PO 2016-0936

LSD: 8

Oil and Gas Required Fields (client use)

Approver ID: | Cost Center:

GL Account: | Routing Code:

Activity Code:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact: Jesse Eagle

Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-DIS-ORG-CL (dissolved organic carbon)	ROU-CL (Ca, Mg, Na, SO4, Cl, alk)	MET-T-CCMS-1-CL (total copper in water) - (F	CL-CU-DIS-ICP (dissolved copper in water)	FILTER-CL (lab filtered and preserved)	Number of Containers
1	SP15-013; Lab Control HA - Week 6	2015/11/10		water		R	R	R	R	
2	SP15-013; Site Control HA - Week 6			water	R	R	R	R	R	
3	SP15-013; 5 ug/L Cu - Week 6			water			R	R	R	
4	SP15-013; 10 ug/L Cu - Week 6			water			R	R	R	
5	SP15-013; 20 ug/L Cu - Week 6			water			R	R	R	
6	SP15-013; 40 ug/L Cu - Week 6			water			R	R	R	
7	SP15-013; 80 ug/L Cu - Week 6			water			R	R	R	
8	SP15-013; 160 ug/L Cu - Week 6			water			R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

****Samples have not been filtered****

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ | SIF Observations Yes ☐ No ☑

Ice packs Yes ☑ No ☐ | Custody seal intact Yes ☑ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C | FINAL COOLER TEMPERATURES °C 10

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: [signature]	Date: 2015/11/10	Time: 1300	Received by:	Date:	Time:	Received by: [signature]	Date: 10-Nov-15	Time: 15:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA-FM-0326d v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

APPENDIX F – Chain of Custody

HydroQual Laboratories Ltd.

WO# 15789
48H Rotifer

#5, 6125 12th Street SE Calgary, Alberta Canada T2H 2K1
Tel (403) 253-7121 Fax (403) 252-9363 www.hydroqual.ca

Water Quality Chain of Custody

Reporting and Billing Information　　Client: ☐　　Reference #: ☐

Client / Operation: Minnow/Minto Samples.	
Contact: Bonnie LO	
Report Address:	
Billing Address: (If different from above)	
Tel:	Fax:
Quote/PO/Job:	E-mail:

Temp. °C

Temp. °C	Sample ID	Sampled By / Date / Time	Location	Method	Volume (L)	Turbidity (NTU)
4.9	W2	—			3x1L	
4.9	W16	—			1x1L	

Rush (Turnaround Time) Requirements:*

***Rush Charges may apply. Rates will be discussed in advance. If a specific deadline for testing or reporting is needed, please specify the requirement here and contact the lab.**

Tests Requested (Codes on Back)

Check Appropriate Box Below

Relinquished By	Date / Time	Received By (HQ)
[signature]	2015/10/05 1147	

Sample Receipt Information:

Date ______ Seals Y N
Time ______ Initials Y N
Condition ______
Temperature ____ For CGE temp must be ≤20°C
Container ____ x ____
Courier ______

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received.

No liability in whole or in part is assumed for the collection, handling or transport of the sample, application or interpretation of the test data or results in part or in whole.

By using this form, the user acknowledges and agrees with the Terms and Conditions available on HydroQual's webstie (http://hydroqual.ca)

Received by Nautilus - NY - Nai Yamamoto.
Oct 06/15 @ 09:00

Nautilus Environmental

4340 Vandever Ave.
San Diego, CA 92120
Phone 858.587.7333
Fax 858.587.3961

Chain of Custody

COC# 2015-09-28 E

9/28/2015 ______ Page__ of __

Sample Collection By: Chris Harry

Report to:

Company	Minto Mine
Address	#13 Calcite centre, 151 Industrial road
City/State/Zip	Whitehorse, Yukon Y1A2V3
Contact	Shelby Charlie/Jasmin Dobson
Phone	604-759-4659
Email	jasmind@mintomine.com/shelbyc@mintomine.com

Invoice To:

Company	Minnow Environmental Inc.
Address	101-1025 Hillside ave.
City/State/Zip	Victoria, BC V8T2A2
Contact	Pierre Stecko
Phone	
Email	pstecko@minnow.ca

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NO. OF CONTAINERS	COMMENTS	21-d Daphnia magna	42-d Hyalella azteca	48-h Brachionus calyciflorus	32-d Pimephales promelas							Receipt Temperature (°C)
15-1344	W2	9/28/2015	14:00	Water	200L Barrel	7	Please contact Pierre for specific analysis required	X	X	X	X							
15-1345	W16	9/28/2015	11:00	Water	200L Barrel	3	Please contact Pierre for specific analysis required	X	X	X	X							
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

PROJECT INFORMATION

Client:	Minnow Environmental
PO No.:	
Shipped Via:	Manitoulin

SAMPLE RECEIPT

Total No. of Containers	
Received Good Condition?	
Matches Test Schedule?	

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY (CLIENT)

(Signature) (Time)
(Printed Name) (Date)
(Company)

RELINQUISHED BY (COURIER)

(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (COURIER)

(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (LABORATORY)

(Signature) (Time)
(Printed Name) (Date)
(Company)

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

Appendix O – Minto Creek Fish Monitoring Program Review and Recommendations

3 Calcite Business Centre, 151 Industrial Road
Whitehorse, Yukon Y1A 2V3
Phone (867) 668-6463 Fax (867) 633-4882
www.accessconsulting.ca

Memorandum

To: Ryan Hebert, Environment Manager, Capstone Mining Corp. Minto Mine

From: David Petkovich, BSc., P. Biol.

CC:

Date: March 30, 2017

Re: Minto Creek Fish Monitoring Program Review and Recommendation

---

INTRODUCTION

Minto Explorations Ltd. (MEL) is required, under the terms of its water use license #QZ14-031 (Amendment 1), to conduct an aquatic environmental monitoring program (AEMP) which includes an annual fisheries monitoring program in Minto Creek. As per water use licence QZ14-031 the AEMP is reviewed every 3 years and changes or modifications to the program are considered or recommended. Based on a current review of the program it is recommended that monitoring of fish in Minto Creek be reduced from an annual program to once every three years, coinciding with the Environmental Effects Monitoring (EEM) program that MEL is required to undertake as prescribed under the Metal Mining Effluent Regulations (MMER) of the Federal Fisheries Act.

The following outlines rationale for the above recommendation that was provided by David Petkovich (P. Biol., BSc.). Mr. Petkovich is an Associate Fisheries and Aquatic Specialist with Alexco Environmental Group of Whitehorse, Yukon and has been involved in most of the fish studies (including EEM programs) and monitoring conducted at the Minto Mine site over the last decade.

REVIEW AND RECOMMENDATION RATIONALE

The fisheries monitoring program has been undertaken annually since 2008 or for nine consecutive years (not including baseline monitoring that occurred prior to mine development). In three year cycles the monitoring program is supported by additional monitoring conducted under the Environmental Effects Monitoring (EEM) program, a program that operating metal mines in Canada are required to undertake as per the Metal Mining Effluent Regulations (MMER) of the Federal Fisheries Act. Additional studies have been undertaken over the last nine years including a mark/recapture study on juvenile chinook salmon and a copper effects study on Yukon River origin juvenile chinook salmon olfaction. The fish monitoring studies have provided a valuable understanding of fish use of Minto Creek which is characterized by the following.

- Minto Creek provides no overwintering habitat as it freezes solid during winter months. Therefore there is no year-round resident population of fish in the creek.
- Minto creek provides no spawning habitat for fish in the creek or at its confluence with the Yukon River
- The majority of fish using the system are juvenile chinook salmon (Onchoryhnchus tshawytscha), as determined by the above investigations. Other species that have been found in the creek in low numbers include round whitefish (Prosopium cylindraceum), Arctic grayling (Thymallus arcticus), Slimy sculpin (Cottus cognatus) and Burbot (Lota lota). Of these, only slimy sculpin have been captured on a regular basis.
- Juvenile chinook salmon (JCS) have not been captured in the creek prior to the month of July in any given year.
- JCS are typically captured in relatively low numbers in the system however during years when the mine was discharging relatively high volumes of water (2009 and 2010) catch per unit effort (CPUE) was substantially higher (10 times or more)
- Due to a natural barrier fish use is limited to the lower 1.2 km of the creek
- Minto creek is a “losing stream” system and at times during summer dry periods, surface flows in lower Minto creek can be very low to zero while there is still flow in upper sections of the creek. This occurred recently in 2016.
- EEM program fish laboratory (exposure) studies conducted in 2011 and 2016 indicate that effluent in lower Minto creek, or the upper concentrations the mine is allowed to discharge at, according to the discharge standards in the current water use licence, do not impair fish growth or health and in fact provides some moderate growth enhancement relative to control group.

Based on the high level of monitoring conducted to date and the number of studies undertaken in addition to the annual monitoring program the knowledge of fish use of the system is well understood. Additional annual fish monitoring of the system is not likely to provide substantial new information while the monitoring itself does present some risk for the low numbers of chinook salmon using the system (e.g. during a past monitoring event traps containing captured fish were removed from the creek by a bear resulting in a number of fish mortalities and destruction of those traps). Therefore it is recommended that the Minto Creek fish monitoring program be reduced in frequency from an annual event to once every three years coinciding with the EEM program under the MMER. An EEM program was conducted in 2016 and therefore the next program will occur in 2019.

This recommendation to reduce fish monitoring frequency is also based on the fact that Minto is discharging effluent from the site under a more defined licence condition (added to amended WUL #QZ14-031 in Aug 2015), and with WUL standards that have not impacted the fish in lower Minto Creek based on studies and investigations conducted to date. If, however, a substantial change to discharge strategy (quantity and/or quality) occurs due to unforeseen circumstances (e.g. requiring an emergency discharge) than fish monitoring should be re-instated until conditions have returned to non-emergency status and fish use, as determined by CPUE (catch per unit effort), has returned to more normal conditions.

Monitoring programs that will continue to provide a safeguard for the aquatic resources of Minto Creek include:

- Compliance water quality and toxicity monitoring under WUL #QZ14-031
- Annual benthic invertebrate monitoring program under WUL #QZ14-03

- Compliance water quality and toxicity monitoring required under the MMER
- Annual sub-lethal toxicity testing as required under MMER – EEM program

These monitoring programs, which will be ongoing, provide an early warning system for degrading aquatic environmental conditions and which, combined with the Adaptive Management Plan provide substantial protection for the fish resources of Minto Creek.

David Petkovich, BSc., P. Biol.

Appendix P – Waste Rock Verification Program Results

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MVF Bulk Fill	MVFWRV-16-01-1	24-Jan-16	6945014.3	385611.584	777.085	<0.01	0.182	0.003	15.1606	0.09375	161.713	Pass
MVF Bulk Fill	MVFWRV-16-01-2	24-Jan-16	6945050.04	385624.138	775.906	0.039	0.198	0.018	16.4934	0.5625	29.322	Pass
MVF Bulk Fill	MVFWRV-16-01-3	24-Jan-16	6945075.51	385649.002	775.18	<0.01	0.162	0.001	13.4946	0.03125	431.827	Pass
MVF Bulk Fill	MVFWRV-16-01-4	24-Jan-16	6945097.33	385681.34	774.646	0.057	0.373	0.038	31.0709	1.1875	26.165	Pass
MVF Bulk Fill	MVFWRV-16-01-5	24-Jan-16	6945085.58	385716.798	774.562	<0.01	0.319	0.001	26.5727	0.03125	850.326	Pass
MVF Bulk Fill	MVFWRV-16-01-6	24-Jan-16	6945052.73	385733.294	775.709	0.018	0.193	0.014	16.0769	0.4375	36.747	Pass
MVF Bulk Fill	MVFWRV-16-01-7	24-Jan-16	6945017.63	385740.259	775.871	0.028	0.456	0.017	37.9848	0.53125	71.501	Pass
MVF Bulk Fill	MVFWRV-16-01-8	24-Jan-16	6944979.29	385740.356	776.853	<0.01	0.206	0.001	17.1598	0.03125	549.114	Pass
MVF Bulk Fill	MVFWRV-16-01-9	24-Jan-16	6944942.93	385735.2	777.283	<0.01	0.002	0.001	0.1666	0.03125	5.331	Pass
MVF Bulk Fill	MVFWRV-16-01-10	24-Jan-16	6944918.59	385719.47	778.162	0.03	0.032	0.001	2.6656	0.03125	85.299	Pass
MVF Bulk Fill	MVFWRV-16-01-11	24-Jan-16	6944928.65	385681.314	778.11	<0.01	0.162	0.001	13.4946	0.03125	431.827	Pass
MVF Bulk Fill	MVFWRV-16-01-12	24-Jan-16	6944939.77	385641.503	778.063	0.039	0.143	0.025	11.9119	0.78125	15.247	Pass
MVF Bulk Fill	MVFWRV-16-01-13	24-Jan-16	6944946.82	385603.939	778.115	<0.01	0.354	0.001	29.4882	0.03125	943.622	Pass
MWDE	MWDEWRV-16-01-1	25-Jan-16	6945597.14	383944.654	958.534	<0.01	0.017	0.001	1.4161	0.03125	45.315	Pass
MWDE	MWDEWRV-16-01-2	25-Jan-16	6945594.98	383984.191	957.773	<0.01	0.001	0.001	0.0833	0.03125	2.666	Fail
MWDE	MWDEWRV-16-01-3	25-Jan-16	6945571.92	383997.489	957.867	0.015	0.064	0.001	5.3312	0.03125	170.598	Pass
MWDE	MWDEWRV-16-01-4	25-Jan-16	6945557.82	383972.632	958.161	<0.01	0.001	0.001	0.0833	0.03125	2.666	Fail
MWDE	MWDEWRV-16-01-5	25-Jan-16	6945539.44	383944.624	958.029	<0.01	0.281	0.001	23.4073	0.03125	749.034	Pass
MWDE	MWDEWRV-16-01-6	25-Jan-16	6945604.33	383890.429	959.182	<0.01	0.001	0.001	0.0833	0.03125	2.666	Fail

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MWDE	MWDEWRV-16-02-1	21-Feb-16	6945479.84	383741.054	948.378	<0.01	0.201	0.002	16.7433	0.0625	267.893	Pass
MWDE	MWDEWRV-16-02-1	21-Feb-16	6945439.48	383750.845	948.06	0.01	0.29	0.019	24.157	0.59375	40.685	Pass
MWDE	MWDEWRV-16-02-3	21-Feb-16	6945403.71	383768.134	947.516	<0.01	0.202	0.001	16.8266	0.03125	538.451	Pass
MWDE	MWDEWRV-16-02-4	21-Feb-16	6945367.8	383784.529	946.797	<0.01	0.168	0.002	13.9944	0.0625	223.910	Pass
MWDE	MWDEWRV-16-02-5	21-Feb-16	6945339.25	383810.237	946.359	<0.01	0.123	0.002	10.2459	0.0625	163.934	Pass
MWDE	MWDEWRV-16-02-6	21-Feb-16	6945335.67	383847.286	946.146	0.087	0.171	0.058	14.2443	1.8125	7.859	Pass
MWDE	MWDEWRV-16-02-7	21-Feb-16	6945350.24	383874.463	946.077	0.011	0.117	0.012	9.7461	0.375	25.990	Pass
MVF Bulk Fill	MVFWRV-16-02-1	22-Feb-16	6944926.38	385590.698	784.51	<0.01	0.066	0.001	5.4978	0.03125	175.930	Pass
MVF Bulk Fill	MVFWRV-16-02-2	22-Feb-16	6944961.79	385604.586	782.947	0.031	0.159	0.121	13.2447	3.78125	3.503	Pass
MVF Bulk Fill	MVFWRV-16-02-3	22-Feb-16	6944996.27	385618.527	782.179	<0.01	0.053	0.001	4.4149	0.03125	141.277	Pass
MVF Bulk Fill	MVFWRV-16-02-4	22-Feb-16	6945031.32	385622.905	781.74	<0.01	0.069	0.001	5.7477	0.03125	183.926	Pass
MVF Bulk Fill	MVFWRV-16-02-5	22-Feb-16	6945063.45	385620.641	781.147	<0.01	0.103	0.003	8.5799	0.09375	91.519	Pass
MVF Bulk Fill	MVFWRV-16-02-6	22-Feb-16	6945093.42	385622.555	780.808	<0.01	0.121	0.001	10.0793	0.03125	322.538	Pass
MVF Bulk Fill	MVFWRV-16-02-7	22-Feb-16	6945089.13	385589.805	780.084	0.013	0.037	0.008	3.0821	0.25	12.328	Pass
MVF Bulk Fill	MVFWRV-16-02-8	22-Feb-16	6945133.77	385578.755	779.205	<0.01	0.292	0.009	24.3236	0.28125	86.484	Pass
MVF Bulk Fill	MVFWRV-16-02-9	22-Feb-16	6945142	385560.801	779.379	<0.01	0.147	0.001	12.2451	0.03125	391.843	Pass
MVF Drainage Blanket	MVFWRV-16-02-10	22-Feb-16	6945192.6	385954.789	738.57	0.029	0.085	0.067	7.0805	2.09375	3.382	Pass
MVF Drainage Blanket	MVFWRV-16-02-11	22-Feb-16	6945205.49	385931.101	738.885	<0.01	0.132	0.001	10.9956	0.03125	351.859	Pass
MVF Drainage Blanket	MVFWRV-16-02-12	22-Feb-16	6945182.27	385908.467	740.368	<0.01	0.094	0.001	7.8302	0.03125	250.566	Pass

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MVF Drainage Blanket	MVFWRV-16-02-13	22-Feb-16	6945164.43	385877.564	742.505	<0.01	0.105	0.001	8.7465	0.03125	279.888	Pass
MVF Drainage Blanket	MVFWRV-16-02-14	22-Feb-16	6945162.38	385849.156	743.717	<0.01	0.068	0.004	5.6644	0.125	45.315	Pass
MWDE	MWDE948-16-03-01	25-Mar-16	6945357.63	383887.247	946.048	<0.01	0.058	0.001	4.8314	0.03125	154.605	Pass
MWDE	MWDE948-16-03-02	25-Mar-16	6945319.57	383879.404	946.113	<0.01	0.049	0.001	4.0817	0.03125	130.614	Pass
MWDE	MWDE948-16-03-03	25-Mar-16	6945292.35	383866.412	945.836	<0.01	0.133	0.001	11.0789	0.03125	354.525	Pass
MWDE	MWDE948-16-03-04	25-Mar-16	6945301.09	383839.776	948.584	<0.01	0.172	0.001	14.3276	0.03125	458.483	Pass
MWDE	MWDE948-16-03-05	25-Mar-16	6945302.41	383797.825	948.032	0.01	0.231	0.002	19.2423	0.0625	307.877	Pass
MWDE	MWDE948-16-03-06	25-Mar-16	6945319.1	383770.897	947.528	0.01	0.071	0.001	5.9143	0.03125	189.258	Pass
MWDE	MWDE948-16-03-07	25-Mar-16	6945346.4	383755.379	947.584	<0.01	0.099	0.002	8.2467	0.0625	131.947	Pass
MWDE	MWDE948-16-03-08	25-Mar-16	6945383.06	383741.468	947.811	0.01	0.091	0.001	7.5803	0.03125	242.570	Pass
MWDE	MWDE948-16-03-09	25-Mar-16	6945415.8	383730.217	947.596	<0.01	0.143	0.001	11.9119	0.03125	381.181	Pass
MWDE	MWDE948-16-03-10	25-Mar-16	6945456.53	383723.303	948.061	0.01	0.081	0.001	6.7473	0.03125	215.914	Pass
MWDE	MWDE960-16-03-01	25-Mar-16	6945538.94	383809.381	959.727	<0.01	0.114	0.001	9.4962	0.03125	303.878	Pass
MWDE	MWDE960-16-03-02	25-Mar-16	6945514.17	383835.907	959.405	0.03	0.123	0.009	10.2459	0.28125	36.430	Pass
MWDE	MWDE960-16-03-03	25-Mar-16	6945508.03	383871.904	959.229	0.01	0.102	0.001	8.4966	0.03125	271.891	Pass
MWDE	MWDE960-16-03-04	25-Mar-16	6945524.76	383914.048	959.234	<0.01	0.137	0.001	11.4121	0.03125	365.187	Pass
MWDE	MWDE960-16-03-05	25-Mar-16	6945536.01	383943.28	959.236	0.01	0.123	0.001	10.2459	0.03125	327.869	Pass
MWDE	MWDE960-16-03-06	25-Mar-16	6945551.98	383973.251	959.347	0.04	0.18	0.029	14.994	0.90625	16.545	Pass
MWDE	MWDE960-16-03-07	25-Mar-16	6945581.21	384004.33	958.464	0.02	0.186	0.008	15.4938	0.25	61.975	Pass

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MWDE	MWDE960-16-03-08	25-Mar-16	6945605.38	383933.392	961.303	0.01	0.108	0.001	8.9964	0.03125	287.885	Pass
MWDE	MWDE960-16-03-09	25-Mar-16	6945604.23	383970.015	962.087	0.27	0.324	0.121	26.9892	3.78125	7.138	Pass
MWDE	MWDE960-16-03-10	25-Mar-16	6945620.71	383993.253	962.2	0.01	0.035	0.001	2.9155	0.03125	93.296	Pass
MWDE	MWDE960-16-03-11	25-Mar-16	6945655.86	383993.668	962.534	<0.01	0.058	0.001	4.8314	0.03125	154.605	Pass
MVF	MVFWRV-16-03-01	25-Mar-16	6945085.43	385908.464	752.009	0.05	0.061	0.022	5.0813	0.6875	7.391	Pass
MVF	MVFWRV-16-03-02	25-Mar-16	6945116.45	385888.537	751.739	<0.01	0.028	0.001	2.3324	0.03125	74.637	Pass
MVF	MVFWRV-16-03-03	25-Mar-16	6945150.9	385869.844	751.678	0.01	0.029	0.001	2.4157	0.03125	77.302	Pass
MVF	MVFWRV-16-03-04	25-Mar-16	6945238.37	385926.744	746.872	<0.01	0.221	0.001	18.4093	0.03125	589.098	Pass
MVF	MVFWRV-16-03-05	25-Mar-16	6945207.12	385945.075	747.238	<0.01	0.142	0.001	11.8286	0.03125	378.515	Pass
MVF	MVFWRV-16-03-06	25-Mar-16	6945176.56	385970.141	747.287	<0.01	0.037	0.001	3.0821	0.03125	98.627	Pass
MVF	MVFWRV-16-03-07	25-Mar-16	6945191.7	385922.303	747.362	<0.01	0.046	0.001	3.8318	0.03125	122.618	Pass
MVF	MVFWRV-16-03-08	25-Mar-16	6945188.5	385885.409	746.877	<0.01	0.049	0.001	4.0817	0.03125	130.614	Pass
MWDE	MWDE960-16-04-01	23-Apr-16	6945590.63	383954.791	962.639	<0.01	0.215	0.001	17.9095	0.03125	573.104	Pass
MWDE	MWDE960-16-04-02	23-Apr-16	6945553.28	383940.708	963.895	0.068	0.196	0.03	16.3268	0.9375	17.415	Pass
MWDE	MWDE960-16-04-03	23-Apr-16	6945531.72	383920.29	964.019	<0.01	0.154	0.001	12.8282	0.03125	410.502	Pass
MWDE	MWDE960-16-04-04	23-Apr-16	6945514.52	383889.941	962.746	<0.01	0.128	0.001	10.6624	0.03125	341.197	Pass
MWDE	MWDE960-16-04-05	23-Apr-16	6945506.52	383849.708	960.085	<0.01	0.039	0.001	3.2487	0.03125	103.958	Pass
MWDE	MWDE960-16-04-06	23-Apr-16	6945505.83	383811.103	958.404	0.151	0.244	0.117	20.3252	3.65625	5.559	Pass
MWDE	MWDE960-16-04-07	23-Apr-16	6945520.45	383775.278	958.395	<0.01	0.159	0.001	13.2447	0.03125	423.830	Pass

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MWDE	MWDE960-16-04-08	23-Apr-16	6945554.28	383757.287	960.142	<0.01	0.073	0.001	6.0809	0.03125	194.589	Pass
MWDE	MWDE960-16-04-09	23-Apr-16	6945593.32	383746.293	959.788	<0.01	0.142	0.001	11.8286	0.03125	378.515	Pass
MWDE	MWDE948-16-04-01	23-Apr-16	6945288.34	383891.029	946.816	<0.01	0.142	0.001	11.8286	0.03125	378.515	Pass
MWDE	MWDE948-16-04-02	23-Apr-16	6945251.58	383907.745	948.266	<0.01	0.096	0.001	7.9968	0.03125	255.898	Pass
MWDE	MWDE948-16-04-03	23-Apr-16	6945227.86	383921.185	949.621	0.092	0.148	0.084	12.3284	2.625	4.697	Pass
MWDE	MWDE948-16-04-04	23-Apr-16	6945237.15	383896.148	949.628	<0.01	0.039	0.008	3.2487	0.25	12.995	Pass
MWDE	MWDE948-16-04-05	23-Apr-16	6945258.71	383870.117	949.38	<0.01	0.006	0.001	0.4998	0.03125	15.994	Pass
MWDE	MWDE948-16-04-06	23-Apr-16	6945327.85	383765.417	947.041	<0.01	0.062	0.001	5.1646	0.03125	165.267	Pass
MWDE	MWDE948-16-04-07	23-Apr-16	6945366.72	383745.24	947.274	<0.01	0.074	0.001	6.1642	0.03125	197.254	Pass
MWDE	MWDE948-16-04-08	23-Apr-16	6945484.66	383789.01	952.677	<0.01	0.083	0.001	6.9139	0.03125	221.245	Pass
MWDE	MWDE948-16-04-09	23-Apr-16	6945443.77	383777.177	953.235	<0.01	0.084	0.001	6.9972	0.03125	223.910	Pass
MWDE	MWDE948-16-04-10	23-Apr-16	6945455.35	383747.156	951.849	<0.01	0.128	0.001	10.6624	0.03125	341.197	Pass
MVF	MVFWRV-16-04-01	23-Apr-16	6945104.23	385982.941	758.284	0.021	0.272	0.001	22.6576	0.03125	725.043	Pass
MVF	MVFWRV-16-04-02	23-Apr-16	6945137.87	385956.541	757.978	<0.01	0.165	0.002	13.7445	0.0625	219.912	Pass
MVF	MVFWRV-16-04-03	23-Apr-16	6945152.16	385920.487	757.664	<0.01	0.079	0.001	6.5807	0.03125	210.582	Pass
MVF	MVFWRV-16-04-04	23-Apr-16	6945147.21	385882.121	757.697	<0.01	0.137	0.001	11.4121	0.03125	365.187	Pass
MVF	MVFWRV-16-04-05	23-Apr-16	6945134.86	385848.101	757	<0.01	0.111	0.001	9.2463	0.03125	295.882	Pass
MVF	MVFWRV-16-04-06	23-Apr-16	6945102.43	385806.027	757.088	<0.01	0.052	0.001	4.3316	0.03125	138.611	Pass
MVF	MVFWRV-16-04-07	23-Apr-16	6945125.58	385812.597	752.489	<0.01	0.154	0.001	12.8282	0.03125	410.502	Pass

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MVF	MVFWRV-16-04-08	23-Apr-16	6945128.68	385796.5	753.543	<0.01	0.236	0.001	19.6588	0.03125	629.082	Pass
MWDE	WRVMWDE 960-160521-1	21-May-16	6945594.02	383991.808	962.155	<0.01	0.084	0.023	6.9972	0.71875	9.735	Pass
MWDE	WRVMWDE 960-160521-2	21-May-16	6945571.55	383955.394	963.367	<0.01	0.253	0.001	21.0749	0.03125	674.397	Pass
MWDE	WRVMWDE 960-160521-3	21-May-16	6945536.95	383927.538	963.907	0.014	0.194	0.001	16.1602	0.03125	517.126	Pass
MWDE	WRVMWDE 960-160521-4	21-May-16	6945500.35	383920.691	962.492	0.064	0.16	0.012	13.328	0.375	35.541	Pass
MWDE	WRVMWDE 960-160521-5	21-May-16	6945469.89	383885.831	959.108	<0.01	0.336	0.001	27.9888	0.03125	895.642	Pass
MWDE	WRVMWDE 960-160521-6	21-May-16	6945446.01	383856.108	956.954	0.164	0.116	0.034	9.6628	1.0625	9.094	Pass
MWDE	WRVMWDE 960-160521-7	21-May-16	6945412.26	383829.848	957.408	<0.01	0.1	0.001	8.33	0.03125	266.560	Pass
MWDE	WRVMWDE 960-160521-8	21-May-16	6945377.78	383826.922	958.468	<0.01	0.262	0.001	21.8246	0.03125	698.387	Pass
MWDE	WRVMWDE 960-160521-9	21-May-16	6945533.7	383828.151	959.933	<0.01	0.063	0.001	5.2479	0.03125	167.933	Pass
MWDE	WRVMWDE 960-160521-10	21-May-16	6945539.35	383791.678	959.909	<0.01	0.096	0.001	7.9968	0.03125	255.898	Pass
MWDE	WRVMWDE 960-160521-11	21-May-16	6945555.5	383756.652	959.987	<0.01	0.105	0.001	8.7465	0.03125	279.888	Pass
MWDE	WRVMWDE 960-160521-12	21-May-16	6945595.93	383744.794	959.575	0.069	0.161	0.041	13.4113	1.28125	10.467	Pass
MVF	WRVMVF16 0521_1	21-May-16	6945148.95	385727.642	764.98	<0.01	0.206	0.001	17.1598	0.03125	549.114	Pass
MVF	WRVMVF16 0521_2	21-May-16	6945136.61	385770.004	765.156	<0.01	0.205	0.001	17.0765	0.03125	546.448	Pass
MVF	WRVMVF16 0521_3	21-May-16	6945108.44	385763.396	765.835	<0.01	0.323	0.001	26.9059	0.03125	860.989	Pass
MVF	WRVMVF16 0521_4	21-May-16	6945089.47	385741.38	766.884	0.018	0.258	0.062	21.4914	1.9375	11.092	Pass
MVF	WRVMVF16 0521_5	21-May-16	6945073.21	385609.888	780.563	0.249	0.054	0.222	4.4982	6.9375	0.648	Fail

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MVF	WRVMVF16 0521_6	21-May-16	6945037.11	385618.517	781.295	<0.01	0.041	0.001	3.4153	0.03125	109.290	Pass
MVF	WRVMVF16 0521_7	21-May-16	6945000.32	385613.459	781.909	0.023	0.055	0.001	4.5815	0.03125	146.608	Pass
MVF	WRVMVF16 0521_8	21-May-16	6944954.39	385599.781	782.962	<0.01	0.077	0.001	6.4141	0.03125	205.251	Pass
MVF	WRVMVF16 0521_9	21-May-16	6944933.71	385557.78	783.81	0.1	0.152	0.058	12.6616	1.8125	6.986	Pass
MWDE	WRVMWDE 946160626_1	26-Jun-16	6945383.76	383718.183	946.547	<0.01	0.282	0.001	23.4906	0.03125	751.699	Pass
MWDE	WRVMWDE 946160626_2	26-Jun-16	6945362.97	383722.159	946.464	<0.01	0.453	0.005	37.7349	0.15625	241.503	Pass
MWDE	WRVMWDE 946160626_3	26-Jun-16	6945344.49	383732.226	946.426	0.011	0.399	0.006	33.2367	0.1875	177.262	Pass
MWDE	WRVMWDE 946160626_4	26-Jun-16	6945327.54	383745.514	946.517	0.011	0.427	0.008	35.5691	0.25	142.276	Pass
MWDE	WRVMWDE 946160626_5	26-Jun-16	6945313.35	383762.688	946.769	0.013	0.392	0.007	32.6536	0.21875	149.274	Pass
MWDE	WRVMWDE 946160626_6	26-Jun-16	6945308.48	383782.515	946.941	0.013	0.291	0.003	24.2403	0.09375	258.563	Pass
MWDE	WRVMWDE 930160626_1	26-Jun-16	6945374.79	383645.256	929.68	0.301	0.413	0.198	34.4029	6.1875	5.560	Pass
MWDE	WRVMWDE 930160626_2	26-Jun-16	6945353.64	383642.207	929.413	0.147	0.372	0.094	30.9876	2.9375	10.549	Pass
MWDE	WRVMWDE 930160626_3	26-Jun-16	6945336.26	383646.59	929.398	0.121	0.383	0.12	31.9039	3.75	8.508	Pass
MWDE	WRVMWDE 930160626_4	26-Jun-16	6945318.42	383657.463	929.439	0.174	0.388	0.151	32.3204	4.71875	6.849	Pass
MWDE	WRVMWDE 930160626_5	26-Jun-16	6945300.06	383673.729	929.445	0.027	0.377	0.029	31.4041	0.90625	34.653	Pass
MVF	WRVMVF16 0626_1	26-Jun-16	6945039.94	385937.419	765.968	0.038	0.334	0.353	27.8222	11.0313	2.522	Fail
MVF	WRVMVF16 0626_2	26-Jun-16	6945061.4	385918.94	765.87	<0.01	0.383	0.015	31.9039	0.46875	68.062	Pass
MVF	WRVMVF16 0626_3	26-Jun-16	6945080.67	385899.529	765.568	0.019	0.414	0.111	34.4862	3.46875	9.942	Pass
MVF	WRVMVF16 0626_4	26-Jun-16	6945100.09	385882.737	764.981	0.063	0.389	0.047	32.4037	1.46875	22.062	Pass

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MVF	WRVMVF160626_5	26-Jun-16	6945119.79	385864.142	764.894	0.01	0.376	0.013	31.3208	0.40625	77.097	Pass
MVF	WRVMVF160626_6	26-Jun-16	6945125.87	385841.104	764.796	0.013	0.507	0.009	42.2331	0.28125	150.162	Pass
MVF	WRVMVF160626_7	26-Jun-16	6945132.03	385814.486	764.591	<0.01	0.289	0.006	24.0737	0.1875	128.393	Pass
MVF	WRVMVF160626_8	26-Jun-16	6945136.25	385797.189	764.611	<0.01	0.424	0.004	35.3192	0.125	282.554	Pass
MVF	WRV-MVF-1607-01	30-Jul-16	6944999.67	385484.676	782.694	<0.01	0.065	0.013	5.4145	0.40625	13.328	Pass
MVF	WRV-MVF-1607-02	30-Jul-16	6945024.49	385487.687	782.693	0.014	0.1	0.011	8.33	0.34375	24.233	Pass
MVF	WRV-MVF-1607-03	30-Jul-16	6945051.07	385481.887	781.44	0.027	0.378	0.133	31.4874	4.15625	7.576	Pass
MVF	WRV-MVF-1607-04	30-Jul-16	6945076.5	385476.997	780.906	0.023	0.309	0.097	25.7397	3.03125	8.491	Pass
MVF	WRV-MVF-1607-05	30-Jul-16	6945100.22	385470.202	780.925	0.017	0.372	0.049	30.9876	1.53125	20.237	Pass
MVF	WRV-MVF-1607-06	30-Jul-16	6945120.96	385486.184	780.424	0.023	0.48	0.043	39.984	1.34375	29.756	Pass
MVF	WRV-MVF-1607-07	30-Jul-16	6945135.78	385508.864	779.719	<0.01	0.127	0.009	10.5791	0.28125	37.615	Pass
MVF	WRV-MVF-1607-08	30-Jul-16	6945149.39	385536.063	779.376	0.017	0.276	0.043	22.9908	1.34375	17.109	Pass
MVF	WRV-MVF-1607-09	30-Jul-16	6945141.66	385560.005	779.168	<0.01	0.304	0.008	25.3232	0.25	101.293	Pass
MVF	WRV-MVF-1607-10	30-Jul-16	6945119.97	385570.896	779.023	<0.01	0.233	0.01	19.4089	0.3125	62.108	Pass
MVF	WRV-MVF-1607-11	30-Jul-16	6945111.46	385599.45	780.253	0.017	0.281	0.021	23.4073	0.65625	35.668	Pass
MVF	WRV-MVF-1607-12	30-Jul-16	6945109.72	385624.526	780.334	0.017	0.133	0.014	11.0789	0.4375	25.323	Pass
MVF	WRV-MVF-1607-13	30-Jul-16	6945149.69	385703.248	764.656	0.01	0.21	0.012	17.493	0.375	46.648	Pass
MVF	WRV-MVF-1607-14	30-Jul-16	6945152.31	385753.642	764.481	<0.01	0.169	0.006	14.0777	0.1875	75.081	Pass
MVF	WRV-MVF-1607-15	30-Jul-16	6945159.89	385778.678	764.096	<0.01	0.224	0.004	18.6592	0.125	149.274	Pass

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MVF	WRV-MVF-1607-16	30-Jul-16	6945166.52	385805.704	764.424	<0.01	0.298	0.011	24.8234	0.34375	72.214	Pass
MVF	WRV-MVF-1607-17	30-Jul-16	6945164.57	385828.747	764.62	<0.01	0.259	0.003	21.5747	0.09375	230.130	Pass
MVF	WRV-MVF-1607-18	30-Jul-16	6945167.89	385903.57	765.274	0.012	0.236	0.013	19.6588	0.40625	48.391	Pass
MVF	WRV-MVF-1607-19	30-Jul-16	6945146.36	385915.589	765.535	0.013	0.249	0.009	20.7417	0.28125	73.748	Pass
MVF	WRV-MVF-1607-20	30-Jul-16	6945122.84	385923.666	765.863	<0.01	0.449	0.003	37.4017	0.09375	398.951	Pass
MVF	WRV-MVF-1607-21	30-Jul-16	6945101.42	385935.571	766.152	<0.01	0.427	0.016	35.5691	0.5	71.138	Pass
MVF	WRV-MVF-1607-22	30-Jul-16	6945073.06	385931.06	766.299	0.031	0.394	0.028	32.8202	0.875	37.509	Pass
MVF	WRV-MVF-1607-23	30-Jul-16	6945049.36	385939.4	766.576	<0.01	0.287	0.013	23.9071	0.40625	58.848	Pass
MVF	WRV-MVF-1607-24	30-Jul-16	6945166.47	385852.442	765.149	<0.01	0.272	0.015	22.6576	0.46875	48.336	Pass
MVF	WRV-MVF-1607-25	30-Jul-16	6945168.68	385877.727	765.119	<0.01	0.406	0.007	33.8198	0.21875	154.605	Pass
MWDE	WRV-MWDE-1607-01	2-Aug-16	6945527.94	383681.266	947.341	0.031	0.424	0.006	35.3192	0.1875	188.369	Pass
MWDE	WRV-MWDE-1607-02	2-Aug-16	6945500.2	383681.143	947.515	0.02	0.304	0.026	25.3232	0.8125	31.167	Pass
MWDE	WRV-MWDE-1607-03	2-Aug-16	6945474.93	383682.535	947.6	0.011	0.598	0.006	49.8134	0.1875	265.671	Pass
MWDE	WRV-MWDE-1607-04	2-Aug-16	6945447.87	383677.587	947.295	<0.01	0.418	0.003	34.8194	0.09375	371.407	Pass
MWDE	WRV-MWDE-1607-05	2-Aug-16	6945418.34	383679.319	946.808	2.964	0.348	1.426	28.9884	44.5625	0.651	Fail
MWDE	WRV-MWDE-1607-06	2-Aug-16	6945391	383682.395	946.972	<0.01	0.431	0.015	35.9023	0.46875	76.592	Pass

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MWDE	WRV-MWDE-1607-07	2-Aug-16	6945363.97	383691.862	947.307	<0.01	0.655	0.01	54.5615	0.3125	174.597	Pass
MWDE	WRV-MWDE-1607-08	2-Aug-16	6945338.94	383708.384	947.132	0.055	0.429	0.045	35.7357	1.40625	25.412	Pass
MWDE	WRV-MWDE-1607-09	2-Aug-16	6945436.75	383747.916	954.31	0.023	0.295	0.03	24.5735	0.9375	26.212	Pass
MWDE	WRV-MWDE-1607-10	2-Aug-16	6945413.01	383762.007	955.279	0.013	0.373	0.013	31.0709	0.40625	76.482	Pass
MWDE	WRV-MWDE-1607-11	2-Aug-16	6945385.56	383781.633	957.078	0.476	0.184	0.308	15.3272	9.625	1.592	Fail
MWDE	WRV-MWDE-1607-12	2-Aug-16	6945364.71	383796.917	958.056	0.017	0.389	0.006	32.4037	0.1875	172.820	Pass
MWDE	WRV-MWDE-1607-13	2-Aug-16	6945361.56	383822.275	958.611	<0.01	0.365	0.002	30.4045	0.0625	486.472	Pass
MWDE	WRV-MWDE-1608-01	29-Aug-16	6945490.77	383919.251	962.521	0.027	0.492	0.007	40.9836	0.21875	187.354	Pass
MWDE	WRV-MWDE-1608-02	29-Aug-16	6945468.96	383907.614	961.306	0.013	0.608	0.001	50.6464	0.03125	1620.69	Pass
MWDE	WRV-MWDE-1608-03	29-Aug-16	6945443.66	383897.026	960.156	0.037	0.63	0.01	52.479	0.3125	167.933	Pass
MWDE	WRV-MWDE-1608-04	29-Aug-16	6945416.79	383885.435	959.988	0.047	0.421	0.015	35.0693	0.46875	74.815	Pass
MWDE	WRV-MWDE-1608-05	29-Aug-16	6945391.39	383875.171	959.846	0.048	0.24	0.009	19.992	0.28125	71.083	Pass
MWDE	WRV-MWDE-1608-06	29-Aug-16	6945366.49	383863.167	959.843	0.597	0.342	0.27	28.4886	8.4375	3.376	Pass

Waste Dump Name	Sample ID	Date Sampled	Northing	Easting	Elevation	Cu%	%C (Tot)	%S (Tot)	NP	AP	NP/AP	Pass/ Fail
MWDE	WRV-MWDE-1608-07	29-Aug-16	6945355.25	383839.691	959.809	0.128	0.252	0.048	20.9916	1.5	13.994	Pass
MWDE	WRV-MWDE-1608-08	29-Aug-16	6945360.85	383810.294	959.39	0.044	0.297	0.014	24.7401	0.4375	56.549	Pass
MWDE	WRV-MWDE-1608-09	29-Aug-16	6945366.17	383780.134	958.12	0.467	0.265	0.218	22.0745	6.8125	3.240	Pass

Appendix Q – ABA Report

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Minto Mine
Water Licence QZ14-031 & Quartz Mining Licence QML-0001
2016 Annual Report
Geochemical Monitoring Report

Prepared by:
Minto Explorations Ltd.
Minto Mine
March 2017

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1 Geochemical Monitoring Program Objectives

This report is submitted to meet requirements under Minto Explorations Ltd., (a subsidiary of Capstone Mining Corporation), Minto Mine (Minto) Type "A" Water Licence QZ14-031-1 (WUL) and Quartz Mining Licence QML-0001.

The WUL specifically addresses the requirement in clause 95 which states "*The Licensee shall implement the updated Geochemical Monitoring Program, including the Waste Rock Verification Program, and the results from this program are to be included in the Annual Report."*

The QML addresses the requirement in Schedule D – Annual Reporting Requirements, under the Environmental Monitoring section, subsection a) which states *"a summary of the programs undertaken for environmental monitoring and surveillance as outlined in the Environmental Monitoring, Surveillance and Reporting Plan".*

Details regarding the Geochemical Monitoring Program can be found in Minto's Environmental Monitoring, Surveillance and Reporting Plan (EMSRP) that was approved by the Yukon Water Board and Yukon Government, Energy Mines and Resources Branch on Ocotber 4th, 2016 and December 13th, 2016. In general, the Geochemical Monitoring Program is comprised of the following components:

- The Acid Base Accounting (ABA) Program, the primary focus of this document;
- The Waste Rock Management Verification Program; and
- Low Grade and Oxide Ore Metals Leaching Characterization Program (currently not implemented).

The objective of the ABA Program is to determine the Neutralization Potential Ratio, otherwise referred to as the NPR (Neutralizing Potential divided by Acid Potential [NP/AP]) for overburden and waste rock. An NPR value of 3 or greater generally indicates non-acid generating material. During 2016, 203 waste rock and overburden samples were collected and analyzed from the Minto North pit and another 10 samples of waste rock was sampled from the Area 118 and Area 2 underground development.

A separate, parallel ABA program was administered to determine the NPR of the tailings solids. During 2016, 12 monthly samples were collected from the the mill, however, only 9 samples were analyzed at the time of writing.

The objective of the Waste Rock Management Verification Program is to verify that the on-site waste rock segregation system is preforming as expected. The results of the Waste Rock Management Verification Program are available in a seperate report and will therefore not be discussed further in this document.

There are currently no details or results for the Low Grade and Oxide Ore Metals Leaching Characterization Program as it is currently under development and therefore will not be discussed further in this document.

2 ABA Program - Waste Rock and Overburden

2.1 Internal Frequency of Sampling – On-site Analysis

On-site total carbon (C(T)) and total sulphur (S(T)) analysis are carried out on drill cuttings from every blast hole. Samples are collected for grade control purposes, and a portion of each sample is sent for S(T) and total carbon C(T) analyses at the on-site laboratory.

2.2 External Frequency of Sampling

External laboratory analysis were completed for composites samples from open pit mining. A sample of drill cuttings was collected from waste blasts with a frequency of approximately one sample for every seven holes drilled. Composite samples from each waste class for each blast are formed from approximately 4-5 individual samples.

External analysis were also carried out for underground ABA samples. The sampling procedure assembles a composite sample every 3300 tonnes (equivalent to approximately 50 m of development) using a grab sample or wall chipping technique.

2.3 Sample Preparation

All composite samples were reduced to 1-2 kg in mass using a riffle splitter. The resulting split sample was labeled according to the ABA Program sample naming standards and shipped to an accredited laboratory. The labeling methodology was consistent with the Mine Environmental ABA Database throughout the reporting period.

2.4 Test Work and Evaluation

Internal samples are analyzed for S(T) and C(T) using an Eltra CS-800 induciton furnace with infrared detectors. The resultant S(T) and C(T) data are converted to equivalent acid and neutralization potential and ultimately, NP:AP ratios are calculated. The calculated NP:AP ratios are used for characterization and segregation of waste rock on-site. This data is used for internal classification and waste rock segregation only, therefore, the results of that program will not be reported in this report.

SGS and ALS Minerals conducted ABA analysis using the MEND (1991) Modified NP method as detailed in the EMSRP for all external samples. Reported results were entered into the Mine Environmental ABA Database. Waste rock and overburden composite samples were also analyzed for total metals for the entire duration of the reporting period.

For the reporting period, the results obtained from SGS and ALS were compared against past results found in the Mine Environmental ABA Database and the results are presented in Section 2.5. Sulphide sulphur ($S(S^{-2})$) results from ALS Minerals were calculated using the differ between total sulphur and sulphate sulphur (HCl Leach). In the event that the $S(S^{-2})$ value was zero or negative the detection limit of <0.01% was used. The acid potential (AP) results from ALS Mineral were calculated using the calculated $S(S^{-2})$ value.

2.5 Discussion

Blasts are numbered by bench (denoted by the toe elevation) and by the sequential blast number for that bench (e.g. 784-01; 784 being the toe elevation of the bench and 01 being the first blast of the bench). Images depicting the location of all samples collecting during the reporting period are provided in Appendix A.

The primary lithology of the deposit is granodiorite. The graniodiorite is divided into sub-units and classified as equigranular granodiorite (eG), porphyroblastic granodiorite (pG), and foliated granodiorite (fG). Locally, very highly-weathered granodiorite near the surface is described as residuum, and surface materials comprised of organics and soil is termed overburden. Other minor lithological units are described as pegmatite (Peg), Andesite (And) and Aplite (Ap).

2.6 Results

The 213 samples collected in the reporting period were analyzed by SGS and ALS Minerals and results were reported according to the Modified NP method (MEND 1991). In the reporting period, the NPR values ranged from 0.80 to 134.40 with a mean NP/mean AP of 14.49 and a median of 35.20. A summary of the results for ABA analysis are attached as Appendix B. Additionally, the SGS and ALS raw lab result files are provided in Appendix C.

2.6.1 NPR

The 2016 NPR results are compared to the results from 2014 and 2015 in Table 1, below.

Table 1. NPR Results Summary for 2014 to 2016.

NPR Values				
Period Ending	**Minimum (NPR)**	**Maximum (NPR)**	**(Mean NP)/(Mean AP)**	**Median (NPR)**
2014 (January to December, 2014)	0.60	167.20	5.31	23.80
2015 (January to December, 2015)	-6.10	102.10	5.08	18.70
2016 (January to December, 2016)	0.80	134.40	14.49	35.20

During the reporting period, 13 samples returned NPR values below the threshold of 3.0. Of the 13 samples with a NPR value less than 3:

- 6 were found to have an increased sulphide sulphur content (and therefore AP) consequently decreasing the NPR;
- 4 samples represented material classified as NAG.
- 9 samples represented material that was placed in the SAT dump.
- 2 sample represented construction grade material . The two samples both had lower sulfide sulfur values (0.09% and 0.03%) and the isolated nature of these results indicate that it is unlikely to be a concern moving forward.

All waste rock and overburden was dispatched based on Minto's *Waste Rock and Overburden Management Plan*.

2.6.2 Paste pH

The paste pH results for 2016 were between 7.61 and 9.39 with a mean value of 8.74 and a median value of 8.76. The paste pH results for 2016 are compared to 2014 and 2015 and displayed in Table 2, below.

Table 2. Paste pH Results Summary for 2014 to 2016.

Paste pH from SGS				
Period Ending	**Minimum (pH)**	**Maximum (pH)**	**Mean (pH)**	**Median (pH)**
2014 (January to December, 2014)	6.44	9.43	8.56	8.66
2015 (January to December, 2015)	5.23	9.47	8.70	8.78
2016 (January to December, 2016)	7.61	9.39	8.75	8.77

The results from 2016 are comparable to previous years results.

2.6.3 Sulphide Sulphur

The sulphide sulphur content $S(S^{-2})$ results for 2016 ranged from <0.01 to 0.75%, with a mean value of 0.05% and a median value of 0.02% as summarized in Table 3. The sulphide sulphur content during 2016 was generally lower than what was found in previous years.

Table 3. Sulphide Sulphur Results Summary for 2014 to 2016.

Sulphide-Sulphur % from SGS				
Period Ending	**Minimum ($S(S^{2-})$)**	**Maximum ($S(S^{2-})$)**	**Mean ($S(S^{2-})$)**	**Median ($S(S^{2-})$)**
2014 (January to December, 2014)	0.01	3.26	0.12	0.02
2015 (January to December, 2015)	<0.01	1.09	0.09	0.02
2016 (January to December, 2016)	<0.01	0.75	0.05	0.02

A total of 6 samples exceeded the sulphide sulphur threshold for construction rock of 0.3% during 2016. Furthermore, all 6 samples samples also had a NPR of less than 3 and therefore represented SAT material.

Figure 1, below, is a plot of sulphide sulphur versus (vs) NPR for all samples analyzed during 2016. Figure 1 illustrates that 6 samples had sulphide sulphur content greater than 0.3% and 13 samples had a NPR threshold of less than 3.

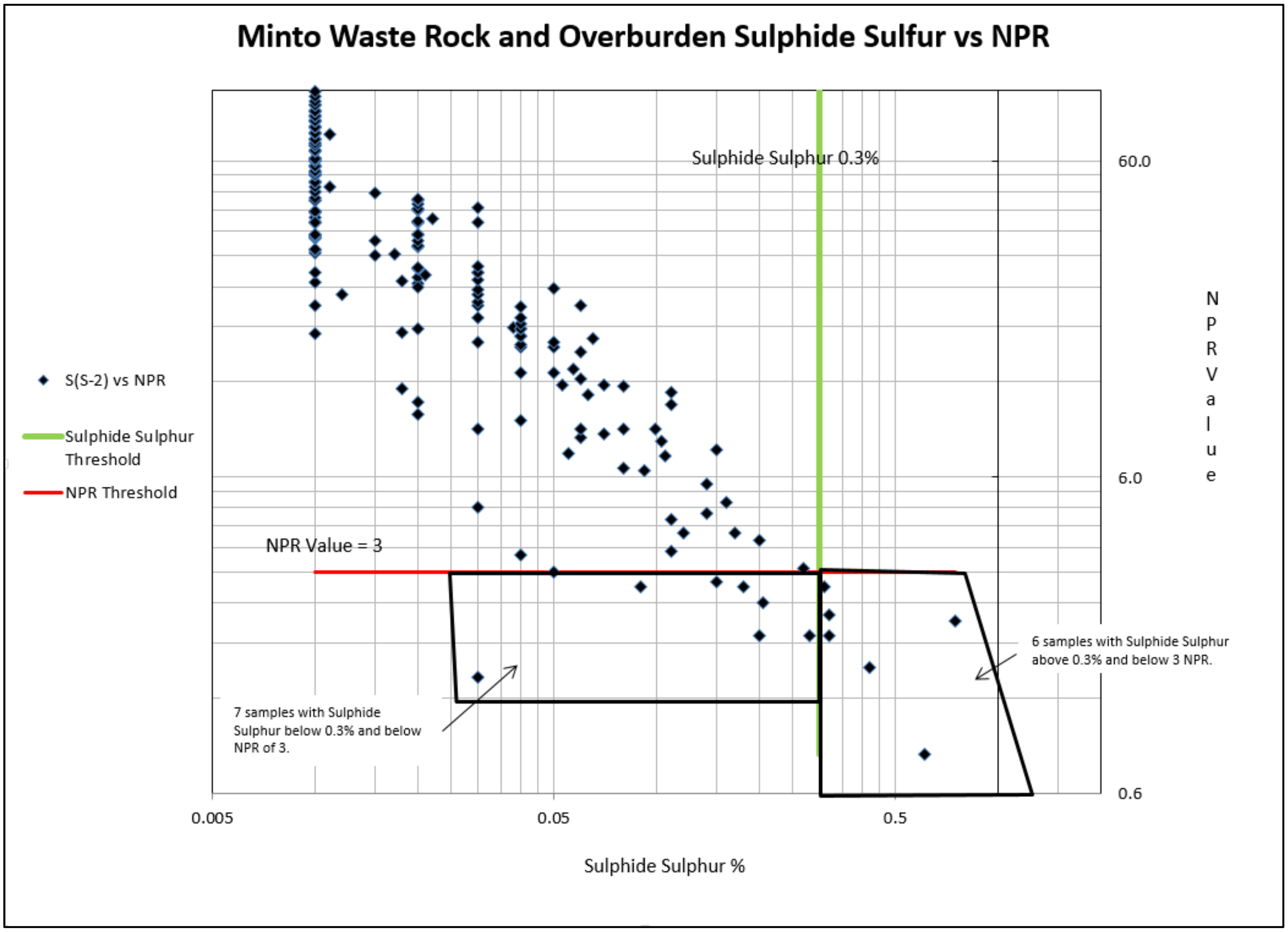


Figure 1. Minto Waste Rock and Overburden Sulphide Sulfur vs NPR, 2016.

3 Tailings

3.1 Frequency of Sampling and Sample Preparation

Minto collects a weekly sample of final tailings. The weekly samples have been filtered and dried in the onsite lab and then combined into a monthly sample which is then riffled down to produce a 1-2 kg composite. Samples are labelled according to the labeling protocol established in the Mine Environmental ABA Database. Samples were collected in October through December however, given Minto North ceasing mining in October the small volume of samples from the Mill were not sent out in time to receive results prior to writing this report.

3.2 Test work and Evaluation

Mirroring the waste rock and overburden analysis, SGS and ALS Minerals conducted ABA analysis using the MEND (1991) Modified NP method as detailed in the EMSRP. Reported results were entered into the Mine Environmental ABA Database. Monthly tailings composite samples were also analyzed for total metals for the 9 months of available samples.

3.3 Results

The results from the SGS and ALS Minerals laboratory tests indicate that 2016 tailings samples were within the threshold of NPR greater than 4 and contain lower than 0.3% sulphide sulphur content as presented in Figure 2, below. The tailings results are summarized in Appendix D and the raw lab results are presented in Appendix C.

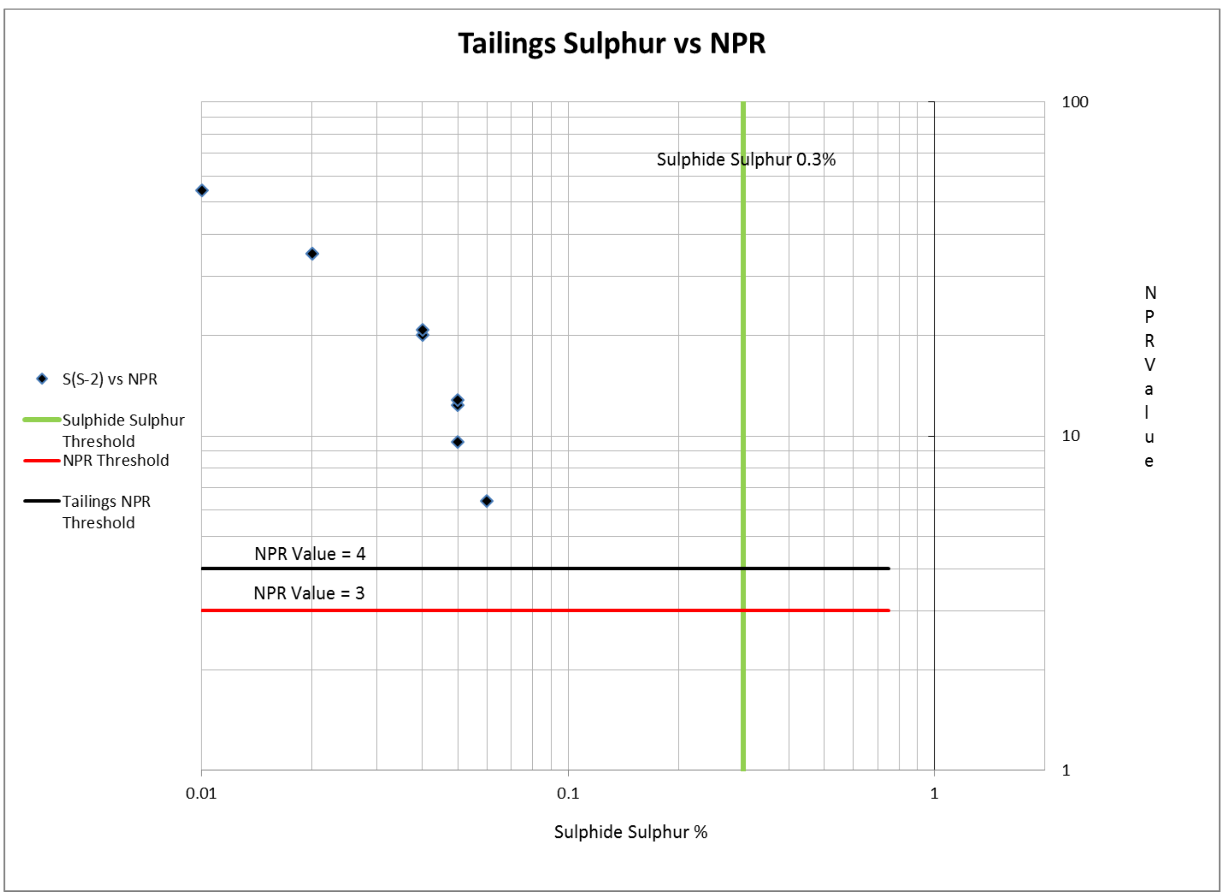


Figure 2. Tailings Sulphide Sulphur vs NPR, 2016.

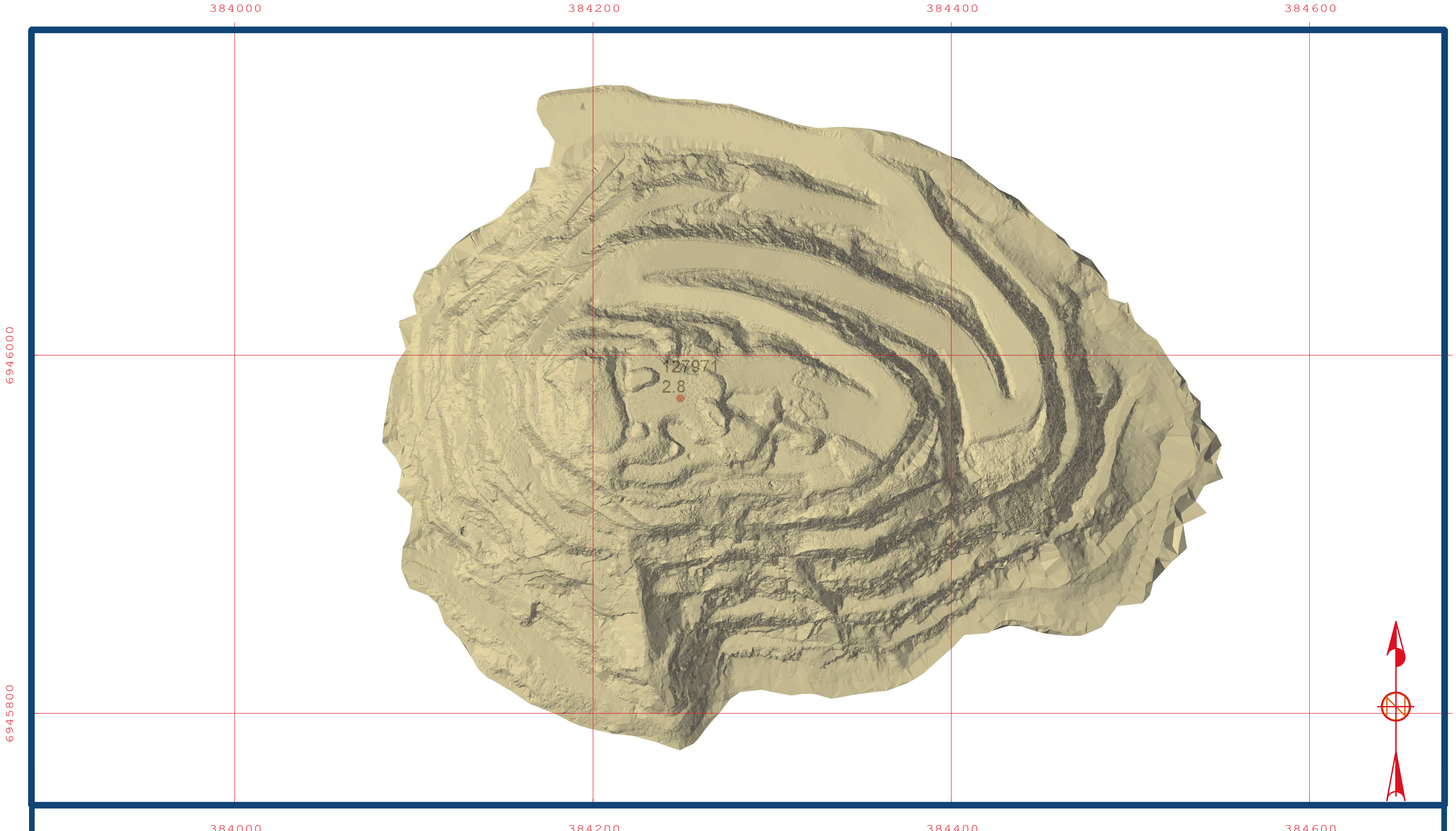
4 Conclusion

The results displayed in this report combined with the previous reporting periods are the foundation for the Mine Environmental ABA Database. Overburden and waste rock development will continue through the subsequent phases of mining and milling and will be sampled, analyzed and reported as required by the WUL and QML and in accordance with the EMSRP.

5 References

MEND. (1991). *Mine Environment Neutral Drainage Program: Acid Rock Drainage Prediciton Manual, MEND Project 1.16.1 (b). Prepared by Coastech Research Inc., North Vancouver, B.C. March 1991.*

Appendix A: Sample Location Images



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23-Mar-2017	MS

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Metres

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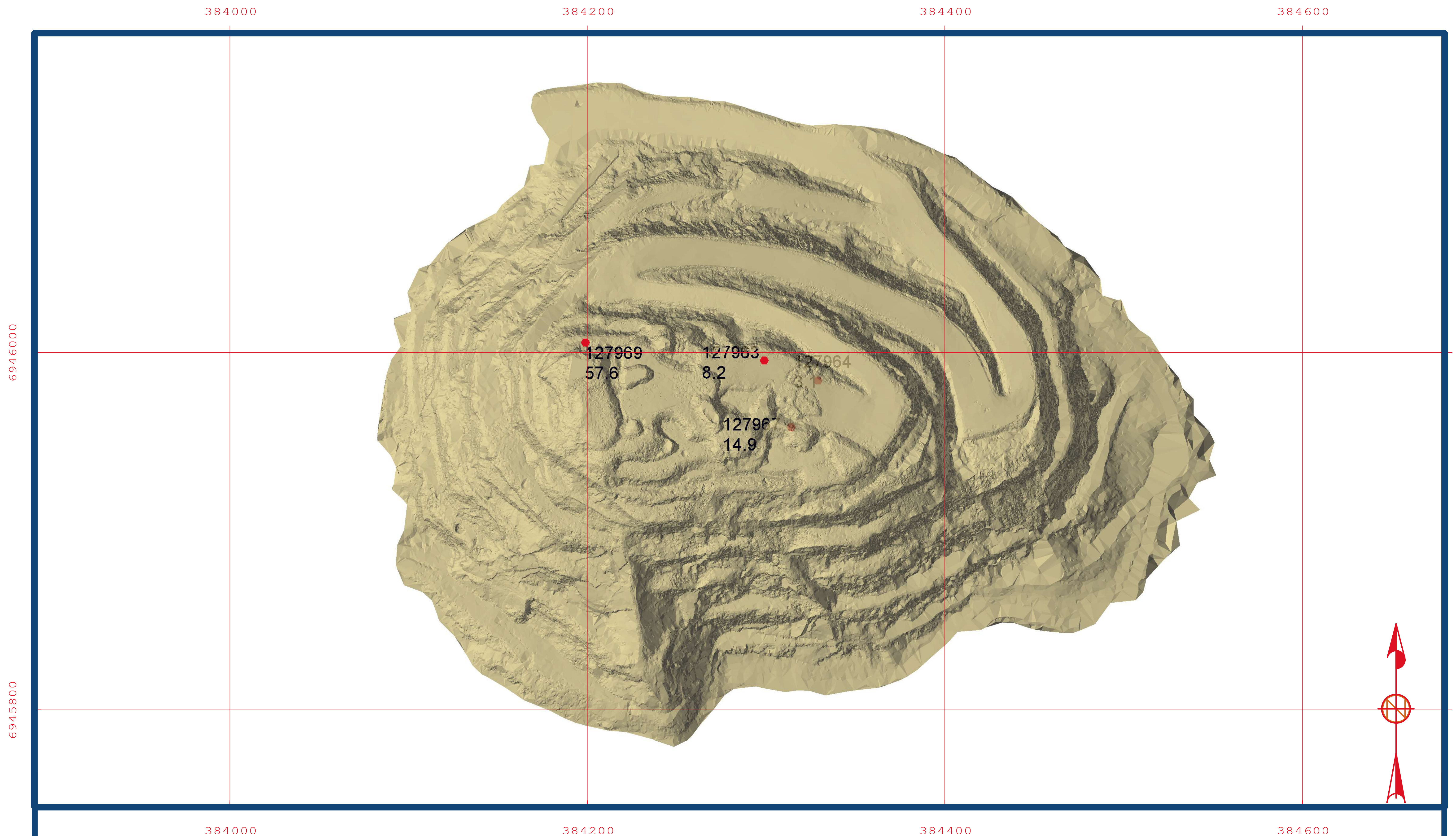

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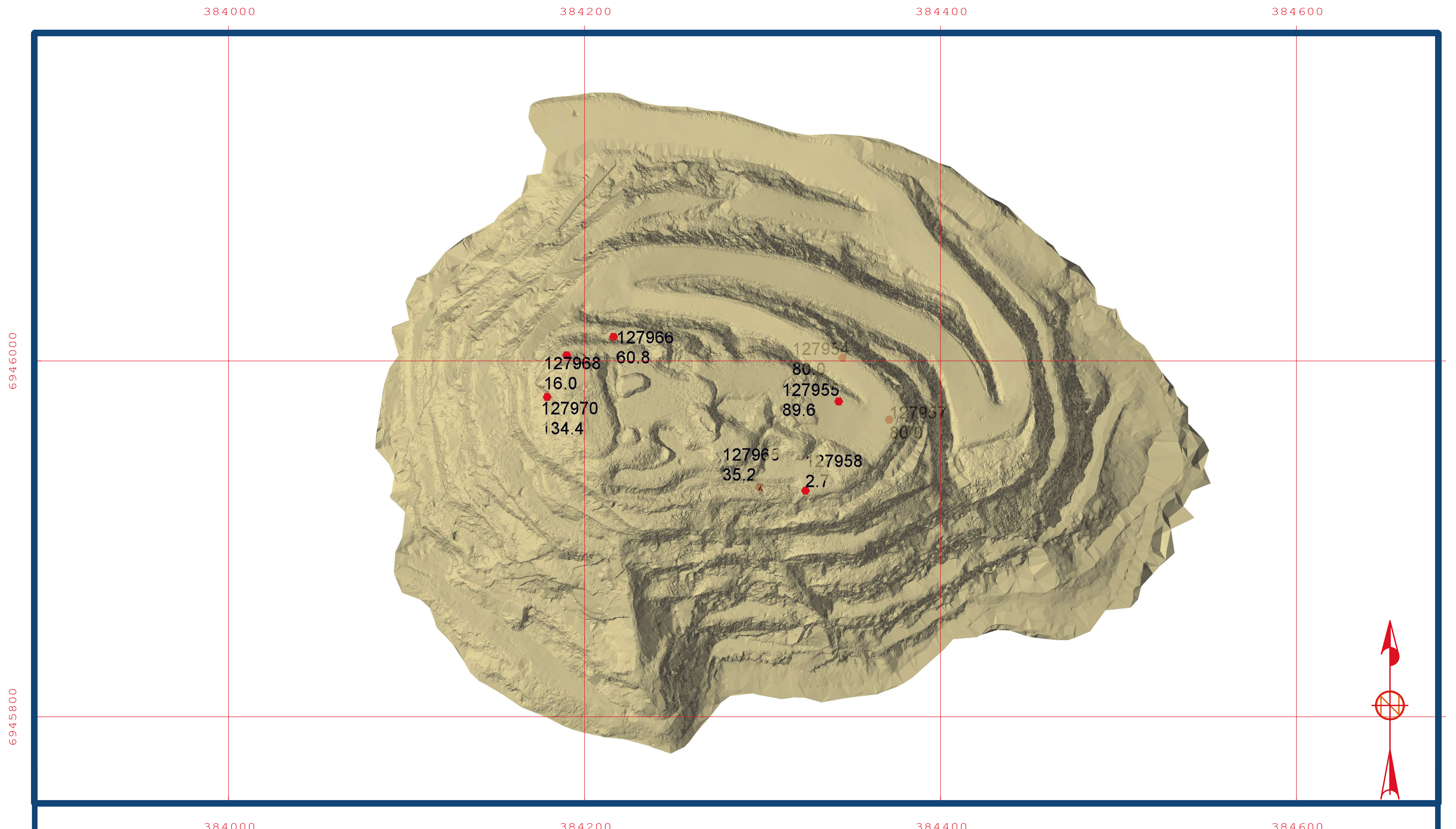

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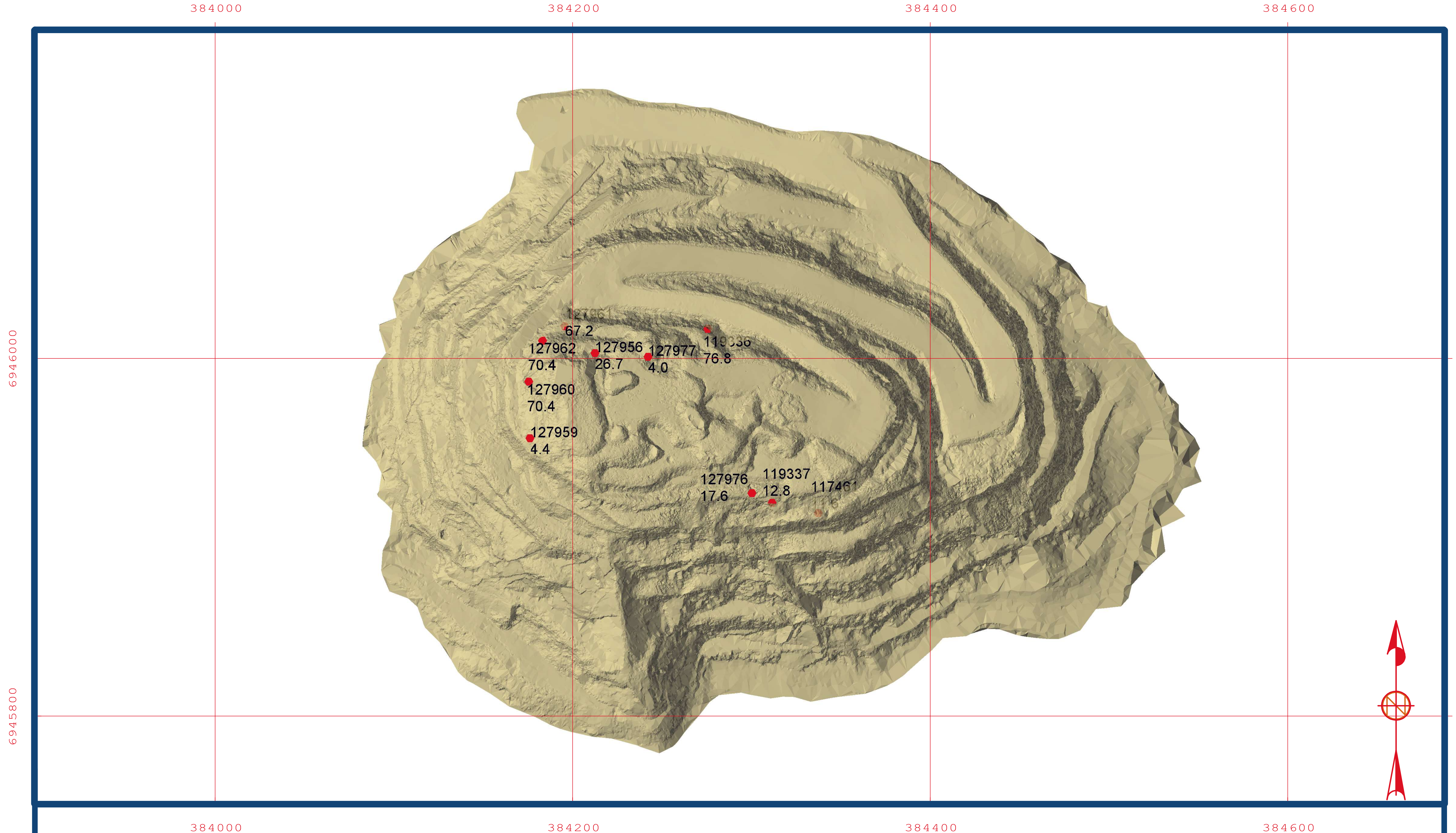

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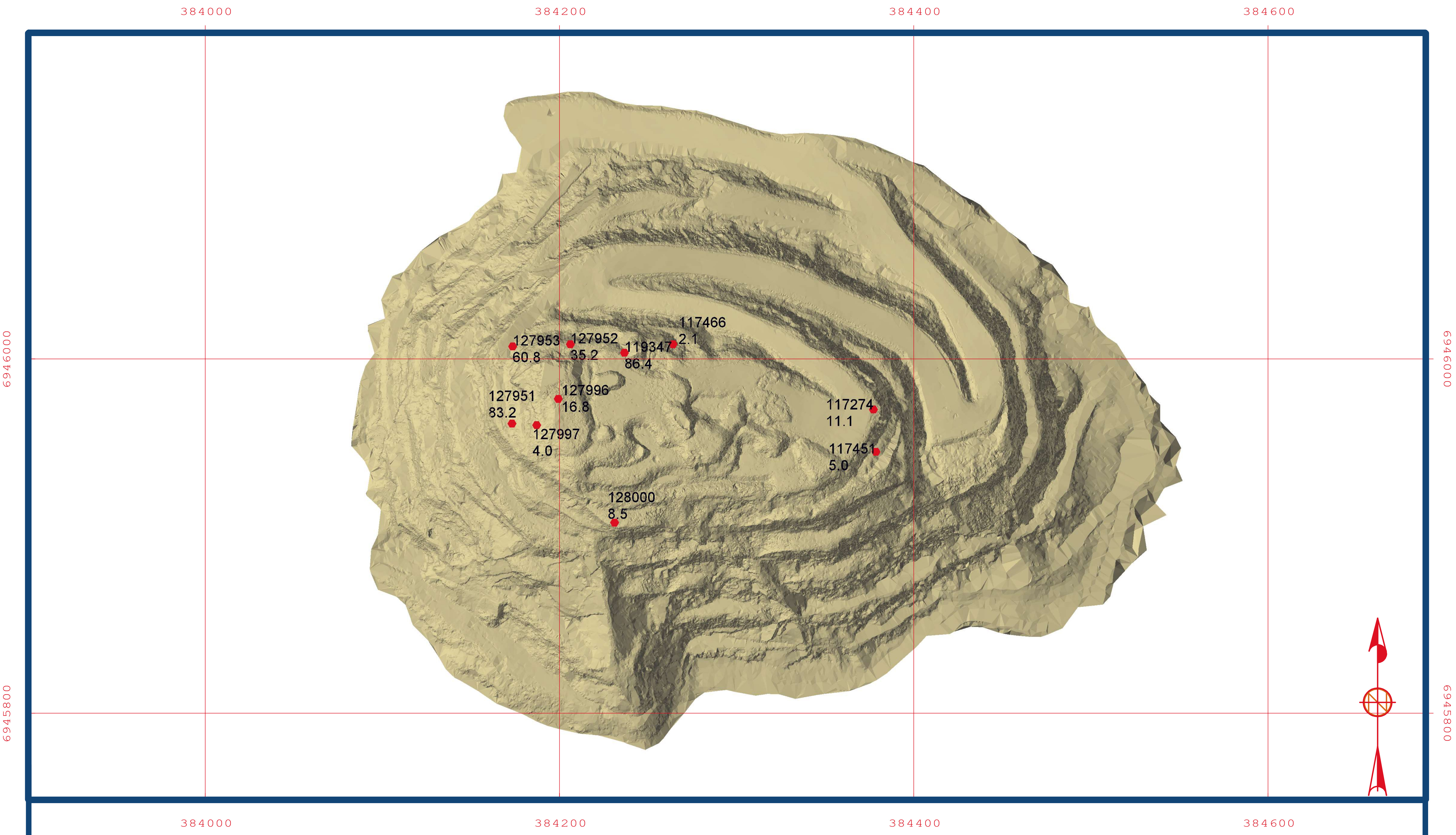

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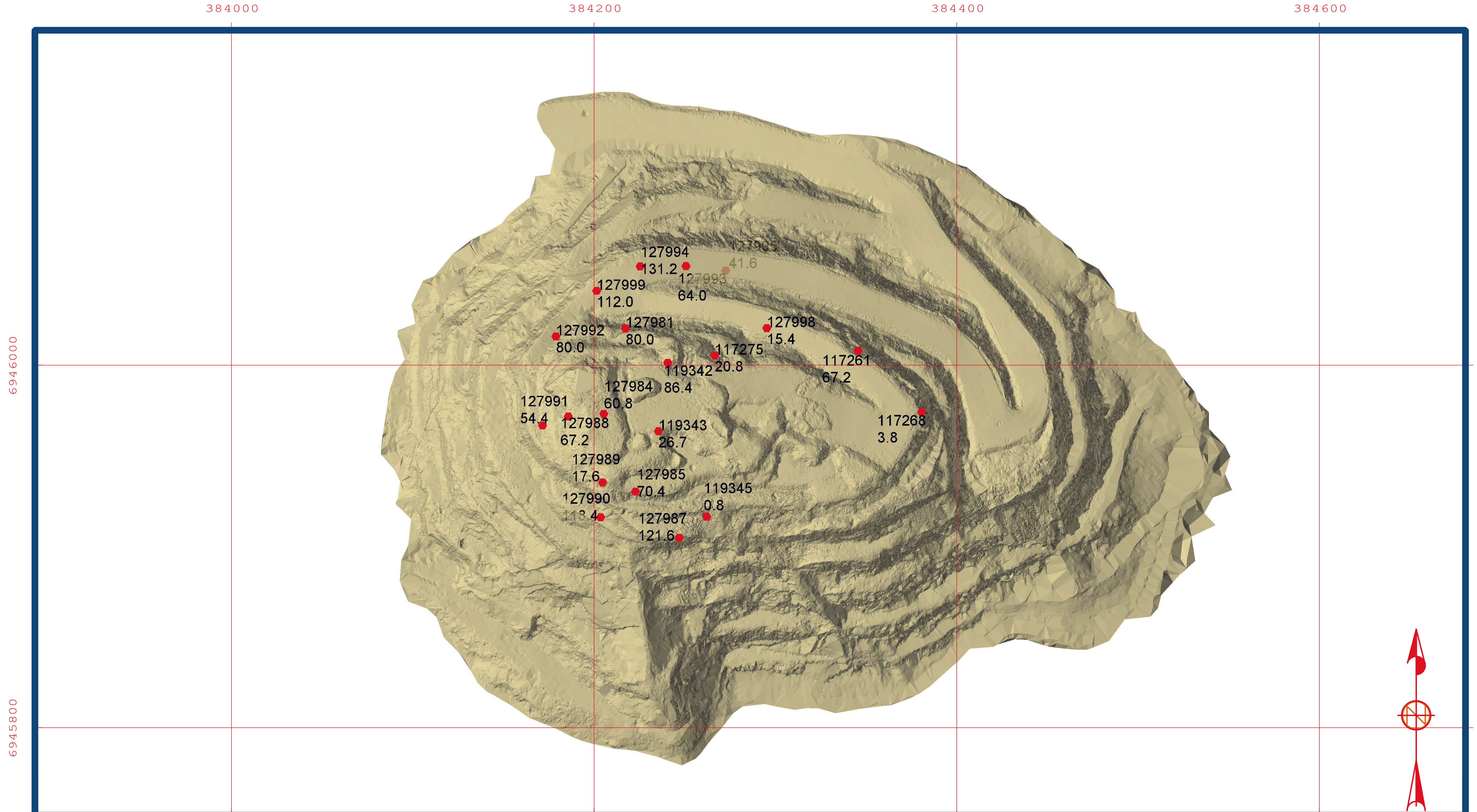

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Metres

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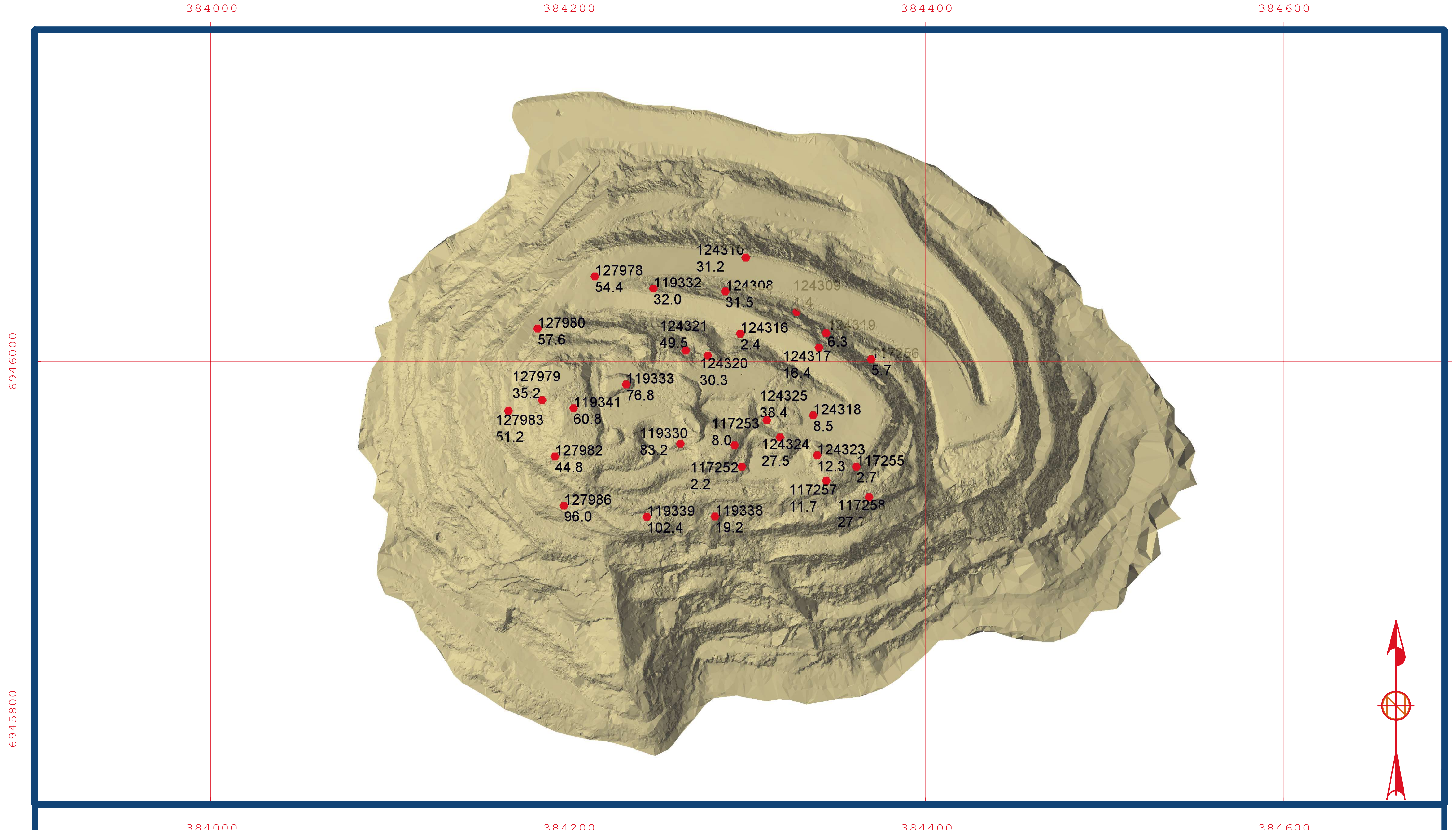

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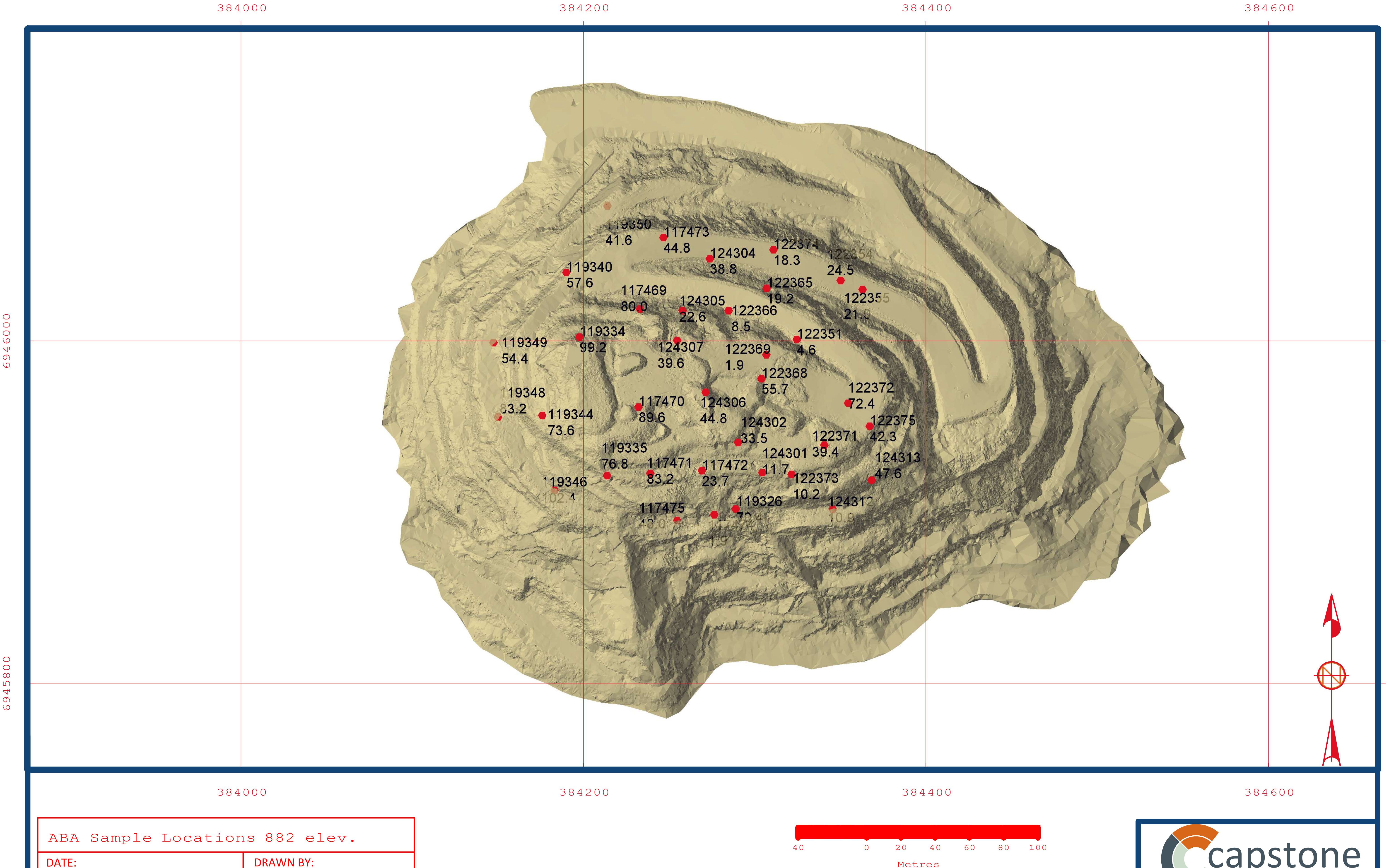

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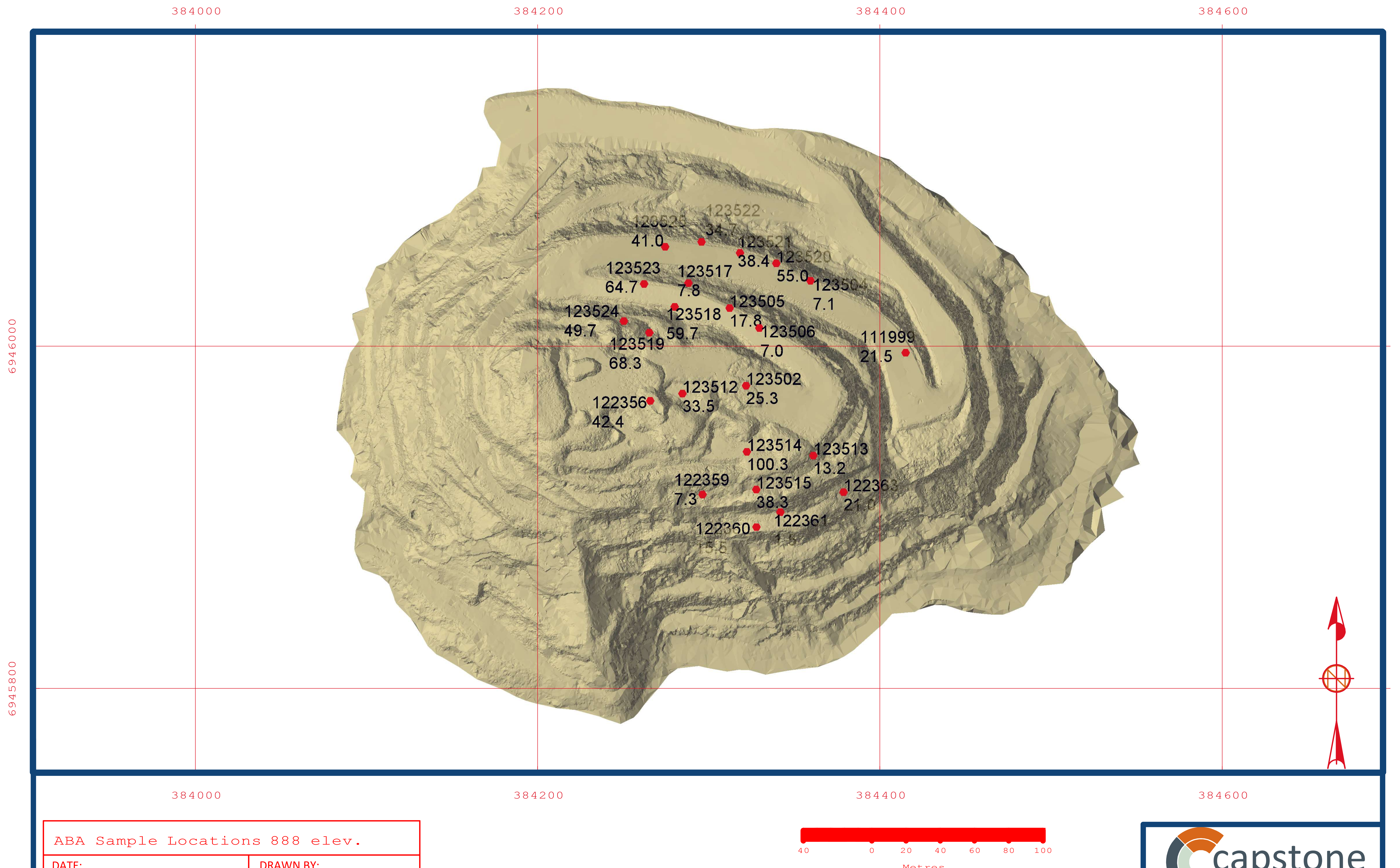

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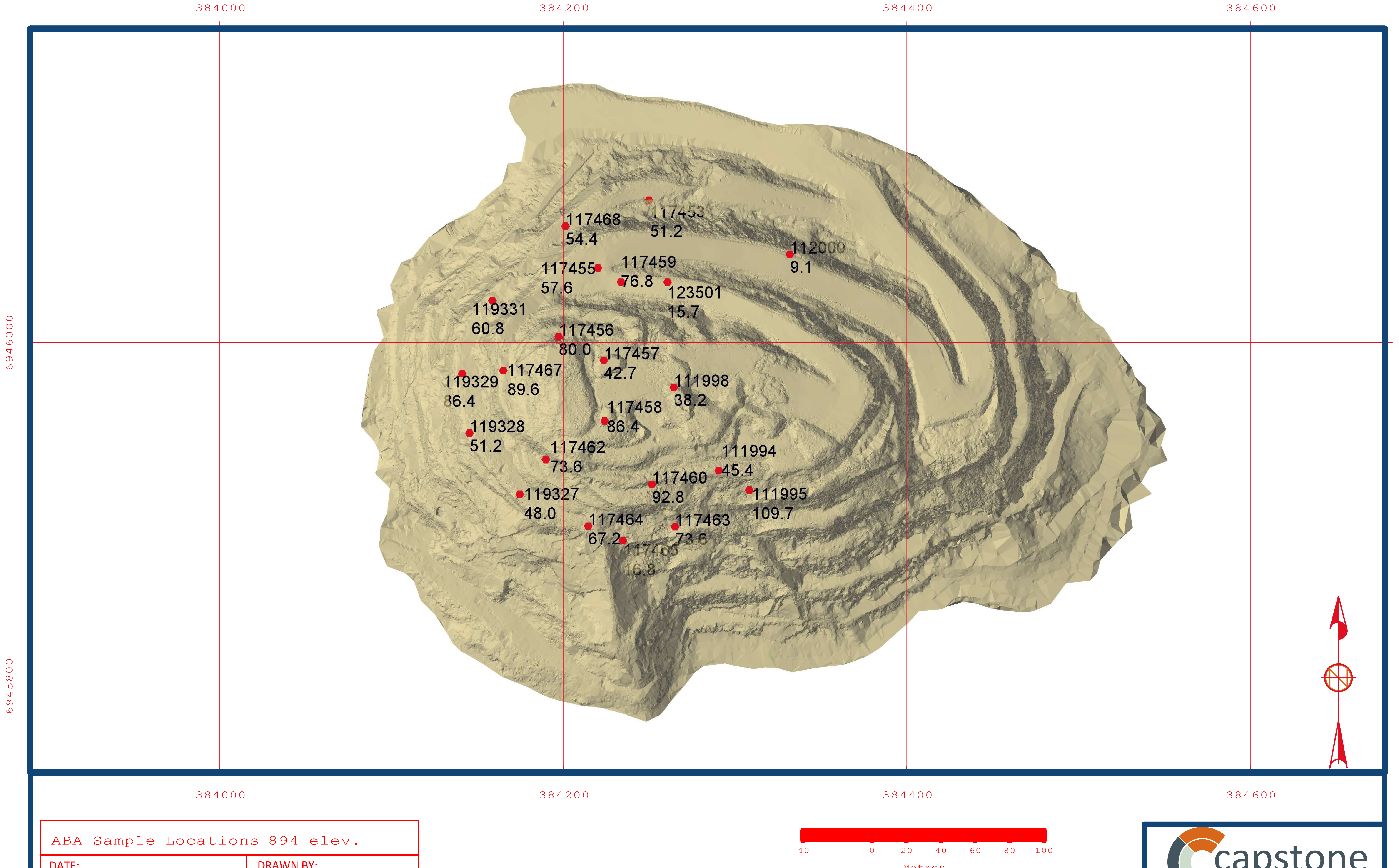

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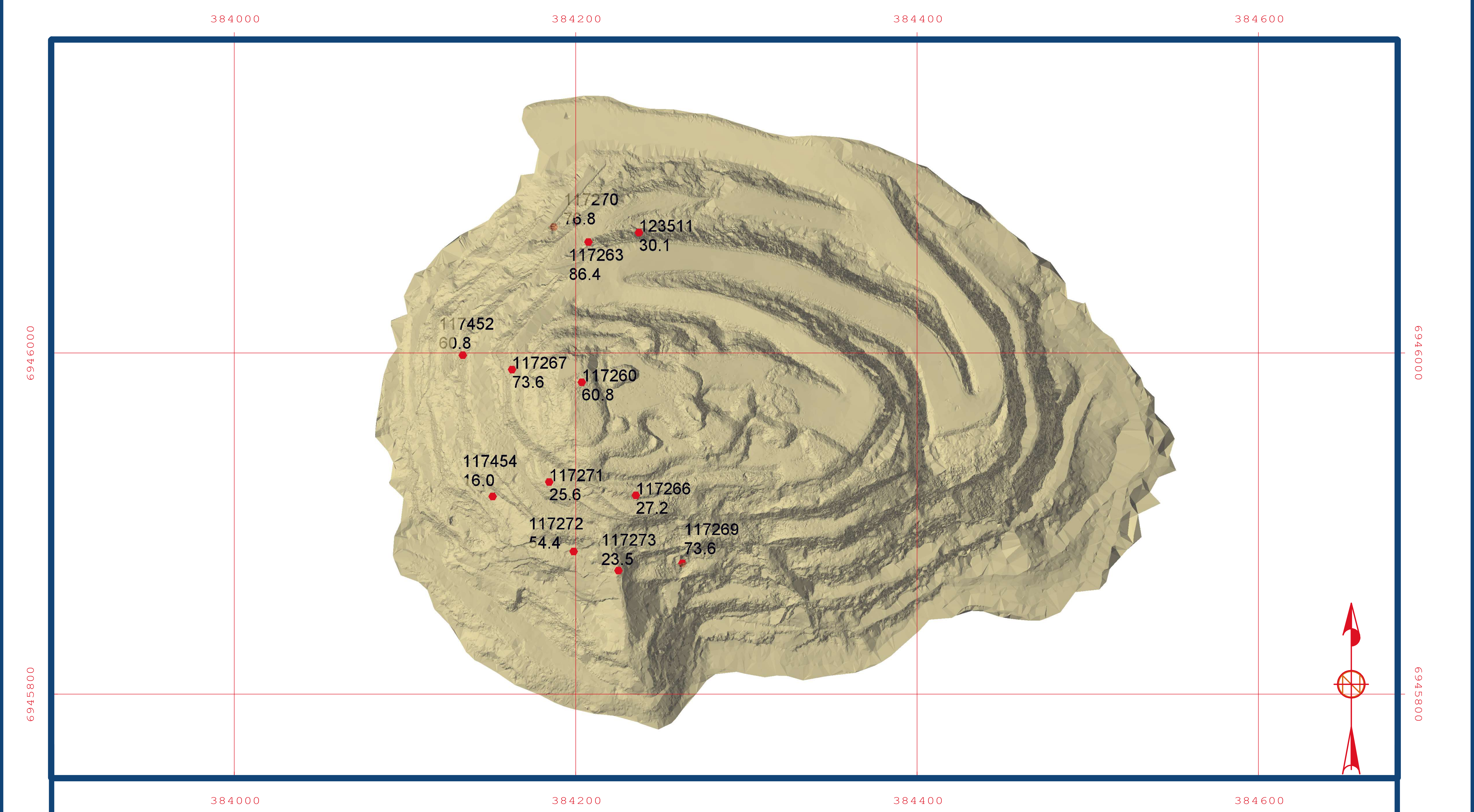

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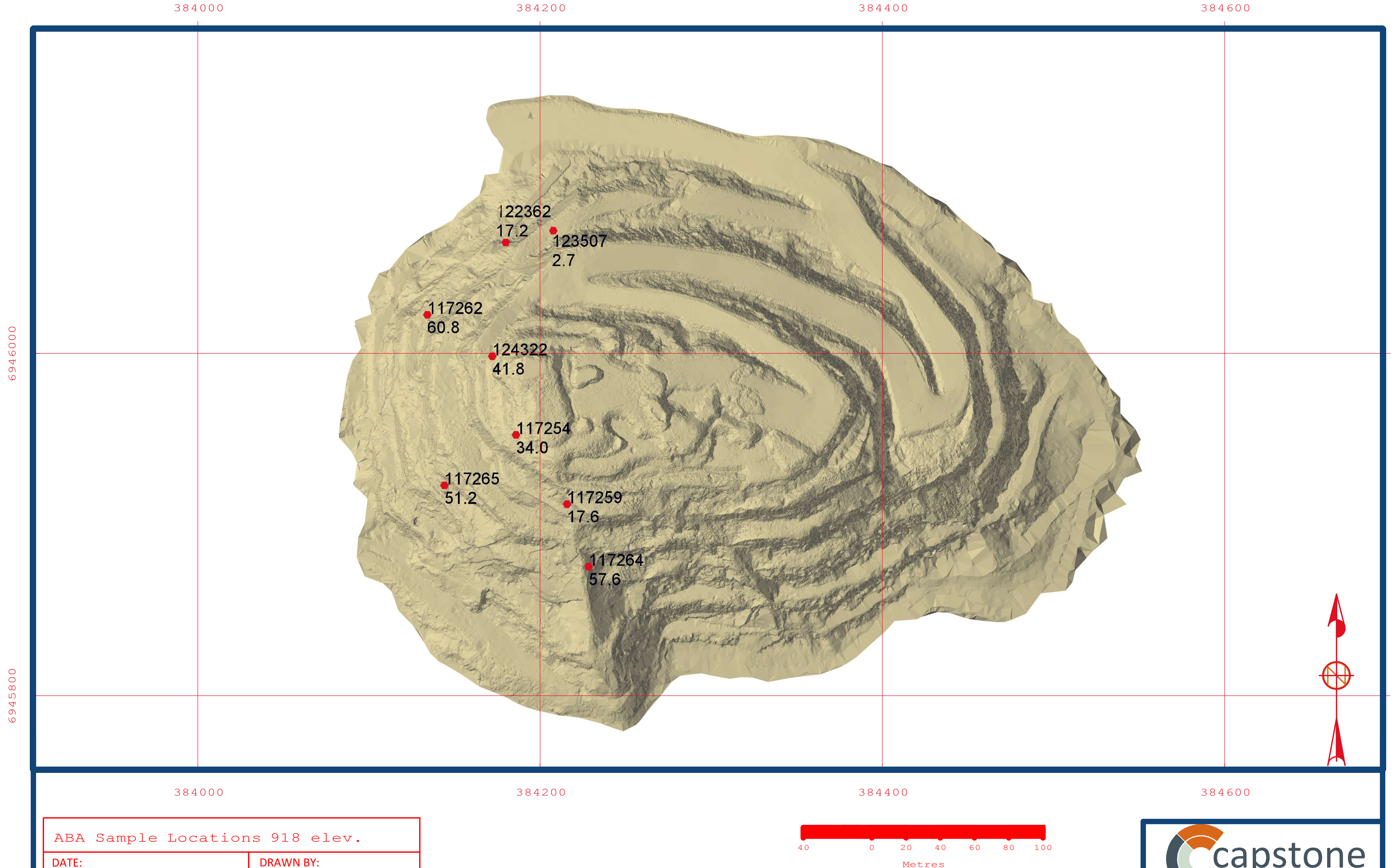

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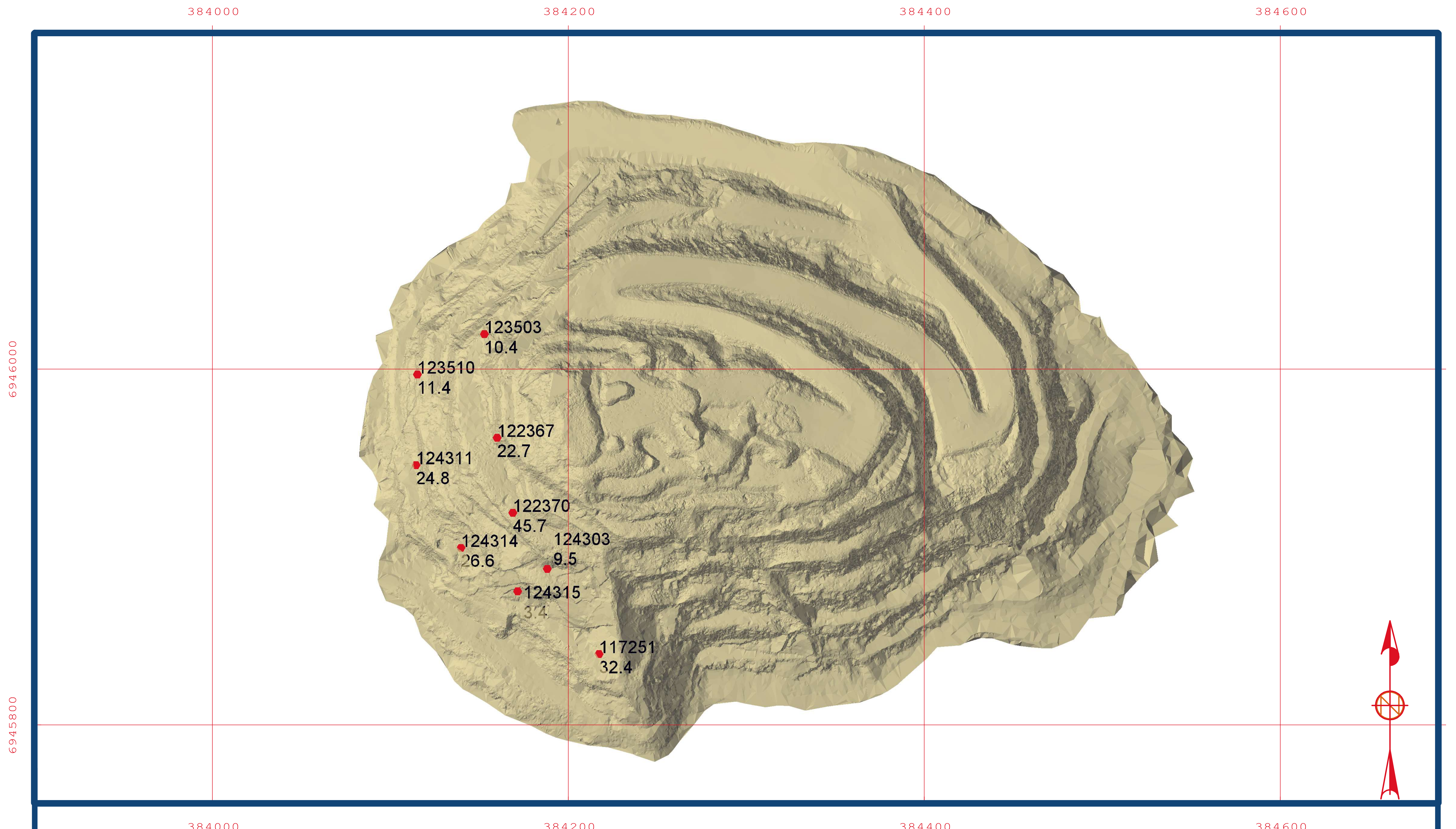

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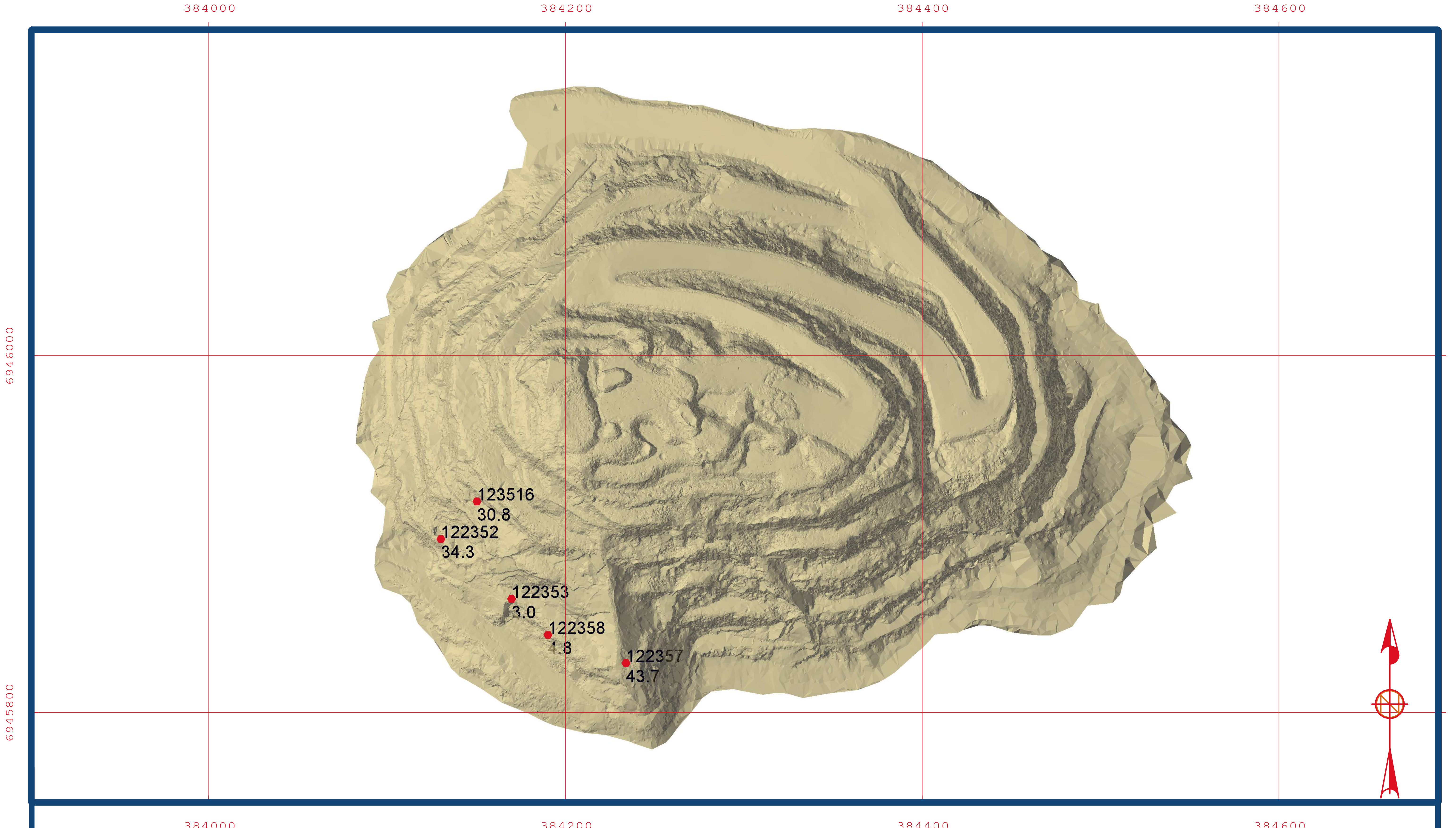

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ABA Sample Locations 942 elev.

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capstone
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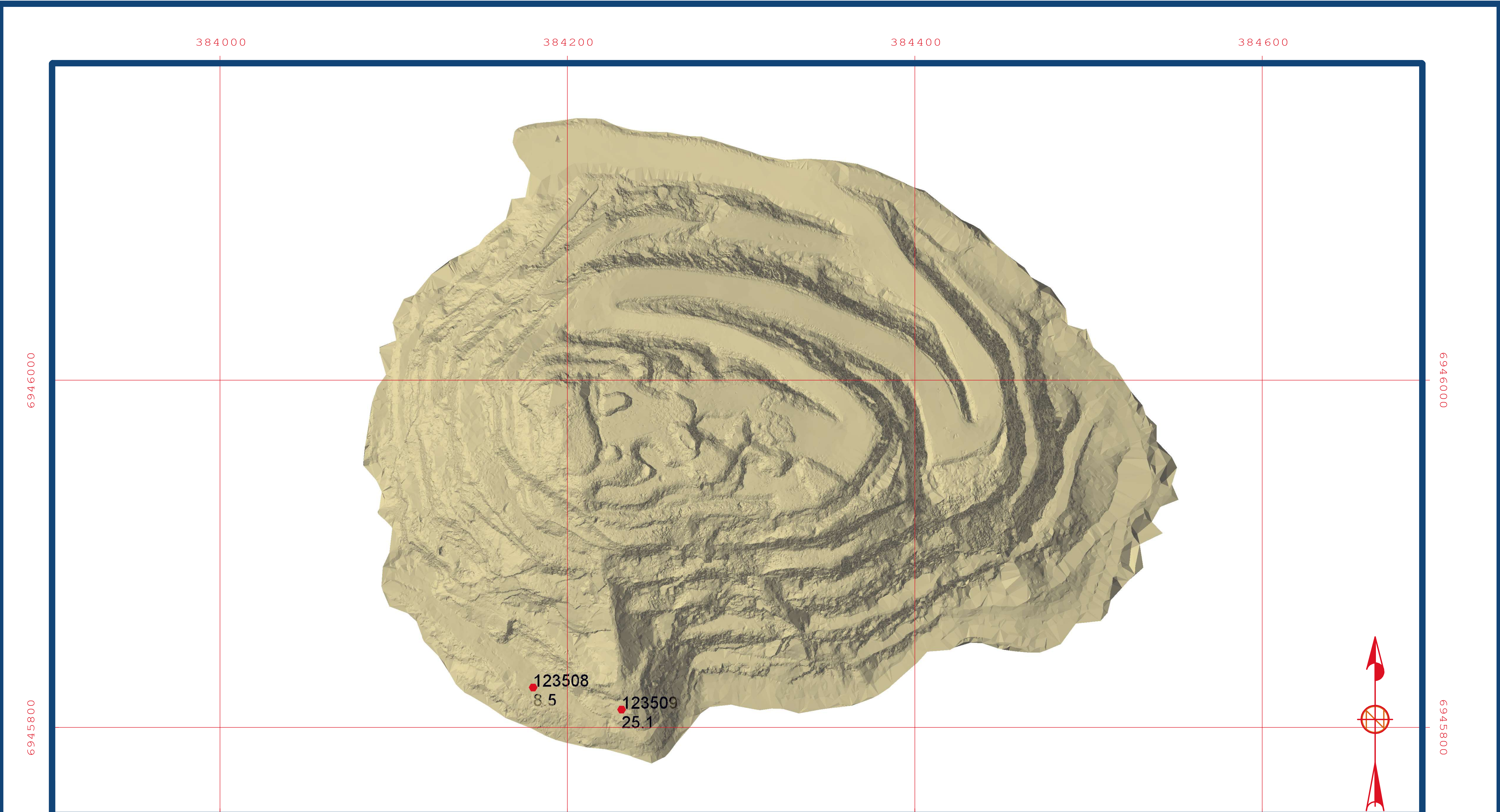

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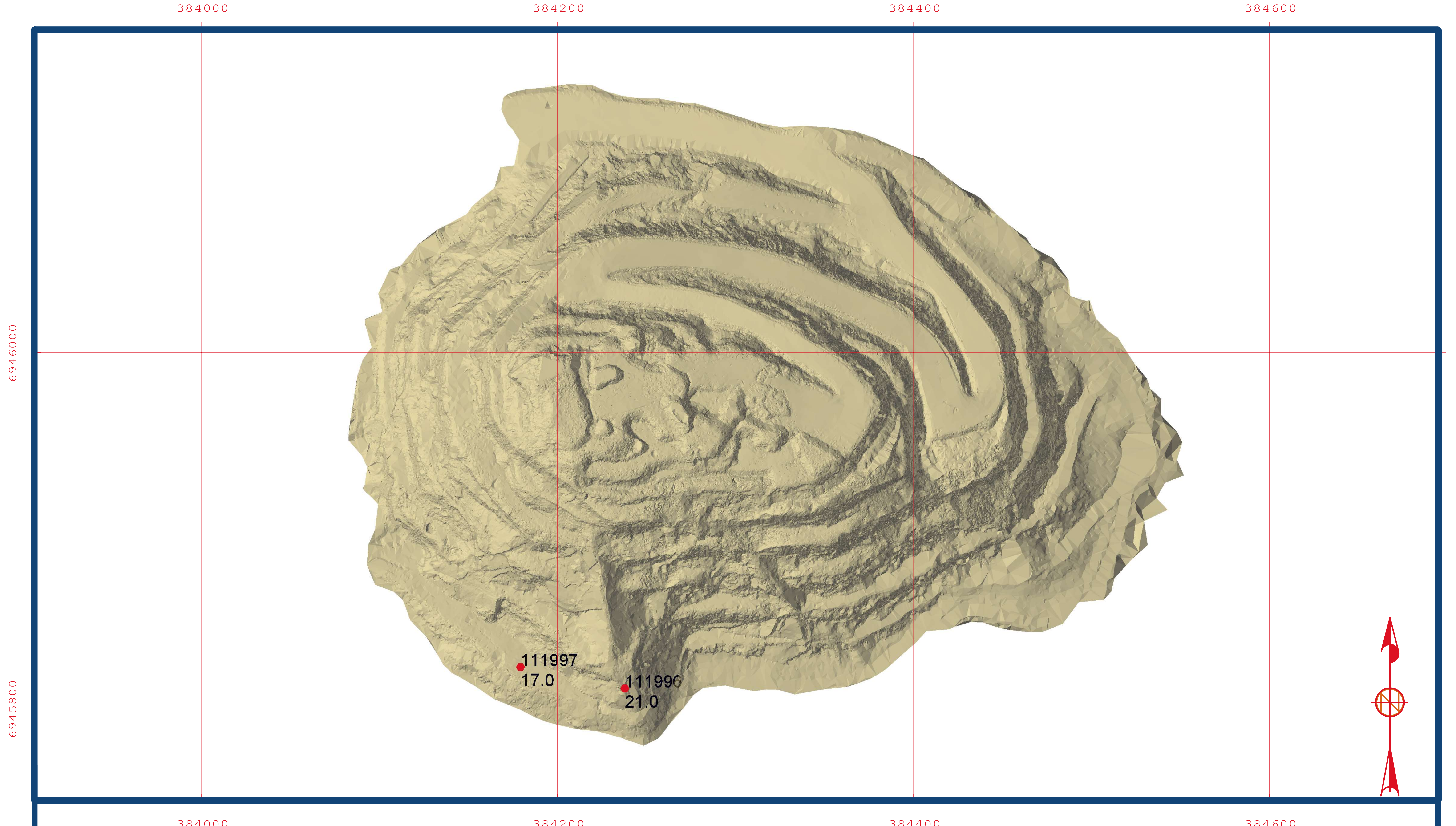

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DATE: 22-Mar-2017

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Metres

capstone
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Appendix B: 2016 Modified NP Method (MEND 1991) ABA Results for Waste Rock and Overburden

Appendix B. Summary Minto North Pit ABA Analysis Results from SGS and ALS Mineral for 2016

Sample Date	ABA ID	Sample Source	Waste Type	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ %	AP $CaCO_3$kg / tonne	NP Modified	Net NP	NP:AP Ratio (NP/AP)
01/01/2016	111994	MNP	CGW	8.83	0.20	16.70	0.23	0.02	<0.01	0.02	0.50	21.3	20.8	45.4
01/01/2016	111995	MNP	CGW	8.88	0.26	21.70	0.26	0.01	<0.01	0.01	0.20	24.0	23.8	109.7
02/01/2016	111996	MNP	CGW	8.53	0.01	0.80	0.05	0.01	<0.01	0.01	0.30	5.9	5.6	21.0
02/01/2016	111997	MNP	NAG	8.36	<0.01	<0.8	0.05	0.01	<0.01	0.01	0.30	5.3	5.0	17.0
04/01/2016	111998	MNP	CGW	8.88	0.24	20.00	0.30	0.02	<0.01	0.02	0.60	23.9	23.3	38.2
05/01/2016	111999	MNP	NAG	9.07	0.21	17.50	0.24	0.03	<0.01	0.03	1.00	21.5	20.5	21.5
07/01/2016	112000	MNP	CGW	8.56	0.09	7.50	0.11	0.04	<0.01	0.04	1.40	12.5	11.1	9.1
09/01/2016	123501	MNP	CGW	8.27	0.19	15.80	0.24	0.04	<0.01	0.04	1.20	18.1	16.9	15.7
13/01/2016	123502	MNP	CGW	8.54	0.21	17.50	0.23	0.03	<0.01	0.03	0.80	19.8	19.0	25.3
14/01/2016	123503	MNP	CGW	7.61	0.01	0.80	0.09	0.02	<0.01	0.02	0.50	5.5	5.0	10.4
15/01/2016	123504	MNP	NAG	7.89	0.10	8.30	0.11	0.06	<0.01	0.06	1.70	12.2	10.5	7.1
15/01/2016	123505	MNP	CGW	8.66	0.22	18.30	0.25	0.04	<0.01	0.04	1.20	21.1	19.9	17.8
15/01/2016	123506	MNP	NAG	8.05	0.25	20.80	0.27	0.11	<0.01	0.11	3.30	23.3	20.0	7.0
15/01/2016	123507	MNP	CGW	7.81	0.03	2.50	0.13	0.09	<0.01	0.09	2.80	7.5	4.8	2.7
16/01/2016	123508	MNP	NAG	8.25	0.05	4.20	0.08	0.03	<0.01	0.03	1.00	8.2	7.2	8.5
16/01/2016	123509	MNP	CGW	8.25	0.13	10.80	0.15	0.02	<0.01	0.02	0.60	14.1	13.5	25.1
17/01/2016	123510	MNP	CGW	7.72	0.02	1.70	0.26	0.02	<0.01	0.02	0.60	6.4	5.8	11.4
18/01/2016	123511	MNP	CGW	8.90	0.11	9.20	0.13	0.02	<0.01	0.02	0.50	14.1	13.6	30.1
20/01/2016	123512	MNP	CGW	9.07	0.15	12.50	0.18	0.02	<0.01	0.02	0.50	15.7	15.2	33.5
22/01/2016	123513	MNP	CGW	8.91	0.23	19.20	0.25	0.06	<0.01	0.06	1.80	23.6	21.8	13.2
22/01/2016	123514	MNP	CGW	8.73	0.71	59.20	0.74	0.02	<0.01	0.02	0.60	62.7	62.1	100.3
22/01/2016	123515	MNP	NAG	8.64	0.44	36.70	0.47	0.03	<0.01	0.03	1.00	39.5	38.5	38.3
23/01/2016	123516	MNP	CGW	7.96	0.05	4.20	0.10	0.01	<0.01	0.01	0.30	10.6	10.3	30.8
24/01/2016	123517	MNP	CGW	8.55	0.27	22.50	0.29	0.10	<0.01	0.10	3.20	25.1	21.9	7.8
24/01/2016	123518	MNP	SAT	8.87	0.16	13.30	0.18	0.01	<0.01	<0.01	<0.3	17.9	17.9	59.7
24/01/2016	123519	MNP	CGW	8.77	0.20	16.70	0.22	0.01	<0.01	<0.01	<0.3	20.5	20.5	68.3
25/01/2016	123520	MNP	CGW	8.77	0.14	11.70	0.15	0.01	<0.01	<0.01	<0.3	16.5	16.5	55.0
25/01/2016	123521	MNP	CGW	8.75	0.19	15.80	0.21	0.02	<0.01	0.02	0.60	21.6	21.0	38.4
26/01/2016	123522	MNP	CGW	9.24	0.07	5.80	0.07	0.01	<0.01	<0.01	<0.3	10.4	10.4	34.7

Appendix B. Summary Minto North Pit ABA Analysis Results from SGS and ALS Mineral for 2016

Sample Date	ABA ID	Sample Source	Waste Type	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ %	AP $CaCO_3$kg / tonne	NP Modified	Net NP	NP:AP Ratio (NP/AP)
28/01/2016	122351	MNP	CGW	8.70	0.18	15.00	0.20	0.14	<0.01	0.14	4.40	20.0	15.6	4.6
29/01/2016	123523	MNP	CGW	8.74	0.20	16.70	0.20	0.01	<0.01	<0.01	<0.3	19.4	19.4	64.7
29/01/2016	123524	MNP	CGW	8.68	0.19	15.80	0.20	0.01	<0.01	<0.01	<0.3	14.9	14.9	49.7
29/01/2016	123525	MNP	CGW	8.89	0.11	9.20	0.11	0.01	<0.01	<0.01	<0.3	12.3	12.3	41.0
30/01/2016	122352	MNP	CGW	8.47	0.07	5.80	0.11	0.01	<0.01	<0.01	<0.3	10.3	10.3	34.3
30/01/2016	122353	MNP	NAG	7.69	<0.01	<0.8	0.04	0.05	<0.01	0.05	1.70	5.1	3.4	3.0
31/01/2016	122354	MNP	CGW	8.81	0.20	16.70	0.21	0.02	<0.01	0.02	0.80	18.4	17.7	24.5
31/01/2016	122355	MNP	NAG	9.04	0.16	13.30	0.15	0.03	<0.01	0.03	0.80	16.4	15.6	21.0
01/02/2016	122356	MNP	CGW	8.44	0.29	24.20	0.32	0.02	<0.01	0.02	0.60	26.5	25.9	42.4
02/02/2016	122357	MNP	CGW	8.45	0.19	15.80	0.23	0.02	<0.01	0.02	0.50	20.5	20.0	43.7
02/02/2016	122358	MNP	NAG	7.97	<0.01	<0.8	0.03	0.03	<0.01	0.03	0.90	4.2	3.3	4.8
03/02/2016	122359	MNP	CGW	8.46	0.37	30.80	0.40	0.15	<0.01	0.15	4.80	34.8	30.0	7.3
04/02/2016	122360	MNP	CGW	8.65	0.19	15.80	0.23	0.04	<0.01	0.04	1.30	19.4	18.2	15.5
04/02/2016	122361	MNP	SAT	8.44	0.18	15.00	0.20	0.42	<0.01	0.42	13.20	19.9	6.7	1.5
05/02/2016	122362	MNP	CGW	8.22	0.05	4.20	0.09	0.02	<0.01	0.02	0.60	9.7	9.1	17.2
06/02/2016	122363	MNP	CGW	8.31	0.43	35.80	0.45	0.06	<0.01	0.06	1.90	39.4	37.5	21.0
06/02/2016	122364	MNP	NAG	8.77	0.14	11.70	0.17	0.02	<0.01	0.02	0.70	17.2	16.5	26.2
07/02/2016	122365	MNP	CGW	8.64	0.21	17.50	0.23	0.04	<0.01	0.04	1.10	21.0	19.9	19.2
07/02/2016	122366	MNP	NAG	8.66	0.20	16.70	0.23	0.08	<0.01	0.08	2.40	20.6	18.2	8.5
08/02/2016	122367	MNP	CGW	8.35	0.03	2.50	0.07	0.01	<0.01	0.01	0.40	8.5	8.1	22.7
09/02/2016	122368	MNP	CGW	8.75	0.16	13.30	0.18	0.01	<0.01	0.01	0.30	17.4	17.1	55.7
10/02/2016	122369	MNP	SAT	8.74	0.18	15.00	0.21	0.32	<0.01	0.32	10.00	19.3	9.3	1.9
11/02/2016	122370	MNP	CGW	8.76	0.10	8.30	0.14	<0.005	<0.01	<0.01	<0.3	13.7	13.7	45.7
12/02/2016	122371	MNP	CGW	8.52	0.27	22.50	0.31	0.02	<0.01	0.02	0.70	27.1	26.4	39.4
12/02/2016	122372	MNP	NAG	8.70	0.26	21.70	0.29	0.01	<0.01	0.01	0.30	24.9	24.6	72.4
12/02/2016	122373	MNP	NAG	8.49	0.38	31.70	0.40	0.11	<0.01	0.11	3.50	35.7	32.2	10.2
13/02/2016	122374	MNP	CGW	8.46	0.24	20.00	0.26	0.04	<0.01	0.04	1.30	23.5	22.2	18.3
14/02/2016	122375	MNP	NAG	8.39	0.31	25.80	0.34	0.02	<0.01	0.02	0.70	29.1	28.4	42.3
15/02/2016	124303	MNP	NAG	8.44	0.02	1.70	0.04	0.02	<0.01	0.02	0.70	6.8	6.1	9.5

Appendix B. Summary Minto North Pit ABA Analysis Results from SGS and ALS Mineral for 2016

Sample Date	ABA ID	Sample Source	Waste Type	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ %	AP $CaCO_3$kg / tonne	NP Modified	Net NP	NP:AP Ratio (NP/AP)
16/02/2016	124304	MNP	CGW	8.49	0.18	15.00	0.27	0.02	<0.01	0.02	0.50	20.6	20.1	38.8
16/02/2016	124305	MNP	CGW	8.47	0.27	22.50	0.31	0.03	<0.01	0.03	1.10	24.0	22.9	22.6
17/02/2016	124306	MNP	CGW	8.73	0.24	20.00	0.27	0.02	<0.01	0.02	0.50	22.4	21.9	44.8
17/02/2016	124307	MNP	CGW	9.12	0.15	12.50	0.17	0.01	<0.01	0.01	0.30	13.6	13.3	39.6
18/02/2016	124301	MNP	NAG	8.49	0.25	20.80	0.26	0.07	<0.01	0.07	2.10	24.5	22.4	11.7
18/02/2016	124302	MNP	CGW	8.66	0.25	20.80	0.26	0.02	<0.01	0.02	0.70	24.1	23.4	33.5
20/02/2016	124308	MNP	CGW	8.12	0.10	8.30	0.11	0.01	<0.01	0.01	0.40	13.8	13.4	31.5
20/02/2016	124309	MNP	CGW	9.01	0.10	8.30	0.11	0.03	<0.01	0.03	0.90	1.2	0.3	1.4
20/02/2016	124310	MNP	CGW	8.98	0.08	6.70	0.09	0.01	<0.01	0.01	0.40	11.7	11.3	31.2
22/02/2016	124311	MNP	CGW	8.62	0.04	3.30	0.07	0.01	<0.01	0.01	0.40	9.3	8.9	24.8
24/02/2016	124312	MNP	CGW	9.13	0.18	15.00	0.20	0.06	<0.01	0.06	2.00	21.4	19.4	10.9
24/02/2016	124313	MNP	CGW	9.07	0.20	16.70	0.22	0.02	<0.01	0.02	0.50	22.3	21.8	47.6
25/02/2016	124316	MNP	NAG	9.18	0.15	12.50	0.15	0.21	<0.01	0.21	6.40	15.6	9.2	2.4
27/02/2016	124314	MNP	CGW	9.39	0.07	5.80	0.08	0.01	<0.01	0.01	0.40	10.8	10.4	26.6
27/02/2016	124315	MNP	NAG	8.76	<0.01	<0.8	0.01	0.04	<0.01	0.04	1.30	4.3	3.0	3.4
28/02/2016	124317	MNP	NAG	8.75	0.38	31.70	0.40	0.07	<0.01	0.07	2.00	33.4	31.4	16.4
28/02/2016	124318	MNP	NAG	8.94	0.27	22.50	0.29	0.10	<0.01	0.10	3.10	26.4	23.3	8.5
28/02/2016	124319	MNP	CGW	9.12	0.18	15.00	0.23	0.09	<0.01	0.09	2.90	18.1	15.2	6.3
01/03/2016	124320	MNP	NAG	9.19	0.15	12.50	0.17	0.02	<0.01	0.02	0.50	16.1	15.6	30.3
01/03/2016	124321	MNP	CGW	9.08	0.21	17.50	0.22	0.01	<0.01	0.01	0.30	17.0	16.7	49.5
02/03/2016	124322	MNP	CGW	8.88	0.22	18.30	0.24	0.02	<0.01	0.02	0.60	23.5	22.9	41.8
05/03/2016	124323	MNP	NAG	8.60	0.19	15.80		0.06		0.06	1.88	23.0	21.0	12.3
05/03/2016	124324	MNP	CGW	9.21	0.13	10.80	0.15	0.02	<0.01	0.02	0.50	14.6	14.1	27.5
05/03/2016	124325	MNP	NAG	9.30	0.06	5.00		<0.01		<0.01	0.31	12.0	12.0	38.4
06/03/2016	117251	MNP	CGW	9.12	0.16	13.30	0.20	0.02	<0.01	0.02	0.50	17.2	16.7	32.4
07/03/2016	117252	MNP	SAT	8.98	0.22	18.30	0.23	0.32	<0.01	0.32	9.90	22.1	12.2	2.2
07/03/2016	117253	MNP	NAG	9.04	0.18	15.00	0.18	0.06	<0.01	0.06	1.90	15.5	13.6	8.0
08/03/2016	117254	MNP	CGW	9.20	0.06	5.00	0.08	0.01	<0.01	<0.01	<0.3	10.2	10.2	34.0
09/03/2016	117255	MNP	SAT	9.10	0.14	11.70	0.15	0.18	<0.01	0.18	5.60	14.8	9.2	2.7

Appendix B. Summary Minto North Pit ABA Analysis Results from SGS and ALS Mineral for 2016

Sample Date	ABA ID	Sample Source	Waste Type	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ %	AP $CaCO_3$kg / tonne	NP Modified	Net NP	NP:AP Ratio (NP/AP)
10/03/2016	117256	MNP	NAG	8.79	0.27	22.50	0.28	0.14	<0.01	0.14	4.40	25.1	20.7	5.7
11/03/2016	117257	MNP	SAT	8.96	0.18	15.00	0.21	0.05	<0.01	0.05	1.70	19.3	17.6	11.7
12/03/2016	117258	MNP	NAG	8.60	0.25	20.80		0.03		0.03	0.94	26.0	25.0	27.7
12/03/2016	117259	MNP	CGW	9.00	<0.05	4.20		0.02		0.02	0.63	11.0	10.0	17.6
15/03/2016	117261	MNP	CGW	9.00	0.16	13.30		0.01		0.01	0.31	21.0	21.0	67.2
17/03/2016	117262	MNP	CGW	9.00	0.10	8.30		<0.01		<0.01	0.31	19.0	19.0	60.8
18/03/2016	117260	MNP	CGW	9.00	0.11	9.20		<0.01		<0.01	0.31	19.0	19.0	60.8
19/03/2016	117263	MNP	CGW	8.60	0.22	18.30		0.01		0.01	0.31	27.0	27.0	86.4
22/03/2016	117264	MNP	CGW	9.00	0.09	7.50		<0.01		<0.01	0.31	18.0	18.0	57.6
25/03/2016	117265	MNP	CGW	9.20	0.08	6.70		<0.01		<0.01	0.31	16.0	16.0	51.2
29/03/2016	117266	MNP	CGW	8.60	0.09	7.50		0.03	0.01	0.02	0.63	17.0	16.0	27.2
02/04/2016	117267	MNP	CGW	8.60	0.17	14.20		0.01	0.01	<0.01	0.31	23.0	23.0	73.6
04/04/2016	117268	MNP	NAG	8.80	0.18	15.00		0.21	0.01	0.20	6.25	24.0	17.0	3.8
06/04/2016	117269	MNP	CGW	8.60	0.18	15.00		0.02	0.01	0.01	0.31	23.0	22.0	73.6
06/04/2016	117271	MNP	CGW	8.90	0.09	7.50		0.03	0.01	0.02	0.63	16.0	15.0	25.6
08/04/2016	117270	MNP	CGW	8.60	0.18	15.00		0.02	0.01	0.01	0.31	24.0	23.0	76.8
10/04/2016	117272	MNP	CGW	9.10	0.08	6.70		0.02	0.01	0.01	0.31	17.0	16.0	54.4
10/04/2016	117273	MNP	NAG	8.70	0.15	12.50		0.04	0.01	0.03	0.94	22.0	21.0	23.5
10/04/2016	117454	MNP	CGW	9.00	0.06	5.00		0.03	<0.01	0.03	0.94	15.0	14.0	16.0
13/04/2016	117274	MNP	NAG	8.50	0.37	30.80		0.12	0.01	0.11	3.44	38.0	34.0	11.1
17/04/2016	117275	MNP	NAG	8.50	0.25	20.80		0.04	<0.01	0.04	1.25	26.0	25.0	20.8
18/04/2016	117451	MNP	SAT	8.60	0.23	19.20		0.19	0.03	0.16	5.00	25.0	19.0	5.0
19/04/2016	117452	MNP	CGW	8.90	0.12	10.00		0.01	0.02	<0.01	0.31	19.0	19.0	60.8
21/04/2016	117453	MNP	CGW	9.20	0.07	5.80		0.02	0.02	<0.01	0.31	16.0	15.0	51.2
26/04/2016	117455	MNP	CGW	9.10	0.10	8.30		0.01	0.01	<0.01	0.31	18.0	18.0	57.6
29/04/2016	117456	MNP	CGW	8.80	0.23	19.20		0.01	0.02	<0.01	0.31	25.0	25.0	80.0
29/04/2016	117457	MNP	NAG	8.60	0.42	35.00		0.04	0.01	0.03	0.94	40.0	39.0	42.7
01/05/2016	117458	MNP	CGW	8.70	0.23	19.20		0.01	0.03	<0.01	0.31	27.0	27.0	86.4
03/05/2016	117459	MNP	CGW	8.80	0.20	16.70		<0.01	<0.01	<0.01	0.31	24.0	24.0	76.8

Appendix B. Summary Minto North Pit ABA Analysis Results from SGS and ALS Mineral for 2016

Sample Date	ABA ID	Sample Source	Waste Type	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ %	AP $CaCO_3$kg / tonne	NP Modified	Net NP	NP:AP Ratio (NP/AP)
03/05/2016	117460	MNP	CGW	8.70	0.24	20.00		0.01	0.02	<0.01	0.31	29.0	29.0	92.8
05/05/2016	117461	MNP	SAT	8.60	0.33	27.50		0.09	0.01	0.08	2.50	29.0	26.0	11.6
09/05/2016	117462	MNP	CGW	8.90	0.15	12.50		0.01	0.03	<0.01	0.31	23.0	23.0	73.6
10/05/2016	117463	MNP	NAG	8.90	0.17	14.20		0.02	0.01	0.01	0.31	23.0	22.0	73.6
12/05/2016	117464	MNP	NAG	9.00	0.15	12.50		<0.01	<0.01	<0.01	0.31	21.0	21.0	67.2
12/05/2016	117465	MNP	SAT	8.80	0.16	13.30		0.05	0.01	0.04	1.25	21.0	19.0	16.8
13/05/2016	117466	MNP	SAT	8.30	0.55	45.80		0.76	0.01	0.75	23.44	50.0	26.0	2.1
14/05/2016	117467	MNP	NAG	8.90	0.22	18.30		0.01	0.02	<0.01	0.31	28.0	28.0	89.6
16/05/2016	117468	MNP	CGW	9.30	0.08	6.70		<0.01	0.01	<0.01	0.31	17.0	17.0	54.4
18/05/2016	117469	MNP	CGW	8.90	0.25	20.80		<0.01	0.02	<0.01	0.31	25.0	25.0	80.0
19/05/2016	117470	MNP	CGW	8.70	0.33	27.50		0.01	0.03	<0.01	0.31	28.0	28.0	89.6
20/05/2016	117471	MNP	CGW	8.70	0.27	22.50		0.01	0.01	<0.01	0.31	26.0	26.0	83.2
20/05/2016	117472	MNP	NAG	8.50	0.41	34.20		0.07	0.02	0.05	1.56	37.0	35.0	23.7
22/05/2016	117473	MNP	NAG	9.30	0.14	11.70		0.01	0.01	<0.01	0.31	14.0	14.0	44.8
25/05/2016	117474	MNP	SAT	9.10	0.20	16.70		0.30	0.02	0.28	8.75	17.0	8.0	1.9
25/05/2016	117475	MNP	CGW	9.30	0.08	6.70		<0.01	0.01	<0.01	0.31	15.0	15.0	48.0
25/05/2016	119326	MNP	CGW	9.00	0.27	22.50		0.01	0.03	<0.01	0.31	22.0	22.0	70.4
26/05/2016	119327	MNP	CGW	9.20	0.19	15.80		<0.01	0.02	<0.01	0.31	15.0	15.0	48.0
27/05/2016	119328	MNP	NAG	9.00	0.20	16.70		0.03	0.03	<0.01	0.31	16.0	15.0	51.2
28/05/2016	119329	MNP	CGW	8.80	0.31	25.80		<0.01	0.01	<0.01	0.31	27.0	27.0	86.4
29/05/2016	119330	MNP	NAG	8.70	0.35	29.20		0.02	0.01	0.01	0.31	26.0	25.0	83.2
30/05/2016	119331	MNP	CGW	9.00	0.27	22.50		<0.01	0.02	<0.01	0.31	19.0	19.0	60.8
02/06/2016	119332	MNP	CGW	9.10	0.26	21.70		0.03	0.01	0.02	0.63	20.0	19.0	32.0
02/06/2016	119333	MNP	CGW	8.90	0.37	30.80		0.01	0.01	<0.01	0.31	24.0	24.0	76.8
03/06/2016	119334	MNP	CGW	8.80	0.41	34.20		<0.01	0.01	<0.01	0.31	31.0	31.0	99.2
04/06/2016	119335	MNP	CGW	9.00	0.19	15.80		0.01	0.02	<0.01	0.31	24.0	24.0	76.8
06/06/2016	119336	MNP	NAG	8.60	0.19	15.80		0.03	0.02	0.01	0.31	24.0	23.0	76.8
06/06/2016	119337	MNP	NAG	8.80	0.15	12.50		0.05	<0.01	0.05	1.56	20.0	18.0	12.8

Appendix B. Summary Minto North Pit ABA Analysis Results from SGS and ALS Mineral for 2016

Sample Date	ABA ID	Sample Source	Waste Type	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ %	AP $CaCO_3$kg / tonne	NP Modified	Net NP	NP:AP Ratio (NP/AP)
08/06/2016	119338	MNP	SAT	8.60	0.12	10.00		0.07	0.04	0.03	0.94	18.0	16.0	19.2
14/06/2016	119341	MNP	NAG	8.90	0.16	13.30		0.01	0.02	<0.01	0.31	19.0	19.0	60.8
17/06/2016	119342	MNP	NAG	8.60	0.26	21.70		0.02	0.02	<0.01	0.31	27.0	26.0	86.4
19/06/2016	119343	MNP	NAG	8.80	0.24	20.00		0.05	0.02	0.03	0.94	25.0	23.0	26.7
24/06/2016	119339	MNP	NAG	8.60	0.22	18.30		0.01	<0.01	0.01	0.31	32.0	32.0	102.4
27/06/2016	119340	MNP	NAG	8.90	0.13	10.80		0.01	<0.01	0.01	0.31	18.0	18.0	57.6
30/06/2016	119344	MNP	CGW	8.90	0.19	15.80		<0.01	<0.01	<0.01	0.31	23.0	23.0	73.6
01/07/2016	119345	MNP	SAT	8.50	0.09	7.50		0.62	0.01	0.61	19.06	16.0	-3.0	0.8
02/07/2016	119346	MNP	CGW	8.80	0.27	22.50		<0.01	0.02	<0.01	0.31	32.0	32.0	102.4
08/07/2016	119348	MNP	NAG	8.50	0.27	22.50		0.01	0.01	<0.01	0.31	26.0	26.0	83.2
09/07/2016	119350	MNP	NAG	8.90	0.09	7.50		0.01	<0.01	0.01	0.31	13.0	13.0	41.6
10/07/2016	119349	MNP	NAG	8.90	0.17	14.20		0.01	<0.01	0.01	0.31	17.0	17.0	54.4
16/07/2016	119347	MNP	NAG	8.70	0.28	23.30		0.03	0.04	<0.01	0.31	27.0	26.0	86.4
17/07/2016	127976	MNP	NAG	8.30	0.26	21.70		0.06	0.02	0.04	1.25	22.0	20.0	17.6
18/07/2016	127977	MNP	NAG	8.60	0.16	13.30		0.15	0.03	0.12	3.75	15.0	10.0	4.0
21/07/2016	127978	MNP	NAG	8.80	0.17	14.20		0.01	<0.01	0.01	0.31	17.0	17.0	54.4
23/07/2016	127979	MNP	NAG	8.90	0.25	20.80		0.03	0.01	0.02	0.63	22.0	21.0	35.2
28/07/2016	127980	MNP	NAG	8.90	0.20	16.70		0.01	0.02	<0.01	0.31	18.0	18.0	57.6
30/07/2016	127981	MNP	NAG	8.70	0.32	26.70		0.01	0.02	<0.01	0.31	25.0	25.0	80.0
01/08/2016	127982	MNP	NAG	9.20	0.09	7.50		0.01	0.02	<0.01	0.31	14.0	14.0	44.8
03/08/2016	127983	MNP	NAG	9.10	0.15	12.50		<0.01	0.02	<0.01	0.31	16.0	16.0	51.2
04/08/2016	127984	MNP	NAG	8.90	0.19	15.80		<0.01	0.01	<0.01	0.31	19.0	19.0	60.8
05/08/2016	127985	MNP	NAG	8.90	0.20	16.70		0.01	0.01	<0.01	0.31	22.0	22.0	70.4
06/08/2016	127986	MNP	NAG	8.60	0.30	25.00		0.01	0.03	<0.01	0.31	30.0	30.0	96.0
07/08/2016	127987	MNP	NAG	8.50	0.41	34.20		0.05	0.06	<0.01	0.31	38.0	36.0	121.6
08/08/2016	127988	MNP	NAG	8.90	0.20	16.70		0.01	<0.01	0.01	0.31	21.0	21.0	67.2
08/08/2016	127989	MNP	SAT	8.80	0.18	15.00		0.06	0.02	0.04	1.25	22.0	20.0	17.6
09/08/2016	127990	MNP	NAG	8.60	0.39	32.50		0.01	0.01	0.01	0.31	37.0	37.0	118.4

Appendix B. Summary Minto North Pit ABA Analysis Results from SGS and ALS Mineral for 2016

Sample Date	ABA ID	Sample Source	Waste Type	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ %	AP $CaCO_3$kg / tonne	NP Modified	Net NP	NP:AP Ratio (NP/AP)
10/08/2016	127991	MNP	NAG	9.20	0.10	8.30		<0.01	0.01	<0.01	0.31	17.0	17.0	54.4
11/08/2016	127992	MNP	NAG	8.80	0.27	22.50		<0.01	<0.01	<0.01	0.31	25.0	25.0	80.0
13/08/2016	127996	MNP	NAG	8.90	0.18	15.00		0.05	0.01	0.04	1.25	21.0	19.0	16.8
13/08/2016	127997	MNP	SAT	8.90	0.16	13.30		0.19	0.02	0.17	5.31	21.0	15.0	4.0
14/08/2016	127993	MNP	NAG	9.10	0.14	11.70		0.01	0.01	<0.01	0.31	20.0	20.0	64.0
14/08/2016	127994	MNP	NAG	8.60	0.42	35.00		0.02	0.01	0.01	0.31	41.0	40.0	131.2
14/08/2016	127995	MNP	NAG	9.20	0.08	6.70		0.03	0.02	0.01	0.31	13.0	12.0	41.6
15/08/2016	127998	MNP	NAG	8.70	0.19	15.80		0.07	0.02	0.05	1.56	24.0	22.0	15.4
16/08/2016	127999	MNP	NAG	8.60	0.39	32.50		0.01	0.02	<0.01	0.31	35.0	35.0	112.0
17/08/2016	128000	MNP	SAT	8.90	0.10	8.30		0.11	0.05	0.06	1.88	16.0	13.0	8.5
18/08/2016	127951	MNP	NAG	8.70	0.25	20.80		0.03	0.03	<0.01	0.31	26.0	25.0	83.2
20/08/2016	127952	MNP	NAG	8.80	0.22	18.30		0.03	0.01	0.02	0.63	22.0	21.0	35.2
21/08/2016	127953	MNP	NAG	9.10	0.16	13.30		0.02	0.04	<0.01	0.31	19.0	18.0	60.8
25/08/2016	127954	MNP	NAG	8.90	0.23	19.20		0.02	0.03	<0.01	0.31	25.0	24.0	80.0
25/08/2016	127955	MNP	NAG	8.70	0.28	23.30		0.03	0.04	<0.01	0.31	28.0	27.0	89.6
26/08/2016	127956	MNP	NAG	8.70	0.28	23.30		0.08	0.05	0.03	0.94	25.0	23.0	26.7
27/08/2016	127957	MNP	NAG	8.90	0.22	18.30		0.03	0.03	<0.01	0.31	25.0	24.0	80.0
29/08/2016	127958	MNP	SAT	8.20	0.31	25.80		0.32	0.01	0.31	9.69	26.0	16.0	2.7
30/08/2016	127959	MNP	NAG	8.80	0.08	6.70		0.12	0.01	0.11	3.44	15.0	11.0	4.4
01/09/2016	127960	MNP	NAG	8.70	0.18	15.00		0.02	0.01	0.01	0.31	22.0	21.0	70.4
02/09/2016	127961	MNP	NAG	8.70	0.20	16.70		0.01	0.02	<0.01	0.31	21.0	21.0	67.2
02/09/2016	127962	MNP	NAG	8.70	0.20	16.70		<0.01	0.01	<0.01	0.31	22.0	22.0	70.4
03/09/2016	127963	MNP	SAT	8.40	0.21	17.50		0.09	0.02	0.07	2.19	18.0	15.0	8.2
03/09/2016	127964	MNP	NAG	8.30	0.30	25.00		0.29	0.02	0.27	8.44	26.0	17.0	3.1
04/09/2016	127965	MNP	SAT	8.70	0.24	20.00		0.05	0.03	0.02	0.63	22.0	20.0	35.2
06/09/2016	127966	MNP	NAG	8.80	0.17	14.20		0.01	<0.01	0.01	0.31	19.0	19.0	60.8
10/09/2016	127967	MNP	SAT	8.60	0.25	20.80		0.07	0.01	0.06	1.88	28.0	26.0	14.9
10/09/2016	127968	MNP	NAG	8.70	0.23	19.20		0.05	<0.01	0.05	1.56	25.0	23.0	16.0

Appendix B. Summary Minto North Pit ABA Analysis Results from SGS and ALS Mineral for 2016														
Sample Date	ABA ID	Sample Source	Waste Type	Paste pH	TIC %	$CaCO_3$ NP	C(T) %	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ %	AP $CaCO_3$kg / tonne	NP Modified	Net NP	NP:AP Ratio (NP/AP)
13/09/2016	127970	MNP	NAG	8.60	0.42	35.00		0.02	0.01	0.01	0.31	42.0	41.0	134.4
17/09/2016	127969	MNP	NAG	8.70	0.15	12.50		0.02	0.01	0.01	0.31	18.0	17.0	57.6
18/09/2016	127971	MNP	NAG	9.00	0.08	6.70		0.17	0.02	0.15	4.69	13.0	8.0	2.8

Summary Area 118 and Area 2 Underground ABA Results												
Sample Date	ABA ID	Waste Type	Paste pH	TIC %	$CaCO_3$ NP	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ %	AP $CaCO_3$kg / tonne	NP Modified NP	Net NP	NP:AP Ratio (NP/AP)
16/04/2016	123696	NAG	8.9	0.1	8.3	0.03	0.01	0.02	0.63	13	14	24
23/04/2016	123697	NAG	8.8	0.06	5	0.01	0.01	0.01	0.31	12	12	38.4
13/05/2016	123698	NAG	8.3	0.11	9.2	0.35	0.27	0.08	2.5	16	5	6.4
21/05/2016	123699	NAG	8.7	0.22	18.3	0.04	0.01	0.04	1.25	16	15	12.8
30/07/2016	127788	NAG	9.2	0.08	6.7	0.01	0.01	0.01	0.31	12	12	38.4
30/07/2016	127785	NAG	9.2	0.08	6.7	0.01	0.02	0.01	0.31	11	11	35.2
30/07/2016	127786	NAG	9.1	0.08	6.7	0.04	0.03	0.01	0.31	12	11	38.4
30/07/2016	127787	NAG	9.2	0.08	6.7	0.01	0.01	0.01	0.31	11	11	35.2
30/07/2016	130440	SAT	8.4	0.1	8.3	0.56	0.36	0.2	6.25	12	-6	1.9
30/07/2016	130441	NAG	8.4	0.08	6.7	0.4	0.29	0.11	3.44	12	-1	3.5

Appendix C: SGS and ALS Minerals Raw Lab Results

CLIENT : Minto Mines
PROJECT : Minto Mines
SGS Project # : 0643
Test : Modified Acid-Base Accounting
Date : February 11, 2016

Sample ID	**Sampling Date**	**Paste pH**	**TIC %**	**CaCO3 NP**	**C(T) %**	**S(T) %**	**S(SO4) %**	**S(S-2) %**	**AP**	**NP**	**Net NP**	**NP:AP Ratio (NP/AP)**	**Fizz Test**
Method Code		Sobek	CSB02V	Calc #N/A	CSA06V 0.005	CSA06V 0.005	CSA07V 0.01	Calc #N/A	Calc #N/A	Modified 0.5	Calc #N/A	Calc #N/A	Sobek #N/A
106893	19-Dec-15	8.46	0.26	21.7	0.269	0.046	<0.01	0.05	1.4	25.6	24.2	17.8	Slight
106894	19-Dec-15	8.57	0.34	28.3	0.36	0.085	<0.01	0.09	2.7	29.9	27.2	11.3	Slight
106895	19-Dec-15	8.82	0.18	15.0	0.2	0.011	<0.01	0.01	0.3	19.0	18.7	55.3	Slight
106896	19-Dec-15	8.45	0.33	27.5	0.335	0.708	<0.01	0.71	22.1	30.6	8.5	1.4	Slight
106897	19-Dec-15	8.40	0.62	51.7	0.615	0.171	<0.01	0.17	5.3	53.3	48.0	10.0	Slight
106898	19-Dec-15	8.79	0.01	0.8	0.057	0.009	<0.01	0.01	0.3	7.5	7.2	26.7	None
106899	21-Dec-15	9.00	0.03	2.5	0.048	0.016	<0.01	0.02	0.5	4.5	4.0	9.0	None
106900	20-Dec-15	8.88	0.16	13.3	0.17	0.276	<0.01	0.28	8.6	17.6	9.0	2.0	None
111976	28-Dec-15	8.94	0.18	15.0	0.196	0.075	<0.01	0.08	2.3	20.0	17.7	8.5	None
111977	28-Dec-15	8.21	0.11	9.2	0.118	0.008	<0.01	0.01	0.3	11.9	11.7	47.6	None
111978	29-Dec-15	8.63	0.27	22.5	0.268	0.628	<0.01	0.63	19.6	26.8	7.2	1.4	Slight
111979	28-Dec-15	8.83	0.16	13.3	0.178	0.054	<0.01	0.05	1.7	17.8	16.1	10.5	Slight
111980	28-Dec-15	8.57	0.28	23.3	0.287	0.032	<0.01	0.03	1.0	26.9	25.9	26.9	Slight
111981	28-Dec-15	9.09	0.13	10.8	0.135	0.023	<0.01	0.02	0.7	15.4	14.7	21.4	None
111982	28-Dec-15	8.57	0.02	1.7	0.041	0.008	<0.01	0.01	0.3	7.3	7.1	29.2	None
111983	28-Dec-15	9.08	0.18	15.0	0.187	0.024	<0.01	0.02	0.8	19.4	18.7	25.9	Slight
111984	29-Dec-15	8.89	0.15	12.5	0.162	0.943	<0.01	0.94	29.5	17.1	-12.4	0.6	None
111985	28-Dec-15	8.53	0.21	17.5	0.22	0.072	<0.01	0.07	2.3	21.9	19.7	9.7	Slight
111986	28-Dec-15	8.82	0.1	8.3	0.13	0.06	<0.01	0.06	1.9	12.8	10.9	6.8	None
111987	28-Dec-15	8.59	0.26	21.7	0.257	0.642	<0.01	0.64	20.1	23.1	3.0	1.2	Slight
111988	28-Dec-15	8.92	0.18	15.0	0.213	0.008	<0.01	0.01	0.3	20.3	20.1	81.2	Slight
111989	29-Dec-15	8.81	0.01	0.8	0.03	0.01	<0.01	0.01	0.3	5.4	5.1	17.3	None
111990	2-Jan-16	8.90	0.08	6.7	0.138	0.066	<0.01	0.07	2.1	11.8	9.7	5.7	None
111991	3-Jan-16	8.54	0.5	41.7	0.498	0.074	<0.01	0.07	2.3	42.1	39.8	18.2	Slight
111992	3-Jan-16	9.06	0.11	9.2	0.143	0.011	<0.01	0.01	0.3	12.3	12.0	35.8	None
111993	3-Jan-16	8.83	0.14	11.7	0.181	0.009	<0.01	0.01	0.3	15.5	15.2	55.1	Slight
111994	3-Jan-16	8.83	0.2	16.7	0.234	0.015	<0.01	0.02	0.5	21.3	20.8	45.4	Slight
111995	3-Jan-16	8.88	0.26	21.7	0.263	0.007	<0.01	0.01	0.2	24.0	23.8	109.7	Slight
111996	4-Jan-16	8.53	0.01	0.8	0.049	0.009	<0.01	0.01	0.3	5.9	5.6	21.0	None
111997	4-Jan-16	8.36	<0.01	<0.8	0.053	0.01	<0.01	0.01	0.3	5.3	5.0	17.0	None
Nov Final Tails	25-Nov-15	8.71	0.29	24.2	0.31	0.054	<0.01	0.05	1.7	22.4	20.7	13.3	Slight
Dec Final Tails	20-Dec-15	8.58	0.24	20.0	0.272	0.045	<0.01	0.05	1.4	21.9	20.5	15.6	Slight
Duplicates													
106893		8.54								25.3			Slight
106898					0.056	0.006							
106899			0.03										
111981							<0.01						
111985			0.21										
111987		8.62								23.4			Slight
111988		8.89			0.212	0.007				20.4			Slight
111995							<0.01						
Dec Final Tails			0.25										
QC													
GTS-2A					1.97	0.33							
RTS-3A							0.96						
RTS-3A							0.96						
SY-4			0.91										
NBM-1										40.4			Slight
Expected Values			0.95		2.01	0.341	0.98			42.0			Slight
Tolerance +/-			0.06		0.15	0.030	0.12			3.0			

Note:

AP = Acid potential in tonnes CaCO3 equivalent per 1000 tonnes of material. AP is determined from calculated sulphide sulphur content: S(T) - S(SO4).

NP = Neutralization potential in tonnes CaCO3 equivalent per 1000 tonnes of material.

NET NP = NP - AP

Carbonate NP is calculated from TIC originating from carbonate minerals and is expressed in kg CaCO3/tonne.

CLIENT : Minto Mines
PROJECT : Minto Project
SGS Project # : 0643
Test : Metals by Aqua Regia Digestion with ICP-MS Finish
Date : February 11, 2016

Sample ID	Ag ppm	Al %	B ppm	Ba ppm	Ca %	Cr ppm	Cu ppm	Fe %	K %	Li ppm	Mg %	Mn ppm	Na %	Ni ppm	P %	S %	Sr ppm	Ti %	V ppm	Zn ppm	Zr ppm	As ppm	Be ppm	Bi ppm
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	0.01	0.01	10	5	0.01	1	0.5	0.01	0.01	1	0.01	2	0.01	0.5	0.005	0.01	0.5	0.01	1	1	0.5	1	0.1	0.02
106893	0.23	1.34	40	101	1.48	100	606	2.18	0.2	8	0.73	491	0.05	3	0.068	0.04	127	0.06	45	64	1.5	2	0.5	0.21
106894	0.17	1.11	40	148	1.55	98	674	2.12	0.32	7	0.62	488	0.05	3.1	0.062	0.1	143	0.06	42	55	1.4	2	0.4	0.07
106895	0.04	1.14	50	148	1.08	94	70.5	2.05	0.3	6	0.66	480	0.06	3.1	0.062	<0.01	82.4	0.08	42	61	1.3	<1	0.4	<0.02
106896	1.04	1.31	40	192	1.45	90	3550	2.73	0.52	8	0.66	411	0.04	2.6	0.075	0.8	208	0.08	54	74	1.3	<1	0.3	0.33
106897	0.34	1.21	40	43	2.52	93	1570	1.92	0.12	6	0.51	487	0.04	2.6	0.066	0.19	133	0.02	35	55	1.2	1	0.6	0.25
106898	0.05	1.13	50	216	0.56	110	78.7	2.4	0.56	8	0.76	553	0.07	3.8	0.079	<0.01	28.4	0.14	60	67	2.1	<1	0.3	0.04
106899	0.08	1.25	50	175	0.79	100	174	2.42	0.47	7	0.79	497	0.07	3.3	0.1	0.01	60.8	0.14	63	63	2.3	1	0.4	0.03
106900	0.81	1.54	50	401	0.96	100	2730	3.18	0.9	8	0.94	599	0.06	3.2	0.093	0.3	124	0.17	76	94	1.9	4	0.3	0.28
111976	0.23	1.13	50	223	1.04	95	502	2.3	0.56	6	0.72	520	0.06	3.1	0.069	0.08	89.7	0.11	50	66	1.9	1	0.3	0.05
111977	0.01	1.12	50	278	0.77	112	8	2.34	0.68	7	0.73	504	0.07	3.3	0.055	<0.01	51.2	0.13	48	60	1.3	<1	0.2	<0.02
111978	0.9	1.22	40	79	1.29	89	4070	2.57	0.29	9	0.73	410	0.04	2.7	0.075	0.74	111	0.04	43	69	1.8	1	0.4	0.54
111979	0.17	1.24	50	178	1.05	105	636	2.35	0.43	7	0.76	480	0.06	3.1	0.062	0.06	95.8	0.1	50	60	1.4	<1	0.3	0.08
111980	0.1	1.16	40	164	1.43	104	310	2.3	0.34	7	0.68	490	0.05	3.2	0.061	0.03	75.2	0.08	45	53	1.3	<1	0.4	0.03
111981	0.11	1.52	50	318	0.93	96	276	2.6	0.61	9	0.92	536	0.06	3.2	0.073	0.02	62.7	0.15	68	82	1.4	1	0.4	0.03
111982	0.02	1.07	50	244	0.5	106	32.2	2.19	0.51	6	0.63	446	0.07	3.3	0.067	<0.01	32.8	0.11	51	54	1.9	2	0.2	<0.02
111983	0.11	1.18	50	177	1.07	89	141	2.55	0.51	7	0.8	570	0.06	2.7	0.076	0.02	75.4	0.11	61	75	1.8	14	0.3	0.03
111984	0.79	1.97	50	279	0.91	91	3320	3.84	1.19	12	1.17	550	0.05	3	0.099	1.04	209	0.19	93	91	1.6	<1	0.3	0.22
111985	1.01	1.37	40	117	1.37	93	1160	3.08	0.22	6	0.88	599	0.06	2.9	0.092	0.08	113	0.09	58	83	1.5	<1	0.4	0.37
111986	0.11	1.28	40	182	0.88	99	179	2.65	0.51	7	0.82	526	0.06	3.3	0.076	0.06	71.1	0.14	59	64	2	1	0.3	0.02
111987	1.65	1.82	40	448	1.27	101	5020	3.49	1.04	10	0.96	559	0.05	3.6	0.091	0.72	236	0.17	78	90	1.3	<1	0.3	0.48
111988	0.02	1.27	50	122	1.29	111	11.7	2.28	0.2	7	0.75	494	0.07	3.7	0.076	<0.01	198	0.07	48	56	1.5	<1	0.4	<0.02
111989	0.06	0.93	50	177	0.47	118	77.1	2	0.43	6	0.59	459	0.07	3.4	0.065	<0.01	35	0.09	49	56	2	<1	0.2	<0.02
111990	0.32	1.18	40	119	0.94	104	913	2.23	0.31	7	0.8	535	0.06	3.4	0.071	0.07	66	0.13	46	63	1.7	3	0.4	0.1
111991	0.24	1.32	40	62	2.12	83	760	2.35	0.11	6	0.57	529	0.05	3	0.068	0.08	134	0.03	38	78	1.4	1	0.5	0.12
111992	0.02	1.04	40	90	1.04	93	26.6	1.87	0.22	6	0.64	430	0.06	3.1	0.049	<0.01	64.2	0.1	38	50	1.3	2	0.4	<0.02
111993	0.01	1.18	50	206	0.95	107	10.9	2.23	0.53	6	0.7	516	0.06	3.8	0.071	<0.01	64.6	0.09	49	60	1.4	<1	0.3	<0.02
111994	0.04	1.21	40	95	1.3	91	87.3	2.15	0.2	7	0.77	496	0.05	3.6	0.067	0.01	92.6	0.08	44	63	1.6	<1	0.4	<0.02
111995	0.03	1.07	40	38	1.36	94	24.2	1.65	0.07	6	0.62	382	0.04	3.2	0.057	<0.01	131	0.02	30	55	1.2	2	0.4	<0.02
111996	0.02	0.97	50	221	0.46	115	30	1.97	0.51	5	0.57	449	0.07	5	0.065	<0.01	32.8	0.1	44	50	1.7	5	0.2	<0.02
111997	0.13	1.24	40	307	0.43	109	372	2.33	0.74	6	0.74	467	0.06	4.6	0.074	<0.01	32.6	0.14	57	65	1.8	4	0.2	0.03
Nov Final Tails	0.5	1.33	40	293	1.08	95	853	3.64	0.75	7	0.81	712	0.05	4.7	0.078	0.06	102	0.13	70	103	2	1	0.2	0.22
Dec Final Tails	0.41	1.43	30	270	1.08	90	635	3.26	0.78	8	0.89	652	0.05	4.1	0.085	0.05	108	0.13	67	100	1.8	1	0.3	0.17
Duplicate																								
106900	0.78	1.54	50	384	0.95	93	2730	3.18	0.9	9	0.95	599	0.06	3.2	0.093	0.31	125	0.16	73	92	1.7	4	0.3	0.3
111990	0.32	1.14	50	113	0.93	105	860	2.12	0.28	7	0.76	516	0.06	3.4	0.073	0.07	66.8	0.13	47	66	1.8	2	0.3	0.09
111993	0.02	1.18	40	199	0.95	104	10.8	2.24	0.53	6	0.71	521	0.06	5.7	0.068	<0.01	63.9	0.09	47	55	1.4	<1	0.3	<0.02
QC																								
CH4	2.14	1.89	50	318	0.63	110	1890	4.72	1.41	13	1.22	339	0.07	50.4	0.065	0.74	10.6	0.22	79	195	16.7	9	0.1	0.49
Expected Values	2.13	1.85	#N/A	293	0.61	103.8	2000	4.79	1.43	12.6	1.18	324	0.06	49.57	0.072	0.73	9.38	0.21	79.27	189.4	11.7	8.14	0.11	0.51
Tolerance (%)	10.9	11.35	#N/A	14.3	14.1	12.4	10.1	10.52	11.74	29.84	12.3	11.5	50.3	12.52	27.4	13.4	23.3	23.3	13.2	11.3	17.7	13.1	241.3	19.7
OREAS 901	0.29	1	40	97	0.09	24	1350	3.66	0.53	3	0.14	293	0.02	34.7	0.056	0.03	20.5	<0.01	21	20	31.4	67	4.5	4.54
Expected Values	0.276	0.992	#N/A	86	0.091	23.0	1440	3.70	0.512	3.1	0.124	300	0.01	34.7	0.059	0.033	21.0	0.01	21	20.2	**31.6**	66	4.49	4.35
Tolerance (%)	19.06	12.52	#N/A	24.53	37.47	20.87	10.09	10.68	14.88	98.65	30.16	11.67	#N/A	13.60	31.19	85.76	15.95	#N/A	#N/A	22.38	13.96	13.79	15.57	11.15

Cd	Ce	Co	Cs	Ga	Ge	Hf	Hg	In	La	Lu	Mo	Nb	Pb	Rb	Sb	Sc	Se	Sn	Ta	Tb	Te	Th	Tl	U	W	Y	Yb
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.01	0.05	0.1	0.05	0.1	0.1	0.05	0.01	0.02	0.1	0.01	0.05	0.05	0.2	0.2	0.05	0.1	1	0.3	0.05	0.02	0.05	0.1	0.02	0.05	0.1	0.05	0.1
0.07	19	6.1	0.18	6.5	<0.1	0.07	<0.01	0.02	9.8	0.08	2.4	0.28	5.9	8.6	<0.05	3.8	<1	0.4	<0.05	0.21	0.05	2.3	0.05	0.21	0.2	5.9	0.6
0.09	20.9	5.9	0.28	5.4	<0.1	0.05	<0.01	0.02	11.5	0.09	9.2	0.27	2.3	15.4	<0.05	3.5	<1	0.4	<0.05	0.22	<0.05	2.3	0.08	0.27	<0.1	6.18	0.6
0.04	17.4	5.8	0.21	5.9	<0.1	0.05	<0.01	<0.02	9.3	0.07	2.42	0.35	4.6	14.1	<0.05	3.7	<1	0.4	<0.05	0.19	<0.05	1.9	0.08	0.17	0.1	5.26	0.5
0.26	28.2	6.5	0.54	6.8	<0.1	<0.05	<0.01	0.13	14.5	0.11	8.13	0.36	3.4	30.8	<0.05	4.4	3	1	<0.05	0.34	0.3	5.9	0.23	0.51	0.1	9.06	0.8
0.63	25.8	5.1	0.17	5.9	<0.1	<0.05	<0.01	0.08	12.9	0.13	3.45	0.11	4.7	6.9	<0.05	4.7	2	0.5	<0.05	0.33	0.08	4.3	0.03	0.44	<0.1	9.62	0.9
0.05	19.1	7	0.37	5.8	0.1	0.1	<0.01	<0.02	9.3	0.1	3.14	0.61	1.9	28.4	<0.05	4.4	<1	0.5	<0.05	0.21	<0.05	2.3	0.15	0.37	0.5	6.07	0.6
0.05	22.9	7.6	0.31	6.3	0.1	0.11	<0.01	0.02	12.7	0.1	3.08	0.54	2.3	25.6	<0.05	4.2	<1	0.5	<0.05	0.21	<0.05	4.1	0.14	0.58	0.2	6	0.6
0.64	21	7.8	0.7	7.9	<0.1	0.06	0.01	0.07	10.7	0.08	2.6	0.45	2.2	48.2	<0.05	4	2	0.8	<0.05	0.23	0.15	3.2	0.3	0.71	<0.1	6.46	0.5
0.07	18.6	7	0.45	5.6	<0.1	0.08	<0.01	0.02	10	0.08	3.01	0.37	1.6	28.4	<0.05	3.4	<1	0.4	<0.05	0.19	<0.05	2.3	0.15	0.4	<0.1	5.52	0.5
0.02	18.6	5.9	0.35	5.3	<0.1	<0.05	<0.01	<0.02	9.8	0.06	2.85	0.34	2.3	29.5	<0.05	3.3	<1	0.4	<0.05	0.17	<0.05	2.3	0.17	0.13	<0.1	4.67	0.4
0.38	33.1	5.6	0.34	6.8	<0.1	0.05	<0.01	0.11	17.4	0.11	3.02	0.21	6.6	17.3	<0.05	4.1	3	1.1	<0.05	0.34	0.25	7.3	0.12	0.4	<0.1	9.43	0.8
0.07	21.1	6	0.39	6	<0.1	<0.05	<0.01	0.03	11.5	0.09	2.74	0.47	2.1	22.3	<0.05	3.7	<1	0.5	<0.05	0.2	0.05	2.8	0.13	0.28	<0.1	5.98	0.6
0.06	22.3	6.1	0.3	5.8	<0.1	0.06	<0.01	0.02	11.5	0.1	2.57	0.34	1.9	17	<0.05	4	<1	0.5	<0.05	0.23	<0.05	2.7	0.09	0.2	0.1	6.74	0.6
0.04	28.1	6.8	0.43	7.8	0.1	<0.05	<0.01	0.02	14.9	0.05	2.16	0.48	2.3	31.8	<0.05	3.4	<1	0.5	<0.05	0.17	<0.05	4.2	0.18	0.29	<0.1	4.02	0.3
0.03	15.9	6.3	0.32	5.2	<0.1	0.08	<0.01	<0.02	8.3	0.09	2.66	0.54	3.7	24.2	<0.05	3.6	<1	0.4	<0.05	0.2	<0.05	1.8	0.13	0.28	<0.1	5.93	0.6
0.04	22.1	7.3	0.46	6.3	0.1	0.09	0.01	<0.02	12.2	0.08	2.17	0.31	3.2	27.7	<0.05	3.8	<1	0.4	<0.05	0.18	<0.05	3.7	0.15	0.58	<0.1	5.31	0.5
0.39	40.6	8.2	1.04	9.3	0.1	<0.05	0.02	0.16	22.9	0.14	4.79	0.79	6.5	60.7	<0.05	6.7	3	1.3	<0.05	0.42	0.27	10.1	0.49	0.4	0.3	11.3	0.9
0.11	21.9	7.5	0.14	6.8	<0.1	<0.05	<0.01	0.02	12.1	0.08	2.04	0.25	3.3	9.8	<0.05	3.2	2	0.4	<0.05	0.2	0.43	2.6	0.05	0.25	<0.1	5.81	0.6
0.04	26.5	8.4	0.37	6.2	0.1	0.08	<0.01	<0.02	14.3	0.09	2.85	0.49	2.1	28.7	<0.05	3.5	<1	0.5	<0.05	0.24	<0.05	5	0.14	0.66	0.6	6.17	0.6
0.49	25.1	7.8	0.65	8.3	<0.1	<0.05	<0.01	0.12	12.5	0.07	4.02	0.75	2.7	52.9	<0.05	3.8	4	1	<0.05	0.27	0.33	2.7	0.35	0.16	0.7	7.25	0.5
0.04	21.8	6.4	0.15	5.8	<0.1	0.06	<0.01	<0.02	12.6	0.09	2.72	0.35	2	9	<0.05	3.8	<1	0.4	<0.05	0.2	<0.05	2.3	0.04	0.18	0.6	5.85	0.6
0.04	14.8	5.4	0.24	4.6	<0.1	0.08	<0.01	<0.02	7.9	0.07	2.65	0.44	1.6	20.5	<0.05	2.9	<1	0.3	<0.05	0.16	<0.05	2.2	0.1	0.28	<0.1	4.53	0.5
0.07	16.9	6.4	0.25	6	<0.1	0.07	<0.01	0.04	9	0.08	2.72	0.59	2.5	15.9	<0.05	3.4	1	0.5	<0.05	0.19	0.07	2	0.1	0.34	0.7	5.64	0.6
0.26	19	6.2	0.15	6.3	<0.1	<0.05	<0.01	0.04	9.8	0.1	15.5	0.14	9.4	5.5	<0.05	4	1	0.5	<0.05	0.24	0.06	2.5	0.03	0.36	0.1	6.97	0.7
0.03	11.3	5	0.17	5	<0.1	0.06	<0.01	<0.02	6	0.07	2.53	0.45	3	9.9	<0.05	2.7	<1	0.4	<0.05	0.14	<0.05	1.1	0.05	0.21	0.3	4.33	0.5
0.04	17.7	6.4	0.46	5.5	<0.1	0.06	<0.01	<0.02	9.1	0.09	2.49	0.38	1.4	23.9	<0.05	3.5	<1	0.4	<0.05	0.21	<0.05	1.9	0.14	0.21	0.5	6.02	0.6
0.04	16.8	6.4	0.16	6.1	<0.1	0.07	<0.01	<0.02	8.7	0.08	3.54	0.27	2.9	8.9	<0.05	3.6	<1	0.4	<0.05	0.18	<0.05	1.9	0.05	0.24	0.4	5.34	0.5
0.04	17.9	5.6	0.11	5.6	<0.1	<0.05	<0.01	<0.02	8.6	0.1	1.96	0.1	6	3.7	<0.05	3	<1	0.4	<0.05	0.22	<0.05	1.3	<0.02	0.29	<0.1	6.28	0.6
0.06	14.4	5.6	0.36	4.6	<0.1	0.07	<0.01	<0.02	7.8	0.09	2.97	0.45	1.2	25.6	<0.05	3.6	<1	0.4	<0.05	0.19	<0.05	1.3	0.14	0.21	0.4	5.87	0.6
0.07	24.8	6.9	0.54	5.8	<0.1	0.07	<0.01	0.03	13.1	0.09	3.49	0.6	1.6	38.2	<0.05	3.4	<1	0.8	<0.05	0.22	<0.05	3.3	0.22	0.31	0.5	6.06	0.6
0.47	21.5	7.2	0.65	8	<0.1	0.05	<0.01	0.07	10.8	0.08	3.59	0.48	2.3	40.8	<0.05	4.2	1	1.1	<0.05	0.25	0.16	3.8	0.34	0.42	<0.1	6.68	0.5
0.2	24.5	6.6	0.67	8	<0.1	0.05	<0.01	0.07	12.3	0.08	2.74	0.47	2	43.5	<0.05	4.2	<1	1.1	<0.05	0.26	0.14	4.7	0.34	0.31	<0.1	6.89	0.5
0.32	20.6	8.1	0.69	7.9	<0.1	0.06	0.01	0.07	10.6	0.07	2.69	0.4	2.3	48.4	<0.05	4	2	0.7	<0.05	0.23	0.18	3.1	0.3	0.48	<0.1	6.29	0.5
0.07	16.3	6.1	0.24	5.9	<0.1	0.08	<0.01	0.04	8.4	0.09	2.7	0.63	2.6	14.9	<0.05	3.5	<1	0.6	<0.05	0.2	0.07	1.8	0.1	0.38	0.8	5.91	0.6
0.03	16.3	6.5	0.46	5.6	<0.1	0.06	<0.01	<0.02	8	0.09	2.56	0.35	1.4	24.4	<0.05	3.5	<1	0.4	<0.05	0.2	<0.05	1.4	0.14	0.19	1	5.92	0.6
1.1	30.7	24.1	2.76	9.4	0.3	0.41	<0.01	0.11	15.3	0.07	3.48	0.23	8.5	63.2	0.33	8.7	2	0.7	<0.05	0.31	0.38	2.3	0.43	0.35	2.7	6.06	0.5
1.17	28.18	23.56	2.6	8.72	0.21	0.29	#N/A	0.1	14	#N/A	3.05	0.19	8.24	67	0.34	8.53	1.57	0.6	0.3	0.27	0.42	2.2	0.4	0.29	2.15	5.66	#N/A
12.1	16.1	11.1	14.8	12.9	127.4	52.8	#N/A	62.1	11.8	#N/A	14.1	75	16.1	10.7	47.3	13.1	169.6	134.5	51.7	28.4	39.6	21.2	22.6	52.9	21.6	12.2	#N/A
0.05	80	70.8	0.97	3.2	0.1	0.88	0.02	0.23	38.4	0.23	3.13	0.1	14.3	25	1.31	5.2	3	0.5	<0.05	0.83	0.06	9.9	0.37	6.78	0.9	19.5	1.6
0.05	78	73	0.97	3.15	0.11	0.8	0.02	0.21	38.1	0.22	3.23	0.1	14.6	23.9	1.47	5.55	2.68	0.58	0.02	0.77	0.076	9.13	0.34	5.84	1.1	18.8	1.49
#N/A	15.77	16.85	22.89	17.94	237.27	#N/A	#N/A	33.81	10.66	21.36	13.87	#N/A	13.42	12.09	18.50	14.50	103.28	139.31	#N/A	16.49	174.47	12.74	24.71	12.14	#N/A	10.66	26.78

CLIENT	**: Minto Mines**	**SGS Project #**	**: 0643**
PROJECT	**: Minto Mines**	**Test**	**: Modified Acid-Base Accounting**
		Date	**: February 18, 2016**

Sample ID	**Sampling Date**	**Paste pH**	**TIC %**	**CaCO3 NP**	**C(T) %**	**S(T) %**	**S(SO4) %**	**S(S-2) %**	**AP**	**NP**	**Net NP**	**NP:AP Ratio (NP/AP)**	**Fizz Test**
Method Code		Sobek	CSB02V	Calc #N/A	CSA06V 0.005	CSA06V 0.005	CSA07V 0.01	Calc #N/A	Calc #N/A	Modified 0.5	Calc #N/A	Calc #N/A	Sobek #N/A
111998	6-Jan-16	8.88	0.24	20.0	0.302	0.02	<0.01	0.02	0.6	23.9	23.3	38.2	Slight
111999	18-Jan-16	9.07	0.21	17.5	0.238	0.032	<0.01	0.03	1.0	21.5	20.5	21.5	Slight
112000	18-Jan-16	8.56	0.09	7.5	0.111	0.044	<0.01	0.04	1.4	12.5	11.1	9.1	None
123501	18-Jan-16	8.27	0.19	15.8	0.236	0.037	<0.01	0.04	1.2	18.1	16.9	15.7	Slight
123502	11-Jan-16	8.54	0.21	17.5	0.231	0.025	<0.01	0.03	0.8	19.8	19.0	25.3	Slight
123503	18-Jan-16	7.61	0.01	0.8	0.092	0.017	<0.01	0.02	0.5	5.5	5.0	10.4	None
123504	18-Jan-16	7.89	0.1	8.3	0.108	0.055	<0.01	0.06	1.7	12.2	10.5	7.1	None
123505	19-Jan-16	8.66	0.22	18.3	0.252	0.038	<0.01	0.04	1.2	21.1	19.9	17.8	Slight
123506	19-Jan-16	8.05	0.25	20.8	0.272	0.106	<0.01	0.11	3.3	23.3	20.0	7.0	Slight
123507	19-Jan-16	7.81	0.03	2.5	0.131	0.088	<0.01	0.09	2.8	7.5	4.8	2.7	None
123508	19-Jan-16	8.25	0.05	4.2	0.081	0.031	<0.01	0.03	1.0	8.2	7.2	8.5	None
123509	19-Jan-16	8.25	0.13	10.8	0.152	0.018	<0.01	0.02	0.6	14.1	13.5	25.1	None
123510	20-Jan-16	7.72	0.02	1.7	0.262	0.018	<0.01	0.02	0.6	6.4	5.8	11.4	None
123511	21-Jan-16	8.90	0.11	9.2	0.134	0.015	<0.01	0.02	0.5	14.1	13.6	30.1	None
123512	22-Jan-16	9.07	0.15	12.5	0.178	0.015	<0.01	0.02	0.5	15.7	15.2	33.5	Slight
123513	23-Jan-16	8.91	0.23	19.2	0.246	0.057	<0.01	0.06	1.8	23.6	21.8	13.2	None
123514	23-Jan-16	8.73	0.71	59.2	0.742	0.02	<0.01	0.02	0.6	62.7	62.1	100.3	Slight
123515	23-Jan-16	8.64	0.44	36.7	0.473	0.033	<0.01	0.03	1.0	39.5	38.5	38.3	Slight
Duplicates													
111998		8.92								23.6			Slight
123503					0.095	0.019							
123508							<0.01						
123512			0.15										
QC													
GTS-2A					2.04	0.354							
RTS-3A							0.98						
SY-4			0.92										
NBM-1										41.5			Slight
Expected Values			0.95		2.01	0.341	0.98			42.0			Slight
Tolerance +/-			0.06		0.15	0.030	0.12			3.0			

CLIENT : **Minto Mines**
PROJECT : **Minto Project**
SGS Project # : **0643**
Test : **Metals by Aqua Regia Digestion with ICP-MS Finish**
Date : **February 18, 2016**

Sample ID	**Ag ppm**	**Al %**	**B ppm**	**Ba ppm**	**Ca %**	**Cr ppm**	**Cu ppm**	**Fe %**	**K %**	**Li ppm**	**Mg %**
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	0.01	0.01	10	5	0.01	1	0.5	0.01	0.01	1	0.01
111998	0.03	1.06	<10	161	1.22	111	24	2.19	0.38	6	0.63
111999	0.09	1.25	20	188	1.2	102	226	2.56	0.53	7	0.74
112000	0.13	1.14	20	193	0.79	101	349	2.32	0.5	7	0.69
123501	0.03	1.26	20	156	1.26	111	72.8	2.5	0.41	6	0.75
123502	0.07	1.05	10	143	1.15	100	165	2.05	0.33	6	0.61
123503	0.03	1	10	126	0.47	118	50.1	2.01	0.26	5	0.41
123504	0.27	1.03	20	162	0.82	107	714	2.07	0.45	6	0.65
123505	0.05	1.21	<10	220	1.16	95	157	2.44	0.51	6	0.71
123506	0.91	1.09	<10	88	1.25	85	1840	2.3	0.21	5	0.62
123507	0.47	1.02	10	141	0.6	109	1200	2.84	0.23	5	0.55
123508	0.27	1.26	<10	201	0.54	99	1070	2.36	0.63	5	0.63
123509	0.07	0.96	10	124	0.86	92	33.4	1.74	0.22	3	0.34
123510	0.05	1.07	<10	176	0.5	107	174	2.23	0.42	6	0.57
123511	0.03	1.13	20	184	0.9	111	45.7	2.3	0.41	6	0.64
123512	0.01	1.05	10	166	0.91	92	11.6	2.08	0.3	6	0.6
123513	0.14	1.33	10	119	1.35	80	509	2.29	0.25	7	0.74
123514	0.02	1.13	<10	91	2.89	79	28.8	1.86	0.21	5	0.56
123515	0.06	1.49	<10	52	2.1	65	178	2.15	0.11	7	0.67
Duplicate											
123510	0.05	1.07	10	174	0.5	109	171	2.24	0.4	6	0.57
QC											
OREAS 901	0.27	1.09	20	91	0.09	25	1430	3.66	0.58	3	0.15
Expected Values	0.276	0.992	#N/A	86	0.091	23.0	1440	3.70	0.512	3.1	0.124
Tolerance (%)	19.06	12.52	#N/A	24.53	37.47	20.87	10.09	10.68	14.88	98.65	30.16

Mn ppm	Na %	Ni ppm	P %	S %	Sr ppm	Ti %	V ppm	Zn ppm	Zr ppm	As ppm	Be ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
2	0.01	0.5	0.005	0.01	0.5	0.01	1	1	0.5	1	0.1
496	0.06	4.7	0.069	<0.01	101	0.08	49	57	1.5	1	0.3
567	0.06	3.5	0.081	0.02	84.4	0.12	62	72	1.7	1	0.4
484	0.06	2.8	0.083	0.04	75.1	0.13	60	65	2.1	1	0.3
556	0.07	3.1	0.087	0.03	106	0.11	58	61	2	1	0.3
463	0.06	3.2	0.066	0.02	75.5	0.08	46	54	1.9	1	0.3
402	0.05	4.2	0.067	<0.01	40.9	0.07	49	49	2.1	3	0.3
462	0.08	2.8	0.068	0.05	58.7	0.11	51	57	1.7	1	0.2
542	0.06	3.5	0.079	0.03	95.8	0.11	53	69	1.5	1	0.3
481	0.05	2.7	0.071	0.1	84.6	0.05	45	66	1.6	1	0.4
521	0.06	4.8	0.09	0.08	60.2	0.07	62	68	3	1	0.3
450	0.06	3	0.08	0.02	34.6	0.13	63	62	1.9	10	0.3
442	0.05	2.7	0.059	<0.01	72.5	0.04	39	46	1.5	2	0.3
503	0.06	4	0.073	<0.01	33.5	0.11	52	57	2.1	3	0.2
515	0.07	3.2	0.072	<0.01	71.2	0.11	56	64	1.8	<1	0.3
472	0.07	3.2	0.063	<0.01	98.7	0.09	46	57	1.6	<1	0.2
528	0.07	2.9	0.077	0.05	146	0.09	51	65	1.4	1	0.4
629	0.06	2.4	0.057	<0.01	99	0.07	42	50	1.5	<1	0.4
550	0.06	2.6	0.067	0.02	145	0.04	43	62	1.4	2	0.6
500	0.06	3.9	0.07	<0.01	34.1	0.11	54	57	2.1	3	0.2
296	0.02	34.7	0.061	0.04	20.2	<0.01	24	20	30.9	66	4.3
300	0.01	34.7	0.059	0.033	21.0	0.01	21	20.2	31.6	66	4.49
11.67	#N/A	13.60	31.19	85.76	15.95	#N/A	#N/A	22.38	13.96	13.79	15.57

Bi ppm	Cd ppm	Ce ppm	Co ppm	Cs ppm	Ga ppm	Ge ppm	Hf ppm	Hg ppm	In ppm	La ppm	Lu ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.02	0.01	0.05	0.1	0.05	0.1	0.1	0.05	0.01	0.02	0.1	0.01
0.03	0.07	16	6.3	0.22	5.4	<0.1	0.05	<0.01	<0.02	8.2	0.09
0.03	0.05	18	7.1	0.41	6.5	<0.1	0.06	<0.01	<0.02	9.1	0.09
0.03	0.05	21.9	7.3	0.34	5.7	<0.1	0.08	<0.01	<0.02	11.4	0.09
<0.02	0.04	22.5	7	0.25	5.8	<0.1	0.08	<0.01	<0.02	11.7	0.1
0.03	0.05	19.1	5.7	0.24	5.3	<0.1	0.06	<0.01	<0.02	9.5	0.09
<0.02	0.04	16.7	5.8	0.25	4.8	<0.1	0.08	<0.01	<0.02	8.3	0.1
0.09	0.07	14.6	5.8	0.28	5	<0.1	0.06	<0.01	0.02	7.4	0.08
0.03	0.04	22	7.1	0.33	5.8	<0.1	<0.05	<0.01	<0.02	11.2	0.07
0.38	0.11	16.5	5.7	0.19	5.8	<0.1	<0.05	<0.01	0.04	8.2	0.07
0.3	0.21	23.5	6.8	0.19	5.8	<0.1	0.11	<0.01	0.03	12.8	0.1
0.04	0.1	28	7.4	0.53	5.8	<0.1	0.07	<0.01	0.06	13.4	0.12
<0.02	0.06	14.9	4.7	0.22	4.5	<0.1	<0.05	<0.01	<0.02	7.2	0.11
<0.02	0.06	17.3	7.2	0.32	4.9	<0.1	0.06	<0.01	<0.02	9.4	0.1
<0.02	0.04	16.6	6.2	0.27	5.2	<0.1	0.06	<0.01	<0.02	8	0.1
<0.02	0.04	18.6	5.4	0.2	5.2	<0.1	0.06	<0.01	<0.02	9.3	0.07
0.06	0.07	20.1	6.1	0.24	6.1	<0.1	0.05	<0.01	0.02	9.9	0.11
<0.02	0.07	18.3	5.1	0.17	5.4	<0.1	<0.05	<0.01	<0.02	9.7	0.11
0.03	0.07	17.5	6.3	0.17	7	<0.1	0.05	<0.01	<0.02	8	0.13
<0.02	0.05	17.1	7.4	0.32	5.1	<0.1	0.06	<0.01	<0.02	9.2	0.1
4.38	0.05	75.7	72.5	1.11	3.4	<0.1	0.82	<0.01	0.21	38.7	0.25
4.35	0.05	78	73	0.97	3.15	0.11	0.8	0.02	0.21	38.1	0.22
11.15	#N/A	15.77	16.85	22.89	17.94	237.27	#N/A	#N/A	33.81	10.66	21.36

Mo ppm	Nb ppm	Pb ppm	Rb ppm	Sb ppm	Sc ppm	Se ppm	Sn ppm	Ta ppm	Tb ppm	Te ppm	Th ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.05	0.05	0.2	0.2	0.05	0.1	1	0.3	0.05	0.02	0.05	0.1
4.07	0.5	3.1	15.9	0.08	3.9	<1	0.5	<0.05	0.21	<0.05	1.4
3.25	0.7	4.9	25.1	<0.05	4.1	<1	0.5	<0.05	0.21	<0.05	1.8
2.71	0.82	1.9	25.6	<0.05	3.2	<1	0.5	<0.05	0.2	<0.05	3.3
3.76	0.81	2.6	17.3	<0.05	4	<1	0.5	<0.05	0.25	<0.05	3.1
2.62	0.53	3.6	15	<0.05	3.5	<1	0.4	<0.05	0.2	<0.05	2.6
3.51	0.72	1.9	13	<0.05	4.3	<1	0.5	<0.05	0.24	<0.05	1.5
2.54	0.53	1.6	21.5	<0.05	3.3	<1	0.4	<0.05	0.18	0.06	1.6
2.74	0.5	2	24.3	<0.05	3.2	<1	0.4	<0.05	0.19	<0.05	3.3
2.62	0.32	3.1	10.2	<0.05	2.9	1	0.5	<0.05	0.17	0.3	2.4
4.18	0.7	2.6	12.3	0.06	3.7	<1	0.6	<0.05	0.22	<0.05	3.8
8.63	0.87	2	36	<0.05	4.6	<1	1.1	<0.05	0.29	<0.05	3.6
2.29	0.25	1.8	11	<0.05	4	<1	0.4	<0.05	0.23	<0.05	1.1
3.93	1.1	2.1	21.4	<0.05	4	<1	0.5	<0.05	0.23	<0.05	1.8
2.6	0.58	18.3	18.7	<0.05	3.9	<1	0.4	<0.05	0.21	<0.05	1.5
2.33	0.52	2.4	14.2	<0.05	3.8	<1	0.4	<0.05	0.19	<0.05	2.3
2.21	0.45	2.4	12.3	<0.05	4.3	<1	0.5	<0.05	0.25	<0.05	2.3
2.03	0.39	3.2	9.5	<0.05	3.4	<1	0.4	<0.05	0.24	<0.05	1.6
1.56	0.23	4.8	5.6	<0.05	4.4	<1	0.5	<0.05	0.31	<0.05	1.6
3.92	1.2	2.1	21.4	<0.05	4.1	<1	0.5	<0.05	0.24	<0.05	1.8
3.04	0.06	14.2	26.5	1.53	5.5	2	0.5	<0.05	0.85	<0.05	9.1
3.23	0.1	14.6	23.9	1.47	5.55	2.68	0.58	0.02	0.77	0.076	9.13
13.87	#N/A	13.42	12.09	18.50	14.50	103.28	139.31	#N/A	16.49	174.47	12.74

Tl ppm	U ppm	W ppm	Y ppm	Yb ppm
ICM14B 0.02	ICM14B 0.05	ICM14B 0.1	ICM14B 0.05	ICM14B 0.1
0.1	0.21	0.8	5.66	0.6
0.13	0.33	0.2	5.6	0.6
0.13	0.51	0.4	5.19	0.5
0.09	0.62	0.5	6.46	0.7
0.08	0.28	0.1	5.33	0.5
0.07	0.29	0.2	6.25	0.7
0.11	0.23	<0.1	4.85	0.5
0.13	0.29	0.4	4.8	0.5
0.05	0.27	0.2	4.42	0.4
0.07	0.61	0.4	5.62	0.6
0.23	0.56	0.2	7.4	0.7
0.06	0.22	<0.1	6.39	0.7
0.11	0.32	0.3	6.02	0.6
0.1	0.23	0.2	5.61	0.6
0.09	0.22	0.3	5	0.5
0.07	0.26	0.2	6.53	0.7
0.05	0.22	0.1	7.43	0.7
0.02	0.26	<0.1	8.25	0.9
0.11	0.32	0.3	6.32	0.7
0.37	6.12	1.1	18.9	1.6
0.34	5.84	1.1	18.8	1.49
24.71	12.14	#N/A	10.66	26.78

CLIENT : **Minto Mines** **Test** : **Modified Acid-Base Accounting**
PROJECT : **Minto Mines** **Date** : **March 3, 2016**
SGS Project # : **0643**

Sample ID	**Sampling Date**	**Paste pH**	**TIC %**	**CaCO3 NP**	**C(T) %**	**S(T) %**	**S(SO4) %**	**S(S-2) %**	**AP**	**NP**	**Net NP**	**NP:AP Ratio (NP/AP)**	**Fizz Test**
Method Code		Sobek	CSB02V	Calc #N/A	CSA06V 0.005	CSA06V 0.005	CSA07V 0.01	Calc #N/A	Calc #N/A	Modified 0.5	Calc #N/A	Calc #N/A	Sobek #N/A
122351	6-Jan-16	8.70	0.18	15.0	0.204	0.14	<0.01	0.14	4.4	20.0	15.6	4.6	Slight
122352	2-Feb-16	8.47	0.07	5.8	0.108	0.005	<0.01	<0.01	<0.3	10.3	10.3	34.3	None
122353	2-Feb-16	7.69	<0.01	<0.8	0.041	0.054	<0.01	0.05	1.7	5.1	3.4	3.0	None
122354	2-Feb-16	8.81	0.2	16.7	0.211	0.024	<0.01	0.02	0.8	18.4	17.7	24.5	Slight
122355	2-Feb-16	9.04	0.16	13.3	0.151	0.025	<0.01	0.03	0.8	16.4	15.6	21.0	None
123516	26-Jan-16	7.96	0.05	4.2	0.103	0.011	<0.01	0.01	0.3	10.6	10.3	30.8	None
123517	26-Jan-16	8.55	0.27	22.5	0.291	0.103	<0.01	0.10	3.2	25.1	21.9	7.8	Slight
123518	26-Jan-16	8.87	0.16	13.3	0.176	0.007	<0.01	<0.01	<0.3	17.9	17.9	59.7	Slight
123519	26-Jan-16	8.77	0.2	16.7	0.216	0.005	<0.01	<0.01	<0.3	20.5	20.5	68.3	Slight
123520	29-Jan-16	8.77	0.14	11.7	0.153	0.005	<0.01	<0.01	<0.3	16.5	16.5	55.0	Slight
123521	29-Jan-16	8.75	0.19	15.8	0.208	0.018	<0.01	0.02	0.6	21.6	21.0	38.4	Slight
123522	29-Jan-16	9.24	0.07	5.8	0.07	0.005	<0.01	<0.01	<0.3	10.4	10.4	34.7	None
123523	2-Feb-16	8.74	0.2	16.7	0.2	0.007	<0.01	<0.01	<0.3	19.4	19.4	64.7	Slight
123524	2-Feb-16	8.68	0.19	15.8	0.196	0.005	<0.01	<0.01	<0.3	14.9	14.9	49.7	Slight
123525	2-Feb-16	8.89	0.11	9.2	0.112	0.009	<0.01	<0.01	<0.3	12.3	12.3	41.0	None
Duplicates													
122351		8.73								19.2			Slight
123516													
123520			0.14										
QC													
GTS-2A					1.98	0.328							
RTS-3A							0.98						
TIC-L1			0.13										
NBM-1										42.3			Slight
Expected Values			0.1325		2.01	0.341	0.98			42.0			Slight
Tolerance +/-			0.02		0.15	0.030	0.12			3.0			

Note:

AP = Acid potential in tonnes CaCO3 equivalent per 1000 tonnes of material. AP is determined from calculated sulphide sulphur content: S(T) - S(SO4).

NP = Neutralization potential in tonnes CaCO3 equivalent per 1000 tonnes of material.

NET NP = NP - AP

Carbonate NP is calculated from TIC originating from carbonate minerals and is expressed in kg CaCO3/tonne.

CLIENT : **Minto Mines**
PROJECT : **Minto Project**
SGS Project # : **0643**
Test : **Metals by Aqua Regia Digestion with ICP-MS Finish**
Date : **March 3, 2016**

Sample ID	**Ag ppm**	**Al %**	**B ppm**	**Ba ppm**	**Ca %**	**Cr ppm**	**Cu ppm**	**Fe %**	**K %**	**Li ppm**	**Mg %**
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	0.01	0.01	10	5	0.01	1	0.5	0.01	0.01	1	0.01
122351	0.43	1.13	10	119	1.12	72	1770	2.21	0.2	8	0.7
122352	0.1	1.26	20	190	0.81	80	104	2.25	0.45	8	0.74
122353	0.79	1.52	<10	191	0.31	88	1870	2.88	0.94	7	0.79
122354	0.17	1.16	20	151	1.06	87	329	2.29	0.44	7	0.71
122355	0.08	1.24	20	183	0.99	77	264	2.43	0.59	8	0.82
123516	0.17	1.2	10	238	0.6	110	271	2.39	0.55	7	0.62
123517	1.7	1.16	10	75	1.28	77	2310	3.03	0.15	7	0.6
123518	0.02	1.25	10	118	1.24	74	25.1	2.04	0.24	6	0.7
123519	0.03	1.14	10	60	1.2	73	30.6	2.22	0.14	8	0.71
123520	0.03	1.13	20	103	1.02	77	45.4	1.99	0.2	7	0.67
123521	0.09	1.45	10	116	1.48	68	191	2.3	0.27	8	0.78
123522	0.03	0.98	20	189	0.76	88	43.2	2.1	0.51	6	0.66
123523	0.02	1.12	10	97	1.19	74	30.8	1.86	0.19	7	0.63
123524	0.04	1.03	10	175	0.75	80	36.2	2.12	0.4	7	0.67
123525	0.04	1.15	20	290	0.76	74	103	2.34	0.6	9	0.76
Duplicate											
123518	0.02	1.23	<10	116	1.24	76	29	2.01	0.24	6	0.69
QC											
OREAS 901	0.28	0.97	20	90	0.08	21	1410	3.5	0.51	4	0.13
Expected Values	0.276	0.992	#N/A	86	0.091	23.0	1440	3.70	0.512	3.1	0.124
Tolerance (%)	19.06	12.52	#N/A	24.53	37.47	20.87	10.09	10.68	14.88	98.65	30.16

Mn ppm	Na %	Ni ppm	P %	S %	Sr ppm	Ti %	V ppm	Zn ppm	Zr ppm	As ppm	Be ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
2	0.01	0.5	0.005	0.01	0.5	0.01	1	1	0.5	1	0.1
432	0.06	3.6	0.076	0.14	82.6	0.08	49	61	2.4	<1	0.4
523	0.07	3.1	0.1	<0.01	57.6	0.11	56	61	1.5	2	0.3
469	0.04	3.1	0.1	0.05	27.2	0.17	83	123	2.6	11	0.2
504	0.07	3.1	0.075	0.02	97	0.1	53	68	1.1	<1	0.3
567	0.08	2.8	0.091	0.03	59.6	0.14	60	76	1.3	<1	0.3
495	0.06	3.6	0.081	<0.01	29.7	0.12	58	70	1.6	6	0.3
522	0.05	2.3	0.069	0.1	90.3	0.03	62	74	1.5	<1	0.4
482	0.07	2.6	0.069	<0.01	125	0.08	46	57	1.1	<1	0.4
513	0.06	2.4	0.077	<0.01	77.7	0.07	50	68	2.8	<1	0.4
489	0.06	2.5	0.069	<0.01	69.8	0.09	45	57	1.1	<1	0.3
540	0.06	2.5	0.093	0.02	145	0.09	58	67	2.1	<1	0.5
463	0.09	2.9	0.09	<0.01	40.4	0.13	57	56	2.1	<1	0.2
450	0.06	2.5	0.062	<0.01	127	0.06	39	56	0.9	<1	0.4
467	0.06	2.9	0.069	<0.01	134	0.08	46	57	1.1	<1	0.3
520	0.08	3.1	0.082	<0.01	68.9	0.13	55	74	1	<1	0.2
478	0.07	2.5	0.07	<0.01	126	0.08	46	58	1	<1	0.4
291	0.02	35.3	0.063	0.03	19.6	<0.01	22	19	29.9	61	4.4
300	0.01	34.7	0.059	0.033	21.0	0.01	21	20.2	31.6	66	4.49
11.67	#N/A	13.60	31.19	85.76	15.95	#N/A	#N/A	22.38	13.96	13.79	15.57

Bi ppm	Cd ppm	Ce ppm	Co ppm	Cs ppm	Ga ppm	Ge ppm	Hf ppm	Hg ppm	In ppm	La ppm	Lu ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.02	0.01	0.05	0.1	0.05	0.1	0.1	0.05	0.01	0.02	0.1	0.01
0.12	0.12	22.4	5.8	0.2	5.9	<0.1	0.1	<0.01	0.04	11.7	0.08
<0.02	0.04	20.2	6.6	0.24	6.1	<0.1	0.07	<0.01	<0.02	11	0.11
0.09	0.21	38.8	8.4	1.08	7.2	0.1	0.08	0.02	0.16	22.3	0.13
0.07	0.04	16.5	6.1	0.29	5.6	<0.1	0.06	<0.01	0.02	9	0.08
0.04	0.04	23.4	6.8	0.41	6.2	<0.1	0.06	<0.01	<0.02	13.1	0.08
0.05	0.05	17.1	6.7	0.39	5.8	<0.1	0.09	0.05	0.05	8.9	0.1
1.13	0.19	19.4	6.3	0.12	6.7	<0.1	0.06	0.05	<0.02	10.8	0.06
<0.02	0.03	14.2	5.9	0.14	6.2	<0.1	0.06	0.03	<0.02	7.7	0.07
<0.02	0.03	23.1	6.1	0.13	6	<0.1	0.14	<0.01	<0.02	13.1	0.08
<0.02	0.03	18.3	6.1	0.15	5.9	<0.1	<0.05	<0.01	<0.02	9.1	0.08
0.03	0.04	21.6	6.9	0.19	7.1	<0.1	0.1	<0.01	<0.02	11.6	0.09
0.02	0.04	18.2	6.1	0.22	4.9	<0.1	0.11	<0.01	<0.02	10.3	0.09
<0.02	0.03	13.8	5.2	0.11	5.4	<0.1	<0.05	<0.01	<0.02	7.5	0.06
<0.02	0.03	16.1	5.7	0.22	4.9	<0.1	0.07	<0.01	<0.02	8.7	0.09
0.03	0.03	7.84	6.4	0.33	5.8	<0.1	<0.05	<0.01	<0.02	4.2	0.05
<0.02	0.03	14.3	5.7	0.13	5.9	<0.1	0.05	0.03	<0.02	7.9	0.07
4.39	0.05	84.9	70.1	0.92	2.9	<0.1	0.9	0.02	0.19	38.3	0.22
4.35	0.05	78	73	0.97	3.15	0.11	0.8	0.02	0.21	38.1	0.22
11.15	#N/A	15.77	16.85	22.89	17.94	237.27	#N/A	#N/A	33.81	10.66	21.36

Mo ppm	Nb ppm	Pb ppm	Rb ppm	Sb ppm	Sc ppm	Se ppm	Sn ppm	Ta ppm	Tb ppm	Te ppm	Th ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.05	0.05	0.2	0.2	0.05	0.1	1	0.3	0.05	0.02	0.05	0.1
2.12	0.48	3.1	10.3	<0.05	2.6	<1	0.5	<0.05	0.2	0.08	4.3
3.53	0.56	1.7	19	<0.05	3.9	<1	0.5	<0.05	0.24	<0.05	2.6
10.8	0.98	4.8	60.5	<0.05	5.2	<1	2.4	<0.05	0.37	0.09	8
2.39	0.45	7	21.7	<0.05	3.4	<1	0.4	<0.05	0.19	0.05	2.3
2.1	0.44	1.8	27.8	<0.05	4.2	<1	0.4	<0.05	0.18	<0.05	3.7
5.39	0.63	11.2	26.7	0.06	4.4	<1	0.6	<0.05	0.2	0.05	2.1
1.82	0.21	3.4	6.9	<0.05	2.9	2	0.4	<0.05	0.17	0.53	3.9
2.06	0.42	2.5	10.4	<0.05	3.6	<1	0.4	<0.05	0.17	<0.05	1.5
1.65	0.34	2.9	6.4	<0.05	3.2	<1	0.4	<0.05	0.2	<0.05	4.6
2.07	0.44	2.2	9.8	<0.05	4.1	<1	0.5	<0.05	0.21	<0.05	2.4
1.87	0.37	3.1	13.2	<0.05	3.9	<1	0.4	<0.05	0.21	<0.05	4
2.39	0.61	1.5	22.8	<0.05	3.4	<1	0.5	<0.05	0.19	<0.05	3
1.92	0.28	2.6	8.1	<0.05	3.1	<1	0.3	<0.05	0.15	<0.05	1.5
1.95	0.28	1.7	16.4	<0.05	3.7	<1	0.3	<0.05	0.2	<0.05	1.8
1.93	0.41	1.3	26.2	<0.05	3	<1	0.4	<0.05	0.12	<0.05	0.8
1.9	0.33	2.5	10	<0.05	3.3	<1	0.3	<0.05	0.16	<0.05	1.6
3.03	0.1	14.1	23.6	1.46	5.1	2	0.5	<0.05	0.77	0.08	9.5
3.23	0.1	14.6	23.9	1.47	5.55	2.68	0.58	0.02	0.77	0.076	9.13
13.87	#N/A	13.42	12.09	18.50	14.50	103.28	139.31	#N/A	16.49	174.47	12.74

Tl ppm	U ppm	W ppm	Y ppm	Yb ppm
ICM14B 0.02	ICM14B 0.05	ICM14B 0.1	ICM14B 0.05	ICM14B 0.1
0.06	0.53	0.9	5.23	0.5
0.1	0.31	0.4	6.98	0.8
0.46	1.36	0.5	9.29	0.9
0.11	0.31	0.2	5.28	0.5
0.15	0.34	0.2	4.71	0.5
0.16	0.33	0.2	6.54	0.7
0.03	0.31	0.1	4.68	0.4
0.05	0.22	0.1	5.25	0.5
0.03	0.56	0.1	5.56	0.6
0.05	0.2	0.1	5.98	0.6
0.06	0.5	0.1	6.07	0.6
0.11	0.55	0.5	5.92	0.6
0.04	0.21	0.1	4.36	0.4
0.09	0.24	<0.1	6.06	0.6
0.14	0.19	0.2	3.66	0.4
0.05	0.22	0.1	5.14	0.5
0.34	6.39	1.1	19	1.5
0.34	5.84	1.1	18.8	1.49
24.71	12.14	#N/A	10.66	26.78

CLIENT : **Minto Mines** **Test** : **Modified Acid-Base Accounting** **SGS Proj : 0643**

PROJECT : **Minto Mines** **Date** : **March 28, 2016**

Sample ID	**Sampling Date**	**Paste pH**	**TIC %**	**CaCO3 NP**	**C(T) %**	**S(T) %**	**S(SO4) %**	**S(S-2) %**	**AP**	**NP**	**Net NP**	**NP:AP Ratio (NP/AP)**	**Fizz Test**
Method Code		Sobek	CSB02V	Calc #N/A	CSA06V 0.005	CSA06V 0.005	CSA07V 0.01	Calc #N/A	Calc #N/A	Modified 0.5	Calc #N/A	Calc #N/A	Sobek #N/A
122356	6-Feb-16	8.44	0.29	24.2	0.317	0.02	<0.01	0.02	0.6	26.5	25.9	42.4	Slight
122357	6-Feb-16	8.45	0.19	15.8	0.226	0.015	<0.01	0.02	0.5	20.5	20.0	43.7	Slight
122358	6-Feb-16	7.97	<0.01	<0.8	0.031	0.028	<0.01	0.03	0.9	4.2	3.3	4.8	None
122359	6-Feb-16	8.46	0.37	30.8	0.398	0.153	<0.01	0.15	4.8	34.8	30.0	7.3	Slight
122360	6-Feb-16	8.65	0.19	15.8	0.229	0.04	<0.01	0.04	1.3	19.4	18.2	15.5	Slight
122361	6-Feb-16	8.44	0.18	15.0	0.195	0.421	<0.01	0.42	13.2	19.9	6.7	1.5	Slight
122362	10-Feb-16	8.22	0.05	4.2	0.094	0.018	<0.01	0.02	0.6	9.7	9.1	17.2	None
122363	10-Feb-16	8.31	0.43	35.8	0.452	0.06	<0.01	0.06	1.9	39.4	37.5	21.0	Slight
122364	10-Feb-16	8.77	0.14	11.7	0.165	0.021	<0.01	0.02	0.7	17.2	16.5	26.2	Slight
122365	10-Feb-16	8.64	0.21	17.5	0.232	0.035	<0.01	0.04	1.1	21.0	19.9	19.2	Slight
122366	10-Feb-16	8.66	0.2	16.7	0.234	0.078	<0.01	0.08	2.4	20.6	18.2	8.5	Slight
122367	10-Feb-16	8.35	0.03	2.5	0.071	0.012	<0.01	0.01	0.4	8.5	8.1	22.7	None
122368	10-Feb-16	8.75	0.16	13.3	0.183	0.01	<0.01	0.01	0.3	17.4	17.1	55.7	Slight
122369	10-Feb-16	8.74	0.18	15.0	0.207	0.321	<0.01	0.32	10.0	19.3	9.3	1.9	Slight
122370	13-Feb-16	8.76	0.1	8.3	0.137	<0.005	<0.01	<0.01	<0.3	13.7	13.7	45.7	Slight
122371	13-Feb-16	8.52	0.27	22.5	0.306	0.022	<0.01	0.02	0.7	27.1	26.4	39.4	Slight
122372	13-Feb-16	8.70	0.26	21.7	0.288	0.011	<0.01	0.01	0.3	24.9	24.6	72.4	Slight
122373	13-Feb-16	8.49	0.38	31.7	0.402	0.112	<0.01	0.11	3.5	35.7	32.2	10.2	Slight
Jan 2016 Tails	20-Jan-16	8.70	0.22	18.3	0.256	0.052	<0.01	0.05	1.6	20.1	18.5	12.4	Slight
Duplicates													
122356		8.46			0.315	0.019				26.1			Slight
122359			0.37										
122371							<0.01						
QC													
GTS-2A					2.06	0.327							
RTS-3A							0.98						
SY-4			0.91										
NBM-1										40.7			Slight
Expected Values			0.95		2.01	0.341	0.98			42.0			Slight
Tolerance +/-			0.06		0.15	0.030	0.12			3.0			

Note: AP = Acid potential in tonnes CaCO3 equivalent per 1000 tonnes of material. AP is determined from calculated sulphide sulphur content: S(T) - S(SO4).

NP = Neutralization potential in tonnes CaCO3 equivalent per 1000 tonnes of material.

NET NP = NP - AP

Carbonate NP is calculated from TIC originating from carbonate minerals and is expressed in kg CaCO3/tonne.

CLIENT : **Minto Mines**
PROJECT : **Minto Project**
SGS Project # : **0643**
Test : **Metals by Aqua Regia Digestion with ICP-MS Finish**
Date : **March 28, 2016**

Sample ID	**Ag ppm**	**Al %**	**B ppm**	**Ba ppm**	**Ca %**	**Cr ppm**	**Cu ppm**	**Fe %**	**K %**	**Li ppm**	**Mg %**	**Mn ppm**
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	0.01	0.01	10	5	0.01	1	0.5	0.01	0.01	1	0.01	2
122356	0.04	1.17	<10	104	1.48	100	75.9	2.18	0.23	6	0.69	533
122357	0.05	1.17	<10	201	1.18	108	106	2.3	0.51	6	0.62	513
122358	1.23	1.55	<10	164	0.29	106	2560	2.62	1.05	7	0.88	635
122359	0.52	1.31	<10	54	1.95	96	2070	2.47	0.11	6	0.66	525
122360	0.08	1.2	<10	158	1.17	102	180	2.18	0.38	7	0.71	504
122361	1.36	1.3	<10	58	1.09	98	4760	2.53	0.12	8	0.76	500
122362	0.27	1.1	<10	129	0.66	100	368	2.26	0.35	6	0.61	650
122363	0.2	1.18	<10	74	2.01	81	629	2.1	0.13	6	0.54	489
122364	0.08	1.22	10	115	1.06	95	128	2.24	0.25	8	0.82	527
122365	0.08	1.2	<10	151	1.26	99	189	2.25	0.37	6	0.71	522
122366	0.78	1.14	<10	182	1.07	106	1260	2.65	0.44	6	0.69	514
122367	0.02	1.06	<10	229	0.6	113	22.9	2.14	0.48	7	0.64	468
122368	0.08	1.08	<10	186	1	108	198	2.11	0.44	6	0.66	490
122369	2.52	0.81	<10	113	0.92	108	6450	1.84	0.32	5	0.44	387
122370	0.02	1.08	<10	186	0.88	116	24.9	2.15	0.4	6	0.64	481
122371	0.13	1.24	<10	106	1.49	95	303	2.12	0.23	7	0.73	508
122372	0.02	1.05	<10	59	1.29	90	16.1	1.73	0.12	6	0.6	435
122373	0.37	1.41	<10	74	1.84	77	1370	2.24	0.24	7	0.7	475
Jan 2016 Tails	0.46	1.29	<10	215	0.95	76	625	3.55	0.8	6	0.83	642
Duplicate												
122362	0.27	1.04	<10	120	0.64	98	346	2.14	0.32	6	0.58	615
QC												
CH4	2.16	1.82	10	303	0.62	111	1940	4.56	1.39	13	1.18	336
Expected Values	2.13	1.85	#N/A	293	0.61	103.8	2000	4.79	1.43	12.6	1.18	324
Tolerance (%)	10.9	11.35	#N/A	14.3	14.1	12.4	10.1	10.52	11.74	29.84	12.3	11.5

Na %	Ni ppm	P %	S %	Sr ppm	Ti %	V ppm	Zn ppm	Zr ppm	As ppm	Be ppm	Bi ppm	Cd ppm	Ce ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.01	0.5	0.005	0.01	0.5	0.01	1	1	0.5	1	0.1	0.02	0.01	0.05
0.06	3.3	0.081	<0.01	110	0.07	47	60	1.3	<1	0.4	0.02	0.04	16.5
0.06	4.9	0.08	<0.01	39.6	0.11	55	64	1.5	6	0.3	<0.02	0.06	16.9
0.05	5.5	0.1	0.02	17.4	0.18	87	102	2.2	29	0.2	0.17	0.04	37.1
0.05	5.6	0.072	0.15	156	0.05	46	64	1.4	<1	0.5	0.26	0.15	18.1
0.07	3.3	0.076	0.03	78.5	0.11	52	64	1.4	2	0.3	0.02	0.05	17.3
0.05	3.2	0.067	0.42	96.8	0.05	43	107	1	<1	0.3	0.53	0.37	13.2
0.05	3.5	0.084	<0.01	63.3	0.09	54	101	2.2	1	0.3	0.16	0.07	22.9
0.05	2.9	0.069	0.05	133	0.04	40	53	1.1	<1	0.5	0.11	0.05	19.8
0.06	3.5	0.076	<0.01	100	0.09	52	70	1.2	<1	0.3	<0.02	0.05	16.3
0.07	3.6	0.076	0.02	82.7	0.1	51	62	1.6	<1	0.3	0.03	0.04	18.1
0.06	3.4	0.065	0.07	65.5	0.1	57	66	1	<1	0.3	0.44	0.12	17.9
0.07	3.8	0.076	<0.01	29	0.12	55	55	1.5	<1	0.2	<0.02	0.03	14.5
0.06	3.4	0.068	0.02	62.8	0.11	49	60	1.4	<1	0.3	0.03	0.05	19.2
0.05	2.9	0.053	0.35	49.9	0.07	36	55	1	<1	0.2	0.91	0.24	13.8
0.06	3.8	0.077	<0.01	38.5	0.1	52	54	1.6	2	0.3	<0.02	0.04	14.7
0.05	3.2	0.074	0.03	124	0.08	46	58	1.1	<1	0.4	0.09	0.05	18.8
0.05	3.2	0.058	<0.01	91	0.03	31	46	1.3	<1	0.4	<0.02	0.06	16.2
0.05	2.8	0.084	0.11	121	0.03	40	69	0.9	<1	0.4	0.44	0.21	19.7
0.05	4.1	0.105	0.05	49.5	0.14	74	103	1.3	<1	0.2	0.13	0.25	19.8
0.05	3.4	0.081	<0.01	60.5	0.08	50	99	2.1	<1	0.3	0.16	0.08	22.7
0.07	50.2	0.068	0.67	9.4	0.22	81	192	14.6	8	0.1	0.42	1.09	30
0.06	49.57	0.072	0.73	9.38	0.21	79.27	189.4	11.7	8.14	0.11	0.51	1.17	28.18
50.3	12.52	27.4	13.4	23.3	23.3	13.2	11.3	17.7	13.1	241.3	19.7	12.1	16.1

Co ppm	Cs ppm	Ga ppm	Ge ppm	Hf ppm	Hg ppm	In ppm	La ppm	Lu ppm	Mo ppm	Nb ppm	Pb ppm	Rb ppm	Sb ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.1	0.05	0.1	0.1	0.05	0.01	0.02	0.1	0.01	0.05	0.05	0.2	0.2	0.05
6.3	0.17	5.6	<0.1	0.06	0.01	<0.02	8.4	0.1	2.3	0.37	2.8	9.7	<0.05
6.6	0.32	5.4	<0.1	0.07	0.01	<0.02	8.9	0.1	3.3	0.54	1.8	23.9	<0.05
5.8	1.07	7.3	<0.1	0.08	0.04	0.19	24.8	0.14	33.5	1.03	3	66.2	<0.05
6.5	0.14	6.9	<0.1	0.06	<0.01	0.03	9.4	0.09	2.31	0.33	4.2	5.3	<0.05
6.4	0.26	5.7	<0.1	0.06	<0.01	<0.02	9	0.09	2.68	0.58	2.3	18.3	<0.05
5.5	0.13	6.2	<0.1	<0.05	0.01	0.11	7	0.04	2.19	0.23	6.4	6.3	<0.05
6.8	0.29	5.4	<0.1	0.09	<0.01	<0.02	13	0.08	4.88	0.54	3.8	20	<0.05
5.5	0.15	5.5	<0.1	<0.05	<0.01	0.03	10.5	0.1	3.75	0.17	2.7	6.5	<0.05
6	0.19	5.7	<0.1	0.06	<0.01	<0.02	8.5	0.08	7.02	0.47	2.3	12.5	<0.05
6.2	0.24	5.5	<0.1	0.07	<0.01	<0.02	9.6	0.08	2.9	0.5	2.4	17.5	<0.05
6.2	0.28	5.9	<0.1	<0.05	<0.01	<0.02	9.4	0.07	2.67	0.45	2.4	20.9	<0.05
5.6	0.27	4.7	<0.1	0.07	<0.01	<0.02	7.9	0.08	2.85	0.62	1.3	21.5	<0.05
5.5	0.24	5.1	<0.1	0.06	<0.01	<0.02	10.2	0.08	3.78	0.47	2.1	20.2	<0.05
3.6	0.23	4	<0.1	<0.05	<0.01	0.1	7.2	0.05	2.47	0.45	3.1	15.4	<0.05
5.8	0.24	5	<0.1	0.07	<0.01	<0.02	8	0.09	3	0.51	1.7	17.6	<0.05
5.7	0.19	5.8	<0.1	<0.05	<0.01	0.02	9.6	0.09	2.28	0.4	3.1	10.5	<0.05
5.2	0.11	5.8	<0.1	0.05	<0.01	<0.02	8	0.09	2.06	0.17	2.8	5.7	<0.05
5.1	0.31	6.5	<0.1	<0.05	<0.01	0.04	10.3	0.09	1.72	0.2	4.8	13.4	<0.05
6.6	0.72	7.8	0.1	<0.05	<0.01	0.07	10.1	0.08	2.5	0.64	1.7	45	<0.05
6.4	0.27	5.5	<0.1	0.1	<0.01	<0.02	12.8	0.08	4.16	0.39	3.9	19.4	<0.05
25.2	2.54	9.1	0.2	0.33	<0.01	0.09	15.1	0.06	2.73	0.23	8.2	68.2	0.26
23.56	2.6	8.72	0.21	0.29	#N/A	0.1	14	#N/A	3.05	0.19	8.24	67	0.34
11.1	14.8	12.9	127.4	52.8	#N/A	62.1	11.8	#N/A	14.1	75	16.1	10.7	47.3

Sc ppm	Se ppm	Sn ppm	Ta ppm	Tb ppm	Te ppm	Th ppm	Tl ppm	U ppm	W ppm	Y ppm	Yb ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.1	1	0.3	0.05	0.02	0.05	0.1	0.02	0.05	0.1	0.05	0.1
4.4	<1	0.4	<0.05	0.19	<0.05	1.6	0.06	0.22	0.1	6.3	0.6
4.4	<1	0.5	<0.05	0.21	<0.05	1.5	0.13	0.22	0.6	6.7	0.6
6.6	2	3.5	<0.05	0.32	0.13	7.9	0.56	1.01	0.6	8.21	0.9
3.9	1	0.5	<0.05	0.21	0.07	1.8	0.02	0.28	1.9	6.62	0.6
4.2	<1	0.5	<0.05	0.19	<0.05	1.8	0.09	0.29	0.3	6.1	0.6
2.8	3	0.4	<0.05	0.11	0.28	2.8	0.05	0.21	<0.1	3.36	0.3
3.3	<1	0.4	<0.05	0.18	0.05	5.1	0.1	0.55	0.5	5.57	0.5
3.8	<1	0.5	<0.05	0.2	<0.05	2.5	0.03	0.23	<0.1	6.45	0.6
4	<1	0.5	<0.05	0.17	<0.05	1.8	0.06	0.31	0.2	5.46	0.5
3.5	<1	0.5	<0.05	0.19	<0.05	2.2	0.09	0.34	<0.1	5.89	0.5
3	1	0.5	<0.05	0.16	0.23	2.4	0.11	0.27	0.1	4.94	0.5
3.9	<1	0.5	<0.05	0.18	<0.05	1.2	0.1	0.19	0.3	5.82	0.6
3.3	<1	0.5	<0.05	0.18	<0.05	2.7	0.12	0.32	<0.1	5.55	0.5
2.6	3	3.1	<0.05	0.14	0.79	2.3	0.1	0.13	0.2	4.13	0.4
3.8	<1	0.5	<0.05	0.18	<0.05	1.2	0.08	0.19	0.4	6.03	0.6
3.6	<1	0.5	<0.05	0.2	<0.05	2.4	0.05	0.29	<0.1	6.35	0.6
3.2	<1	0.4	<0.05	0.18	<0.05	1.8	0.03	0.2	0.2	5.87	0.6
3.7	1	0.5	<0.05	0.22	0.11	3.7	0.09	0.37	<0.1	6.93	0.6
3.8	<1	1	<0.05	0.21	0.17	4.5	0.35	0.33	<0.1	6.38	0.5
3.2	<1	0.4	<0.05	0.18	<0.05	5.1	0.1	0.64	0.3	5.34	0.5
8.9	2	0.6	<0.05	0.25	0.41	2.1	0.39	0.28	1.7	5.7	0.4
8.53	1.57	0.6	0.3	0.27	0.42	2.2	0.4	0.29	2.15	5.66	#N/A
13.1	169.6	134.5	51.7	28.4	39.6	21.2	22.6	52.9	21.6	12.2	#N/A

CLIENT : **Minto Mines**
PROJECT : **Minto Mines**
SGS Project # : **0643**
Test : **Modified Acid-Base Accounting**
Date : **March 28, 2016**

Sample ID	**Sampling Date**	**Paste pH**	**TIC %**	**CaCO3 NP**	**C(T) %**	**S(T) %**	**S(SO4) %**	**S(S-2) %**	**AP**	**NP**	**Net NP**	**NP:AP Ratio (NP/AP)**	**Fizz Test**
Method Code		Sobek	CSB02V	Calc #N/A	CSA06V 0.005	CSA06V 0.005	CSA07V 0.01	Calc #N/A	Calc #N/A	Modified 0.5	Calc #N/A	Calc #N/A	Sobek #N/A
122374	15-Feb-16	8.46	0.24	20.0	0.261	0.041	<0.01	0.04	1.3	23.5	22.2	18.3	Slight
122375	15-Feb-16	8.39	0.31	25.8	0.343	0.022	<0.01	0.02	0.7	29.1	28.4	42.3	Slight
124301	21-Feb-16	8.49	0.25	20.8	0.263	0.067	<0.01	0.07	2.1	24.5	22.4	11.7	Slight
124302	21-Feb-16	8.66	0.25	20.8	0.255	0.023	<0.01	0.02	0.7	24.1	23.4	33.5	Slight
124303	24-Feb-16	8.44	0.02	1.7	0.043	0.023	<0.01	0.02	0.7	6.8	6.1	9.5	None
124304	24-Feb-16	8.49	0.18	15.0	0.266	0.017	<0.01	0.02	0.5	20.6	20.1	38.8	Slight
124305	24-Feb-16	8.47	0.27	22.5	0.312	0.034	<0.01	0.03	1.1	24.0	22.9	22.6	Slight
124306	24-Feb-16	8.73	0.24	20.0	0.273	0.016	<0.01	0.02	0.5	22.4	21.9	44.8	Slight
124307	24-Feb-16	9.12	0.15	12.5	0.167	0.011	<0.01	0.01	0.3	13.6	13.3	39.6	None
124308	24-Feb-16	8.12	0.1	8.3	0.11	0.014	<0.01	0.01	0.4	13.8	13.4	31.5	None
124309	24-Feb-16	9.01	0.1	8.3	0.111	0.028	<0.01	0.03	0.9	1.2	0.3	1.4	Slight
124310	24-Feb-16	8.98	0.08	6.7	0.091	0.012	<0.01	0.01	0.4	11.7	11.3	31.2	None
124311	24-Feb-16	8.62	0.04	3.3	0.07	0.012	<0.01	0.01	0.4	9.3	8.9	24.8	None
Duplicates													
122374		8.60								22.9			Slight
124301					0.261	0.068							
124303			0.02										
124309							<0.01						
QC													
GTS-2A					2.03	0.345							
RTS-3A							1.02						
SY-4			0.92										
NBM-1										41.0			Slight
Expected Values			0.95		2.01	0.341	0.98			42.0			Slight
Tolerance +/-			0.06		0.15	0.030	0.12			3.0			

Note:

AP = Acid potential in tonnes CaCO3 equivalent per 1000 tonnes of material. AP is determined from calculated sulphide sulphur content: S(T) - S(SO4).

NP = Neutralization potential in tonnes CaCO3 equivalent per 1000 tonnes of material.

NET NP = NP - AP

Carbonate NP is calculated from TIC originating from carbonate minerals and is expressed in kg CaCO3/tonne.

CLIENT : **Minto Mines**
PROJECT : **Minto Project**
SGS Project # : **0643**
Test : **Metals by Aqua Regia Digestion with ICP-MS Finish**
Date : **March 28, 2016**

Sample ID	**Ag ppm**	**Al %**	**B ppm**	**Ba ppm**	**Ca %**	**Cr ppm**	**Cu ppm**	**Fe %**	**K %**	**Li ppm**	**Mg %**
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	0.01	0.01	10	5	0.01	1	0.5	0.01	0.01	1	0.01
122374	0.17	1.18	30	136	1.35	105	369	2.21	0.33	6	0.7
122375	0.05	1.14	30	170	1.47	103	91.4	2.05	0.34	6	0.62
124301	0.24	1.31	20	84	1.34	86	726	2.2	0.19	7	0.75
124302	0.14	1.17	30	312	1.19	92	242	2.37	0.62	9	0.69
124303	0.21	1.45	30	328	0.4	93	830	2.67	1	7	0.79
124304	0.02	1.19	20	156	1.26	91	37.6	1.88	0.29	6	0.64
124305	0.06	1.2	20	130	1.37	92	164	2.26	0.31	7	0.73
124306	0.03	1.02	30	176	1.19	98	45.1	1.91	0.38	6	0.6
124307	0.02	0.77	30	226	0.63	119	10.7	1.54	0.49	4	0.44
124308	0.03	1.04	30	146	0.94	94	29.5	1.96	0.37	5	0.66
124309	0.2	1.11	30	106	1.05	93	317	2	0.31	6	0.72
124310	0.05	1.05	30	206	0.79	102	62.2	2.04	0.52	6	0.69
124311	0.03	1.06	30	244	0.61	107	36.7	2.14	0.57	6	0.62
Duplicate											
122374	0.18	1.19	20	139	1.36	106	370	2.2	0.34	6	0.71
QC											
OREAS 901	0.28	1.01	40	89	0.09	24	1380	3.44	0.53	3	0.14
Expected Values	0.276	0.992	#N/A	86	0.091	23.0	1440	3.70	0.512	3.1	0.124
Tolerance (%)	19.06	12.52	#N/A	24.53	37.47	20.87	10.09	10.68	14.88	98.65	30.16

Mn ppm	Na %	Ni ppm	P %	S %	Sr ppm	Ti %	V ppm	Zn ppm	Zr ppm	As ppm	Be ppm
ICM14B 2	ICM14B 0.01	ICM14B 0.5	ICM14B 0.005	ICM14B 0.01	ICM14B 0.5	ICM14B 0.01	ICM14B 1	ICM14B 1	ICM14B 0.5	ICM14B 1	ICM14B 0.1
505	0.06	3.8	0.085	0.03	100	0.09	52	59	1.7	<1	0.4
464	0.05	3.8	0.074	<0.01	120	0.06	43	52	1.1	<1	0.3
507	0.04	3	0.074	0.06	110	0.05	42	70	1.2	<1	0.4
534	0.05	3.8	0.074	0.01	79.3	0.12	59	64	2.3	<1	0.2
440	0.05	3.4	0.085	0.02	18.9	0.17	74	73	1.6	8	0.2
446	0.07	3.1	0.076	<0.01	273	0.09	42	48	1.3	<1	0.4
530	0.05	4	0.089	0.02	132	0.08	50	61	1.7	<1	0.4
481	0.06	3.2	0.067	<0.01	73.1	0.08	44	55	1.4	<1	0.3
328	0.06	2.8	0.036	<0.01	38.9	0.09	35	45	0.9	<1	0.1
446	0.08	3.2	0.068	<0.01	53.5	0.12	49	53	1.8	<1	0.3
430	0.07	3.1	0.085	0.02	83.1	0.12	52	56	1.7	<1	0.4
490	0.09	3.3	0.068	<0.01	51.5	0.13	51	55	2.1	<1	0.2
454	0.06	3.7	0.085	<0.01	25.6	0.12	56	53	1.7	2	0.2
509	0.06	3.4	0.087	0.03	100	0.1	53	60	1.9	<1	0.4
282	0.02	34.5	0.061	0.03	19.9	<0.01	22	18	32.7	60	4.7
300	0.01	34.7	0.059	0.033	21.0	0.01	21	20.2	31.6	66	4.49
11.67	#N/A	13.60	31.19	85.76	15.95	#N/A	#N/A	22.38	13.96	13.79	15.57

Bi ppm	Cd ppm	Ce ppm	Co ppm	Cs ppm	Ga ppm	Ge ppm	Hf ppm	Hg ppm	In ppm	La ppm	Lu ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.02	0.01	0.05	0.1	0.05	0.1	0.1	0.05	0.01	0.02	0.1	0.01
0.04	0.05	23.3	6.3	0.25	5.6	<0.1	0.09	<0.01	<0.02	12.5	0.1
0.02	0.05	22.2	5.5	0.27	5.1	<0.1	<0.05	<0.01	<0.02	11.4	0.09
0.18	0.1	24	5.4	0.17	6.2	<0.1	<0.05	<0.01	0.02	12.3	0.08
0.12	0.05	25.3	6.1	0.51	5.7	0.1	0.11	0.03	<0.02	12.4	0.08
0.04	0.16	31.2	7	0.76	6.6	0.1	0.06	0.03	0.05	18.5	0.1
<0.02	0.03	11.7	5.5	0.19	4.8	<0.1	0.05	<0.01	<0.02	5.9	0.07
0.03	0.05	25	6.6	0.23	5.6	<0.1	0.08	<0.01	<0.02	13.4	0.11
<0.02	0.03	19.3	5.1	0.23	4.7	<0.1	0.06	<0.01	<0.02	9.9	0.09
<0.02	0.02	13.8	3.8	0.29	3.5	<0.1	<0.05	<0.01	<0.02	8.4	0.04
<0.02	0.03	13.6	5.3	0.25	4.9	<0.1	0.08	<0.01	<0.02	7.2	0.08
0.04	0.03	20.2	6	0.19	5.1	<0.1	0.08	<0.01	<0.02	11	0.08
<0.02	0.03	14.7	5.5	0.29	4.6	<0.1	0.1	<0.01	<0.02	7.5	0.09
<0.02	0.02	15.1	5.8	0.33	4.7	<0.1	0.08	<0.01	<0.02	8.3	0.08
0.04	0.05	23.6	6.3	0.24	5.6	<0.1	0.08	<0.01	<0.02	12.6	0.1
4.09	0.04	77.8	65.6	0.99	2.8	<0.1	0.87	<0.01	0.22	37.6	0.24
4.35	0.05	78	73	0.97	3.15	0.11	0.8	0.02	0.21	38.1	0.22
11.15	#N/A	15.77	16.85	22.89	17.94	237.27	#N/A	#N/A	33.81	10.66	21.36

Mo ppm	Nb ppm	Pb ppm	Rb ppm	Sb ppm	Sc ppm	Se ppm	Sn ppm	Ta ppm	Tb ppm	Te ppm	Th ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.05	0.05	0.2	0.2	0.05	0.1	1	0.3	0.05	0.02	0.05	0.1
3.2	0.47	2.7	17.1	<0.05	3.5	<1	0.5	<0.05	0.21	<0.05	3.8
2.33	0.31	1.6	15.9	<0.05	3.5	<1	1.6	<0.05	0.21	<0.05	3
2.91	0.23	3.8	9.6	<0.05	3.2	<1	0.6	<0.05	0.21	<0.05	4.1
2.06	0.31	1.9	32.3	<0.05	3.5	<1	0.6	<0.05	0.2	<0.05	4.2
3.9	0.6	4.4	57.1	<0.05	3.1	<1	1.4	<0.05	0.26	<0.05	5.1
2.39	0.39	2	12	<0.05	2.8	<1	0.4	<0.05	0.15	<0.05	1.1
2.24	0.42	2.8	14.6	<0.05	3.6	<1	0.5	<0.05	0.24	<0.05	3.9
2.42	0.48	2.4	16.7	<0.05	3.6	<1	0.5	<0.05	0.2	<0.05	2.2
2.62	0.29	1.3	23.5	<0.05	1.8	<1	0.3	<0.05	0.08	<0.05	1.8
2.17	0.59	1.9	15.6	<0.05	3.2	<1	0.5	<0.05	0.17	<0.05	1.3
2.74	0.66	2.5	14.4	<0.05	3.1	<1	4.1	<0.05	0.18	<0.05	3.2
2.27	0.66	1.4	22.9	<0.05	3.4	<1	0.5	<0.05	0.19	<0.05	1.6
2.66	0.58	3.4	26.1	<0.05	4.1	<1	0.5	<0.05	0.17	<0.05	1.7
3.16	0.46	2.4	17.4	<0.05	3.4	<1	0.5	<0.05	0.21	<0.05	3.8
3	<0.05	13.3	25.1	1.31	5	2	0.6	<0.05	0.74	0.06	8.8
3.23	0.1	14.6	23.9	1.47	5.55	2.68	0.58	0.02	0.77	0.076	9.13
13.87	#N/A	13.42	12.09	18.50	14.50	103.28	139.31	#N/A	16.49	174.47	12.74

Tl ppm	U ppm	W ppm	Y ppm	Yb ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.02	0.05	0.1	0.05	0.1
0.08	0.5	0.4	6.67	0.6
0.09	0.24	0.4	6.63	0.6
0.05	0.23	<0.1	6.41	0.6
0.18	0.47	<0.1	5.95	0.5
0.29	0.61	0.2	7.68	0.7
0.06	0.18	0.3	5.16	0.5
0.07	0.55	0.2	7.32	0.7
0.1	0.23	0.2	6.21	0.6
0.14	0.13	0.2	2.58	0.2
0.08	0.22	0.4	5.51	0.5
0.07	0.44	0.5	5.78	0.6
0.12	0.28	0.4	6.2	0.6
0.13	0.25	0.2	5.81	0.6
0.09	0.52	0.4	6.61	0.6
0.34	6.2	0.9	19.9	1.5
0.34	5.84	1.1	18.8	1.49
24.71	12.14	#N/A	10.66	26.78

CLIENT : **Minto Mines**
PROJECT : **Minto Project**
SGS Project # : **0643**
Test : **Metals by Aqua Regia Digestion with ICP-MS Finish**
Date : **April 13, 2016**

Sample ID	**Ag ppm**	**Al %**	**B ppm**	**Ba ppm**	**Ca %**	**Cr ppm**	**Cu ppm**	**Fe %**	**K %**	**Li ppm**	**Mg %**
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	0.01	0.01	10	5	0.01	1	0.5	0.01	0.01	1	0.01
117251	0.04	1.13	40	192	0.87	111	196	2.31	0.52	6	0.6
117252	0.96	1.29	50	90	1.15	93	4450	2.52	0.3	7	0.72
117253	0.22	1.39	50	416	0.74	99	798	2.91	0.96	9	0.76
117254	0.02	1.12	40	173	0.73	95	34.9	2.22	0.41	7	0.68
117255	0.55	1.46	50	304	0.77	102	2080	2.69	0.88	7	0.81
117256	1.14	1.16	40	214	1.19	94	3100	2.75	0.52	6	0.63
117257	0.15	1.4	60	314	0.97	105	609	2.58	0.65	8	0.82
124312	0.06	1.62	50	56	1.31	81	149	2.4	0.12	8	0.81
124313	0.03	1.46	40	142	1.21	86	29.5	2.46	0.32	9	0.89
124314	0.03	1.12	50	256	0.75	98	37.2	2.28	0.58	7	0.69
124315	0.21	1.34	50	192	0.29	109	1050	2.59	0.91	5	0.69
124316	1.9	1.34	50	127	0.87	95	4610	2.72	0.4	7	0.77
124317	0.39	1.03	40	60	1.57	93	1000	2.08	0.14	6	0.48
124318	0.33	1.09	50	113	1.26	98	1160	2.09	0.25	6	0.6
124319	0.24	1.03	50	146	0.96	92	485	2.07	0.41	6	0.64
124320	0.06	1.04	40	100	0.95	94	106	2.01	0.22	6	0.66
124321	0.03	0.82	40	151	0.8	106	28.1	1.78	0.28	5	0.49
124322	0.01	1.17	50	125	1.18	91	51.3	2.09	0.28	6	0.71
124324	0.03	1.18	50	176	0.88	99	32	2.28	0.39	7	0.78
Duplicate											
124314	0.03	1.14	50	259	0.76	101	35.8	2.32	0.59	6	0.7
QC											
CH4	2.17	1.87	50	299	0.59	109	1970	4.82	1.43	13	1.18
Expected Values	2.13	1.85	#N/A	293	0.61	103.8	2000	4.79	1.43	12.6	1.18
Tolerance (%)	10.9	11.35	#N/A	14.3	14.1	12.4	10.1	10.52	11.74	29.84	12.3

Mn ppm	Na %	Ni ppm	P %	S %	Sr ppm	Ti %	V ppm	Zn ppm	Zr ppm	As ppm	Be ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
2	0.01	0.5	0.005	0.01	0.5	0.01	1	1	0.5	1	0.1
488	0.06	3.7	0.077	<0.01	40.7	0.1	53	67	1.4	8	0.3
515	0.06	3.2	0.078	0.32	96.1	0.07	48	77	0.9	<1	0.5
537	0.06	3.6	0.077	0.06	81.1	0.16	70	78	0.8	1	0.2
492	0.08	4.3	0.071	<0.01	43.4	0.12	51	54	1.3	2	0.3
516	0.06	3.4	0.074	0.18	73.2	0.15	63	64	0.9	2	0.3
549	0.06	3.6	0.08	0.14	55.6	0.11	62	77	1.3	1	0.3
549	0.06	3.8	0.082	0.05	127	0.14	59	62	0.8	<1	0.3
436	0.05	3.1	0.074	0.06	144	0.06	49	52	1	2	0.6
613	0.05	3.4	0.08	<0.01	114	0.09	52	61	0.8	1	0.5
506	0.08	3.8	0.094	<0.01	31.8	0.13	56	59	1.4	1	0.2
324	0.05	3.6	0.08	0.03	16.4	0.15	73	69	2.2	10	0.2
508	0.05	3.5	0.069	0.21	54.9	0.1	52	79	0.6	1	0.2
387	0.04	2.8	0.048	0.06	66.3	0.01	34	52	1.4	1	0.3
520	0.06	3.3	0.071	0.1	90.3	0.04	36	54	0.8	<1	0.2
443	0.06	3.1	0.078	0.03	75.7	0.09	50	68	1.3	2	0.4
481	0.06	3.3	0.069	<0.01	60.5	0.07	42	61	1.1	<1	0.4
396	0.05	3.4	0.058	<0.01	64.8	0.05	38	48	0.9	<1	0.2
493	0.05	3.4	0.076	<0.01	75.3	0.06	47	59	1.2	1	0.3
508	0.06	3.6	0.068	<0.01	69.1	0.1	53	58	1	1	0.3
515	0.09	3.6	0.091	<0.01	32.8	0.13	56	58	1.4	3	0.3
321	0.07	49.5	0.069	0.67	9.5	0.22	83	202	14.1	9	0.1
324	0.06	49.57	0.072	0.73	9.38	0.21	79.27	189.4	11.7	8.14	0.11
11.5	50.3	12.52	27.4	13.4	23.3	23.3	13.2	11.3	17.7	13.1	241.3

Bi ppm	Cd ppm	Ce ppm	Co ppm	Cs ppm	Ga ppm	Ge ppm	Hf ppm	Hg ppm	In ppm	La ppm	Lu ppm
ICM14B 0.02	ICM14B 0.01	ICM14B 0.05	ICM14B 0.1	ICM14B 0.05	ICM14B 0.1	ICM14B 0.1	ICM14B 0.05	ICM14B 0.01	ICM14B 0.02	ICM14B 0.1	ICM14B 0.01
<0.02	0.1	17.8	5.9	0.28	5.5	0.1	0.1	0.03	<0.02	9.3	0.09
0.46	0.24	20.5	5.4	0.29	7.2	0.1	<0.05	<0.01	0.13	10.2	0.06
0.11	0.08	25.7	7	0.54	6.9	0.1	<0.05	0.05	0.04	13.1	0.06
<0.02	0.04	13.2	5.7	0.21	5.5	0.1	<0.05	0.05	<0.02	7	0.07
0.33	0.14	23.4	6	0.7	6.8	0.1	<0.05	0.03	0.1	11.7	0.09
0.32	0.48	14.7	6.1	0.42	6.6	0.1	0.05	0.04	0.07	7.8	0.05
0.06	0.14	27.4	6.6	0.39	6.9	0.1	<0.05	<0.01	0.03	14.3	0.07
<0.02	0.03	23.8	5.9	0.1	7.4	<0.1	0.06	0.02	<0.02	13	0.08
<0.02	0.06	26.8	6.7	0.22	7.2	<0.1	<0.05	0.03	<0.02	14.2	0.07
<0.02	0.03	14.9	6.1	0.23	5.4	0.1	0.08	0.05	<0.02	8	0.09
0.04	0.07	33.7	7.5	0.73	6.5	0.1	0.05	0.01	0.1	19.6	0.14
0.7	0.24	22.7	6.4	0.22	7.3	0.1	<0.05	0.08	0.05	11.9	0.03
0.09	0.12	15.5	4.3	0.21	5.6	<0.1	0.05	<0.01	<0.02	8.8	0.03
0.06	0.19	18.6	5.2	0.25	5.5	<0.1	<0.05	0.04	0.03	9.4	0.08
0.06	<0.01	25.9	6.2	0.22	5.5	<0.1	0.06	0.04	<0.02	14.5	0.07
0.03	<0.01	17.6	5.5	0.14	5.9	0.1	0.07	<0.01	<0.02	9.3	0.07
<0.02	0.02	17	5.1	0.16	4.5	<0.1	<0.05	0.01	<0.02	9.6	0.06
<0.02	<0.01	15.8	6	0.2	5.8	<0.1	0.08	0.01	<0.02	8.4	0.09
<0.02	0.03	21.3	6	0.23	6.1	<0.1	<0.05	<0.01	0.02	10.4	0.11
<0.02	0.07	13.9	6.4	0.25	5.5	<0.1	0.08	0.01	<0.02	7.6	0.08
0.55	1.2	28.7	24.1	2.59	9.5	0.3	0.37	<0.01	0.11	14.3	0.05
0.51	1.17	28.18	23.56	2.6	8.72	0.21	0.29	#N/A	0.1	14	#N/A
19.7	12.1	16.1	11.1	14.8	12.9	127.4	52.8	#N/A	62.1	11.8	#N/A

Mo ppm	Nb ppm	Pb ppm	Rb ppm	Sb ppm	Sc ppm	Se ppm	Sn ppm	Ta ppm	Tb ppm	Te ppm	Th ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.05	0.05	0.2	0.2	0.05	0.1	1	0.3	0.05	0.02	0.05	0.1
3.47	0.5	4	24.3	<0.05	4	<1	0.6	<0.05	0.2	<0.05	2.4
2.31	0.43	4.3	16	<0.05	5	2	0.9	<0.05	0.18	0.21	4.9
2.52	0.6	2	43.7	<0.05	3.4	<1	0.6	<0.05	0.18	0.07	5.3
2.63	0.52	5.9	16.3	<0.05	3.4	<1	0.4	<0.05	0.14	0.09	1.2
5.53	0.93	2	43	<0.05	4.2	3	1	<0.05	0.23	0.06	5.1
2.79	0.51	2.6	27.6	<0.05	3.2	2	0.6	<0.05	0.17	0.22	1.7
3.51	0.71	2	30.1	<0.05	4	<1	0.6	<0.05	0.21	<0.05	4.6
2.37	0.51	3.8	6.2	<0.05	3.4	<1	0.5	<0.05	0.19	<0.05	4.9
2.22	0.39	2.6	14.2	<0.05	4.2	<1	0.5	<0.05	0.21	<0.05	4.2
2.43	0.64	2.1	24.5	<0.05	4.1	<1	0.6	<0.05	0.21	<0.05	1.4
9.36	1.18	3	52.9	<0.05	4.4	<1	1.8	<0.05	0.28	0.11	6.7
2.46	0.53	3.5	18.1	<0.05	2.4	2	0.6	<0.05	0.12	0.3	3.7
2.34	0.07	2.3	7.5	<0.05	1.5	2	0.3	<0.05	0.1	0.21	2.6
2.7	0.24	2.5	12.4	<0.05	3.2	<1	0.5	<0.05	0.21	<0.05	3.8
3.02	0.46	22.2	20.5	<0.05	2.5	<1	0.4	<0.05	0.14	<0.05	5.3
2.7	0.45	2.4	9.4	<0.05	3.4	<1	0.5	<0.05	0.16	<0.05	2.1
2.68	0.32	1.9	12.2	<0.05	2.9	<1	0.4	<0.05	0.13	<0.05	2
2.46	0.24	9.1	11.7	<0.05	3.5	<1	0.4	<0.05	0.18	<0.05	1.6
2.62	0.6	2.2	16.6	<0.05	4.1	<1	0.5	<0.05	0.21	<0.05	3.5
2.93	0.54	1.4	25.1	<0.05	4.3	<1	0.6	<0.05	0.16	<0.05	1.3
3.12	0.29	7.5	69.3	0.35	8.7	2	0.7	<0.05	0.26	0.54	2.2
3.05	0.19	8.24	67	0.34	8.53	1.57	0.6	0.3	0.27	0.42	2.2
14.1	75	16.1	10.7	47.3	13.1	169.6	134.5	51.7	28.4	39.6	21.2

Tl ppm	U ppm	W ppm	Y ppm	Yb ppm
ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
0.02	0.05	0.1	0.05	0.1
0.14	0.29	0.3	6.59	0.7
0.13	0.24	0.2	6.49	0.5
0.28	0.16	0.3	5.13	0.4
0.11	0.18	0.3	5.22	0.4
0.3	0.35	0.4	7.73	0.6
0.13	0.26	0.2	5.12	0.4
0.2	0.33	1.2	6.14	0.5
0.04	0.79	0.2	5.58	0.5
0.07	0.25	0.4	6.18	0.5
0.11	0.23	0.5	6.31	0.5
0.33	1.04	0.4	8.18	0.8
0.13	0.17	0.1	2.94	0.2
0.04	0.45	<0.1	3.06	0.2
0.08	0.24	0.1	6.22	0.6
0.1	0.43	0.4	5.13	0.4
0.04	0.13	0.2	5.25	0.5
0.08	0.15	<0.1	4.68	0.5
0.06	0.2	0.2	5.93	0.5
0.11	0.25	0.2	8.03	0.9
0.12	0.22	0.4	6.25	0.6
0.38	0.27	2.6	5.81	0.5
0.4	0.29	2.15	5.66	#N/A
22.6	52.9	21.6	12.2	#N/A

CLIENT : **Minto Mines**
PROJECT : **Minto Mines**
SGS Project # : **0643**
Test : **Modified Acid-Base Accounting**
Date :**March 29, 2016**

Sample ID	**Sampling Date**	**Paste pH**	**TIC %**	**CaCO3 NP**	**C(T) %**	**S(T) %**	**S(SO4) %**	**S(S-2) %**	**AP**	**NP**	**Net NP**	**NP:AP Ratio (NP/AP)**	**Fizz Test**
Method Code		Sobek	CSB02V	Calc #N/A	CSA06V 0.005	CSA06V 0.005	CSA07V 0.01	Calc #N/A	Calc #N/A	Modified 0.5	Calc #N/A	Calc #N/A	Sobek #N/A
99470 (original)	10-Aug-15	5.23	<0.01	<0.8	1.92	0.022	<0.01	0.02	0.7	-4.2	-4.9	-6.1	None
99470 (re-assay)		5.23	-	-	-	-	-	-	-	-3.7	-	-	None
Duplicate													
99470 (re-assay)		5.28								-4.1			None
QC													
GTS-2A					1.97	0.338							
RTS-3A							0.92						
SY-4			0.91										
NBM-1										41.6			Slight
NBM-1										39.2			Slight
Expected Values			0.95		2.01	0.341	0.98			42.0			Slight
Tolerance +/-			0.06		0.15	0.030	0.12			3.0			

Note:

AP = Acid potential in tonnes CaCO3 equivalent per 1000 tonnes of material. AP is determined from calculated sulphide sulphur content: S(T) - S(SO4).

NP = Neutralization potential in tonnes CaCO3 equivalent per 1000 tonnes of material.

NET NP = NP - AP

Carbonate NP is calculated from TIC originating from carbonate minerals and is expressed in kg CaCO3/tonne.

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 30-MAR-16
Report Date: 19-APR-16 09:58 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1750666
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers: 2016-001
Legal Site Desc:

Comments: Please note, the ALS Minerals version of the finalized report and QC can be found at the end of the attachment.

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1750666-1	L1750666-2	L1750666-3	L1750666-4	L1750666-5
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	15-MAR-16	15-MAR-16	15-MAR-16	15-MAR-16	22-MAR-16
	Sampled Time					
	Client ID	124323	124325	117258	117259	117260
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.6	9.3	8.6	9.0	9.0
Organic / Inorganic Carbon	Carbon (C) (%)	0.19	0.06	0.25	<0.05	0.11
Acid Base Accounting	FIZZ RATING (Unity)	2	1	2	1	2
	MPA (tCaCO3/1Kt)	1.9	<0.3	0.9	0.6	<0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	23	12	26	11	19
	NNP (tCaCO3/1Kt)	21	12	25	10	19
	Ratio (NP/MPA) (Unity)	12.27	76.80	27.73	17.60	121.60
Metals	Sulphur (S) (%)	0.06	<0.01	0.03	0.02	<0.01
Total Metals	Aluminum (Al) (%)	1.55	1.23	1.39	1.23	1.20
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	4.5	0.6	0.5	1.9	0.5
	Barium (Ba) (ppm)	310	290	250	240	210
	Beryllium (Be) (ppm)	0.31	0.28	0.38	0.27	0.24
	Bismuth (Bi) (ppm)	0.33	0.01	0.05	0.04	0.01
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.07	0.01	0.04	0.05	0.01
	Calcium (Ca) (%)	0.98	0.58	1.31	0.66	0.89
	Cerium (Ce) (ppm)	23.5	19.10	28.7	18.45	15.15
	Cesium (Cs) (ppm)	0.43	0.38	0.31	0.30	0.24
	Chromium (Cr) (ppm)	6	5	7	6	5
	Cobalt (Co) (ppm)	6.5	5.9	7.2	6.3	6.2
	Copper (Cu) (ppm)	839	32.0	315	275	7.0
	Gallium (Ga) (ppm)	7.05	5.57	6.71	5.51	5.62
	Germanium (Ge) (ppm)	0.08	0.08	0.06	0.08	0.05
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.04	0.05	0.05	0.06	0.06
	Indium (In) (ppm)	0.033	0.017	0.030	0.018	0.016
	Iron (Fe) (%)	2.73	2.29	2.54	2.33	2.40
	Lanthanum (La) (ppm)	12.3	9.8	14.7	10.7	8.4
	Lead (Pb) (ppm)	2.2	1.2	1.7	8.8	2.6
	Lithium (Li) (ppm)	7.9	7.2	7.1	6.4	6.7
	Magnesium (Mg) (%)	0.83	0.71	0.74	0.68	0.69
	Manganese (Mn) (ppm)	542	570	587	489	499
	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.38	0.49	0.66	0.53	0.21
	Nickel (Ni) (ppm)	2.4	2.3	2.6	2.1	2.2

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID / Description / Sampled Date / Sampled Time / Client ID	L1750666-6	L1750666-7	L1750666-8	L1750666-9	L1750666-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	23-MAR-16	23-MAR-16	24-MAR-16	25-MAR-16	25-MAR-16
	Sampled Time					
	Client ID	117261	117262	117263	117264	117265
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	9.0	9.0	8.6	9.0	9.2
Organic / Inorganic Carbon	Carbon (C) (%)	0.16	0.10	0.22	0.09	0.08
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	0.3	<0.3	0.3	<0.3	<0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	21	19	27	18	16
	NNP (tCaCO3/1Kt)	21	19	27	18	16
	Ratio (NP/MPA) (Unity)	67.20	121.60	86.40	115.20	102.40
Metals	Sulphur (S) (%)	0.01	<0.01	0.01	<0.01	<0.01
Total Metals	Aluminum (Al) (%)	1.18	1.29	1.16	1.20	1.07
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	1.2	1.0	0.8	3.6	2.1
	Barium (Ba) (ppm)	110	190	130	200	240
	Beryllium (Be) (ppm)	0.42	0.37	0.43	0.30	0.22
	Bismuth (Bi) (ppm)	0.02	0.01	0.12	0.01	0.01
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.03	0.02	0.07	0.04	0.04
	Calcium (Ca) (%)	1.14	1.03	1.26	0.88	0.78
	Cerium (Ce) (ppm)	16.30	15.60	23.4	17.80	13.50
	Cesium (Cs) (ppm)	0.15	0.21	0.27	0.28	0.24
	Chromium (Cr) (ppm)	6	6	5	4	5
	Cobalt (Co) (ppm)	5.4	6.3	6.3	6.2	5.6
	Copper (Cu) (ppm)	71.2	8.3	356	108.5	97.2
	Gallium (Ga) (ppm)	5.88	6.00	5.66	5.67	4.86
	Germanium (Ge) (ppm)	0.06	0.08	0.06	0.07	0.06
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.07	0.06	0.07	0.06	0.07
	Indium (In) (ppm)	0.018	0.016	0.019	0.020	0.015
	Iron (Fe) (%)	2.06	2.36	2.34	2.32	2.09
	Lanthanum (La) (ppm)	8.8	8.7	13.7	10.1	7.7
	Lead (Pb) (ppm)	3.0	19.4	9.5	3.8	1.4
	Lithium (Li) (ppm)	7.2	7.6	5.5	6.5	6.0
	Magnesium (Mg) (%)	0.64	0.71	0.54	0.66	0.59
	Manganese (Mn) (ppm)	485	536	599	504	464
	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.55	0.60	0.88	0.77	0.59
	Nickel (Ni) (ppm)	2.2	2.4	2.1	2.3	2.2

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID		L1750666-1	L1750666-2	L1750666-3	L1750666-4	L1750666-5
Description		Waste	Waste	Waste	Waste	Waste
Sampled Date		15-MAR-16	15-MAR-16	15-MAR-16	15-MAR-16	22-MAR-16
Sampled Time						
Client ID		124323	124325	117258	117259	117260
Grouping	**Analyte**					
SOIL						
Total Metals	Niobium (Nb) (ppm)	0.19	0.18	0.10	0.19	0.15
	Phosphorus (P) (ppm)	830	560	760	750	670
	Potassium (K) (%)	0.73	0.74	0.45	0.58	0.47
	Rhenium (Re) (ppm)	<0.001	<0.001	0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	35.4	34.5	22.2	28.1	21.1
	Scandium (Sc) (ppm)	3.7	3.5	4.7	3.3	3.4
	Selenium (Se) (ppm)	1.2	0.3	0.5	0.3	0.2
	Silver (Ag) (ppm)	0.26	0.02	0.12	0.13	0.02
	Sodium (Na) (%)	0.07	0.10	0.07	0.09	0.09
	Strontium (Sr) (ppm)	92.1	47.0	161.5	52.2	74.8
	Sulfur (S) (%)	0.07	0.01	0.03	0.02	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.07	<0.01	0.01	0.02	<0.01
	Thallium (Tl) (ppm)	0.20	0.19	0.12	0.12	0.09
	Thorium (Th) (ppm)	3.1	2.5	4.0	1.9	1.2
	Tin (Sn) (ppm)	0.5	0.5	0.6	0.4	0.4
	Titanium (Ti) (%)	0.133	0.139	0.080	0.137	0.106
	Tungsten (W) (ppm)	0.18	0.55	0.60	0.34	0.16
	Uranium (U) (ppm)	0.23	0.15	0.23	0.29	0.17
	Vanadium (V) (ppm)	60	52	50	55	54
	Yttrium (Y) (ppm)	7.02	6.96	10.10	5.36	4.85
	Zinc (Zn) (ppm)	70	60	63	57	57
	Zirconium (Zr) (ppm)	0.7	0.8	0.7	1.1	0.9
Permanent Gases	Carbon Dioxide (CO2) (%)	0.7	0.2	0.9	0.2	0.4

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1750666-6	L1750666-7	L1750666-8	L1750666-9	L1750666-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	23-MAR-16	23-MAR-16	24-MAR-16	25-MAR-16	25-MAR-16
	Sampled Time					
	Client ID	117261	117262	117263	117264	117265
Grouping	**Analyte**					
SOIL						
Total Metals	Niobium (Nb) (ppm)	0.18	0.15	0.13	0.17	0.17
	Phosphorus (P) (ppm)	610	720	800	780	680
	Potassium (K) (%)	0.22	0.44	0.34	0.51	0.51
	Rhenium (Re) (ppm)	<0.001	<0.001	0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	10.5	20.6	18.6	24.3	23.5
	Scandium (Sc) (ppm)	3.4	3.7	3.5	3.8	3.3
	Selenium (Se) (ppm)	0.3	0.3	0.4	0.3	0.2
	Silver (Ag) (ppm)	0.04	0.02	0.26	0.04	0.04
	Sodium (Na) (%)	0.08	0.08	0.06	0.08	0.09
	Strontium (Sr) (ppm)	97.0	60.7	83.2	50.7	44.8
	Sulfur (S) (%)	0.01	0.01	0.02	0.01	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.01	<0.01	0.03	0.01	<0.01
	Thallium (Tl) (ppm)	0.05	0.09	0.09	0.10	0.10
	Thorium (Th) (ppm)	1.6	1.2	3.8	1.8	1.1
	Tin (Sn) (ppm)	0.4	0.4	0.4	0.5	0.4
	Titanium (Ti) (%)	0.091	0.111	0.075	0.117	0.116
	Tungsten (W) (ppm)	0.28	0.29	0.22	0.36	0.27
	Uranium (U) (ppm)	0.30	0.20	0.41	0.27	0.17
	Vanadium (V) (ppm)	44	54	49	54	48
	Yttrium (Y) (ppm)	6.20	6.03	6.50	5.94	5.37
	Zinc (Zn) (ppm)	55	72	86	65	56
	Zirconium (Zr) (ppm)	1.0	1.2	1.4	1.0	1.0
Permanent Gases	Carbon Dioxide (CO2) (%)	0.6	0.4	0.8	0.3	0.3

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ABA-OA-VOL08-AX	Soil	Acid Base Accounting	OA-VOL08
CARBON-C-GAS05-AX	Soil	Carbon, TOC and CO2	C-GAS05
ME-MS41-AX	Soil	Aqua Regia ICPMS	Aqua Regia ICPMS
A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.			
PH-OA-ELE07-AX	Soil	pH	OA-ELE07
SULPHUR-S-IR08-AX	Soil	Sulphur (S) using LECO analyzer	S-IR08

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location

Chain of Custody Numbers:

2016-001

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

CERTIFICATE VA16050376

Project: L1750666

P.O. No.: L1750666

This report is for 10 Sand samples submitted to our lab in Vancouver, BC, Canada on 4-APR-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
PUL-QC	Pulverizing QC Test
PUL-31	Pulverize split to 85% <75 um
SPL-21	Split sample - riffle splitter

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

CERTIFICATE OF ANALYSIS VA16050376

Sample Description / Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	OA-VOL08m MPA tCaCO3/1Kt 0.3	OA-VOL08m FIZZ RAT Unity 1	OA-VOL08m NNP tCaCO3/1Kt 1	OA-VOL08m NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08m Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	S-CAL06 S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2	ME-MS41 Ag ppm 0.01	ME-MS41 Al % 0.01
L1750666-1 124323	1.00	1.9	2	21	23	8.6	12.27	0.06	0.01	0.02	0.05	0.19	0.7	0.26	1.55
L1750666-2 124325	0.96	<0.3	1	12	12	9.3	76.80	<0.01	0.01	<0.01	<0.01	0.06	0.2	0.02	1.23
L1750666-3 117258	0.82	0.9	2	25	26	8.6	27.73	0.03	0.02	<0.01	0.01	0.25	0.9	0.12	1.39
L1750666-4 117259	0.98	0.6	1	10	11	9.0	17.60	0.02	0.01	<0.01	0.01	<0.05	0.2	0.13	1.23
L1750666-5 117260	0.86	<0.3	2	19	19	9.0	121.60	<0.01	0.01	<0.01	<0.01	0.11	0.4	0.02	1.20
L1750666-6 117261	1.02	0.3	2	21	21	9.0	67.20	0.01	0.01	<0.01	<0.01	0.16	0.6	0.04	1.18
L1750666-7 117262	0.96	<0.3	2	19	19	9.0	121.60	<0.01	0.01	0.01	<0.01	0.10	0.4	0.02	1.29
L1750666-8 117263	1.06	0.3	2	27	27	8.6	86.40	0.01	0.02	0.02	<0.01	0.22	0.8	0.26	1.16
L1750666-9 117264	1.00	<0.3	2	18	18	9.0	115.20	<0.01	0.01	<0.01	<0.01	0.09	0.3	0.04	1.20
L1750666-10 117265	1.02	<0.3	2	16	16	9.2	102.40	<0.01	0.02	<0.01	<0.01	0.08	0.3	0.04	1.07

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	As	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga
	Units	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm
	LOR	0.1	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05
L1750666-1 124323		4.5	<0.2	<10	310	0.31	0.33	0.98	0.07	23.5	6.5	6	0.43	839	2.73	7.05
L1750666-2 124325		0.6	<0.2	<10	290	0.28	0.01	0.58	0.01	19.10	5.9	5	0.38	32.0	2.29	5.57
L1750666-3 117258		0.5	<0.2	<10	250	0.38	0.05	1.31	0.04	28.7	7.2	7	0.31	315	2.54	6.71
L1750666-4 117259		1.9	<0.2	<10	240	0.27	0.04	0.66	0.05	18.45	6.3	6	0.30	275	2.33	5.51
L1750666-5 117260		0.5	<0.2	<10	210	0.24	0.01	0.89	0.01	15.15	6.2	5	0.24	7.0	2.40	5.62
L1750666-6 117261		1.2	<0.2	<10	110	0.42	0.02	1.14	0.03	16.30	5.4	6	0.15	71.2	2.06	5.88
L1750666-7 117262		1.0	<0.2	<10	190	0.37	0.01	1.03	0.02	15.60	6.3	6	0.21	8.3	2.36	6.00
L1750666-8 117263		0.8	<0.2	<10	130	0.43	0.12	1.26	0.07	23.4	6.3	5	0.27	356	2.34	5.66
L1750666-9 117264		3.6	<0.2	<10	200	0.30	0.01	0.88	0.04	17.80	6.2	4	0.28	108.5	2.32	5.67
L1750666-10 117265		2.1	<0.2	<10	240	0.22	0.01	0.78	0.04	13.50	5.6	5	0.24	97.2	2.09	4.86

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method Analyte Units LOR	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2
L1750666-1 124323		0.08	0.04	<0.01	0.033	0.73	12.3	7.9	0.83	542	0.38	0.07	0.19	2.4	830	2.2
L1750666-2 124325		0.08	0.05	<0.01	0.017	0.74	9.8	7.2	0.71	570	0.49	0.10	0.18	2.3	560	1.2
L1750666-3 117258		0.06	0.05	<0.01	0.030	0.45	14.7	7.1	0.74	587	0.66	0.07	0.10	2.6	760	1.7
L1750666-4 117259		0.08	0.06	<0.01	0.018	0.58	10.7	6.4	0.68	489	0.53	0.09	0.19	2.1	750	8.8
L1750666-5 117260		0.05	0.06	<0.01	0.016	0.47	8.4	6.7	0.69	499	0.21	0.09	0.15	2.2	670	2.6
L1750666-6 117261		0.06	0.07	<0.01	0.018	0.22	8.8	7.2	0.64	485	0.55	0.08	0.18	2.2	610	3.0
L1750666-7 117262		0.08	0.06	<0.01	0.016	0.44	8.7	7.6	0.71	536	0.60	0.08	0.15	2.4	720	19.4
L1750666-8 117263		0.06	0.07	<0.01	0.019	0.34	13.7	5.5	0.54	599	0.88	0.06	0.13	2.1	800	9.5
L1750666-9 117264		0.07	0.06	<0.01	0.020	0.51	10.1	6.5	0.66	504	0.77	0.08	0.17	2.3	780	3.8
L1750666-10 117265		0.06	0.07	<0.01	0.015	0.51	7.7	6.0	0.59	464	0.59	0.09	0.17	2.2	680	1.4

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.

2103 Dollarton Hwy
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Phone: +1 (604) 984 0221 Fax: +1 (604) 984 0218
www.alsglobal.com

To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method Analyte Units LOR	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1
L1750666-1 124323		35.4	<0.001	0.07	<0.05	3.7	1.2	0.5	92.1	<0.01	0.07	3.1	0.133	0.20	0.23	60
L1750666-2 124325		34.5	<0.001	0.01	<0.05	3.5	0.3	0.5	47.0	<0.01	<0.01	2.5	0.139	0.19	0.15	52
L1750666-3 117258		22.2	0.001	0.03	<0.05	4.7	0.5	0.6	161.5	<0.01	0.01	4.0	0.080	0.12	0.23	50
L1750666-4 117259		28.1	<0.001	0.02	<0.05	3.3	0.3	0.4	52.2	<0.01	0.02	1.9	0.137	0.12	0.29	55
L1750666-5 117260		21.1	<0.001	0.01	<0.05	3.4	0.2	0.4	74.8	<0.01	<0.01	1.2	0.106	0.09	0.17	54
L1750666-6 117261		10.5	<0.001	0.01	<0.05	3.4	0.3	0.4	97.0	<0.01	0.01	1.6	0.091	0.05	0.30	44
L1750666-7 117262		20.6	<0.001	0.01	<0.05	3.7	0.3	0.4	60.7	<0.01	<0.01	1.2	0.111	0.09	0.20	54
L1750666-8 117263		18.6	0.001	0.02	<0.05	3.5	0.4	0.4	83.2	<0.01	0.03	3.8	0.075	0.09	0.41	49
L1750666-9 117264		24.3	<0.001	0.01	<0.05	3.8	0.3	0.5	50.7	<0.01	0.01	1.8	0.117	0.10	0.27	54
L1750666-10 117265		23.5	<0.001	0.01	<0.05	3.3	0.2	0.4	44.8	<0.01	<0.01	1.1	0.116	0.10	0.17	48

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
L1750666-1 124323		0.18	7.02	70	0.7
L1750666-2 124325		0.55	6.96	60	0.8
L1750666-3 117258		0.60	10.10	63	0.7
L1750666-4 117259		0.34	5.36	57	1.1
L1750666-5 117260		0.16	4.85	57	0.9
L1750666-6 117261		0.28	6.20	55	1.0
L1750666-7 117262		0.29	6.03	72	1.2
L1750666-8 117263		0.22	6.50	86	1.4
L1750666-9 117264		0.36	5.94	65	1.0
L1750666-10 117265		0.27	5.37	56	1.0

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ALS Minerals

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Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

CERTIFICATE OF ANALYSIS VA16050376

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	PUL-QC	S-CAL06
S-GRA06	S-GRA06a	S-IR08	SPL-21
WEI-21			

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BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

QC CERTIFICATE VA16050376

Project: L1750666

P.O. No.: L1750666

This report is for 10 Sand samples submitted to our lab in Vancouver, BC, Canada on 4-APR-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
PUL-QC	Pulverizing QC Test
PUL-31	Pulverize split to 85% <75 um
SPL-21	Split sample - riffle splitter

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description / Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
STANDARDS															
Buffer pH6					6.0										
Buffer pH6					6.0										
Target Range - Lower Bound					5.3										
Upper Bound					6.7										
GS313-8							1.17								
Target Range - Lower Bound							1.19								
Upper Bound							1.29								
KZK-1	25.0	2	31	56		2.24									
KZK-1	25.0	2	32	57		2.28									
Target Range - Lower Bound	22.9	<1	30	54		2.18									
Upper Bound	27.1	>4	38	64		2.53									
MA-3a										2.37	8.7				
Target Range - Lower Bound										2.31	8.4				
Upper Bound										2.77	10.2				
OGGeo08												21.4	2.17	118.0	<0.2
Target Range - Lower Bound												18.15	2.05	107.0	<0.2
Upper Bound												22.2	2.53	131.0	0.4
OREAS-45d												0.13	4.61	6.9	<0.2
Target Range - Lower Bound												0.10	4.36	5.8	<0.2
Upper Bound												0.15	5.36	7.3	0.4
SY-4										0.86	3.2				
Target Range - Lower Bound										0.84	3.0				
Upper Bound										1.08	4.0				
UTS-1								0.89							
Target Range - Lower Bound								0.83							
Upper Bound								0.93							
UTS-1									0.88						
Target Range - Lower Bound									0.81						
Upper Bound									0.95						
UTS-2							3.34								
Target Range - Lower Bound							3.11								
Upper Bound							3.35								
UTS-4								1.78							
Target Range - Lower Bound								1.64							
Upper Bound								1.84							
UTS-4									1.73						
Target Range - Lower Bound									1.61						
Upper Bound									1.87						

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description / Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf
Units	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
LOR	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05	0.05	0.02
STANDARDS															
Buffer pH6															
Buffer pH6															
Target Range - Lower Bound															
Upper Bound															
GS313-8															
Target Range - Lower Bound															
Upper Bound															
KZK-1															
KZK-1															
Target Range - Lower Bound															
Upper Bound															
MA-3a															
Target Range - Lower Bound															
Upper Bound															
OGGeo08	<10	100	0.79	11.30	0.86	20.3	63.3	98.7	82	9.91	8760	5.17	8.52	0.19	0.72
Target Range - Lower Bound	<10	60	0.61	9.44	0.82	16.75	56.7	87.2	75	8.68	7800	4.51	8.05	0.21	0.72
Upper Bound	30	110	0.89	11.55	1.02	20.5	69.3	107.0	93	10.70	8980	5.53	9.95	0.45	0.92
OREAS-45d	<10	80	0.53	0.25	0.09	0.03	24.5	27.8	474	2.15	345	13.90	16.35	0.08	0.48
Target Range - Lower Bound	<10	50	0.42	0.26	0.06	<0.01	22.3	23.5	419	2.09	321	12.30	16.05	<0.05	0.40
Upper Bound	30	110	0.68	0.34	0.11	0.05	27.3	28.9	515	2.67	369	15.05	19.75	0.23	0.54
SY-4															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-2															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Method / Analyte	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb	Re
Units	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
LOR	0.01	0.005	0.01	0.2	0.1	0.01	5	0.05	0.01	0.05	0.2	10	0.2	0.1	0.001
STANDARDS															
Buffer pH6															
Buffer pH6															
Target Range - Lower Bound															
Upper Bound															
GS313-8															
Target Range - Lower Bound															
Upper Bound															
KZK-1															
KZK-1															
Target Range - Lower Bound															
Upper Bound															
MA-3a															
Target Range - Lower Bound															
Upper Bound															
OGGeo08	0.41	1.525	1.08	31.4	31.6	0.96	389	881	0.29	1.25	9050	810	7230	125.0	1.410
Target Range - Lower Bound	0.41	1.335	0.94	27.7	29.8	0.84	350	811	0.26	0.97	7760	700	6520	109.5	1.295
Upper Bound	0.57	1.645	1.18	34.3	36.6	1.05	438	991	0.34	1.29	9480	880	7970	134.5	1.585
OREAS-45d	0.07	0.080	0.09	10.8	12.1	0.13	363	1.49	0.03	0.42	187.5	330	16.1	20.0	<0.001
Target Range - Lower Bound	0.02	0.071	0.07	8.8	10.6	0.12	328	1.45	<0.01	0.27	158.0		15.1	18.7	<0.001
Upper Bound	0.06	0.099	0.12	11.2	13.2	0.17	412	1.89	0.05	0.51	194.0		18.9	23.1	0.003
SY-4															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-2															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
OGGeo08		2.80	19.45	6.5	10.5	12.2	65.1	0.02	0.15	17.2	0.319	1.34	4.67	81	2.90	17.20
Target Range - Lower Bound		2.51	17.70	6.0	9.7	12.0	59.6	<0.01	0.14	15.6	0.279	1.14	4.45	70	2.58	15.35
Upper Bound		3.09	24.1	7.6	12.3	15.1	73.2	0.03	0.20	19.6	0.353	1.58	5.55	88	3.60	18.85
OREAS-45d		0.05	0.30	47.0	1.3	1.6	11.0	0.01	0.05	10.9	0.076	0.13	1.55	206	0.06	4.77
Target Range - Lower Bound		0.02	0.22	37.3	0.7	1.3	9.7	<0.01	0.02	10.0	0.068	0.07	1.43	180	<0.05	4.52
Upper Bound		0.07	0.49	45.8	1.7	2.3	12.3	0.03	0.06	12.6	0.096	0.17	1.85	222	0.16	5.64
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																

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Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
		STANDARDS	
Buffer pH6			
Buffer pH6			
Target Range - Lower Bound			
Upper Bound			
GS313-8			
Target Range - Lower Bound			
Upper Bound			
KZK-1			
KZK-1			
Target Range - Lower Bound			
Upper Bound			
MA-3a			
Target Range - Lower Bound			
Upper Bound			
OGGeo08		7060	22.8
Target Range - Lower Bound		6500	19.5
Upper Bound		7950	27.5
OREAS-45d		26	20.8
Target Range - Lower Bound		25	16.2
Upper Bound		36	23.2
SY-4			
Target Range - Lower Bound			
Upper Bound			
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-2			
Target Range - Lower Bound			
Upper Bound			
UTS-4			
Target Range - Lower Bound			
Upper Bound			
UTS-4			
Target Range - Lower Bound			
Upper Bound			

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QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
BLANKS																
BLANK											<0.05	<0.2				
Target Range - Lower Bound											<0.05	<0.2				
Upper Bound											0.10	0.4				
BLANK													<0.01	<0.01	<0.1	<0.2
Target Range - Lower Bound													<0.01	<0.01	<0.1	<0.2
Upper Bound													0.02	0.02	0.2	0.4
BLANK						6.0										
Target Range - Lower Bound						5.5										
Upper Bound						6.9										
BLANK									<0.01							
Target Range - Lower Bound									<0.01							
Upper Bound									0.02							
BLANK										<0.01						
Target Range - Lower Bound										<0.01						
Upper Bound										0.02						
BLANK								<0.01								
Target Range - Lower Bound								<0.01								
Upper Bound								0.02								
DUPLICATES																
ORIGINAL													0.44	0.34	1360	0.2
DUP													0.43	0.34	1345	0.2
Target Range - Lower Bound													0.40	0.31	1285	<0.2
Upper Bound													0.47	0.37	1420	0.4
L1750666-3 117258									0.02							
DUP									0.01							
Target Range - Lower Bound									<0.01							
Upper Bound									0.02							
L1750666-10 117265		<0.3	2	16	16	9.2	102.40			<0.01	0.08	0.3				
DUP		<0.3	2	16	16	9.2	102.40			0.01	0.09	0.3				
Target Range - Lower Bound		<0.3	<1	14	14	8.6	97.27			<0.01	<0.05	<0.2				
Upper Bound		0.6	3	18	18	9.8	107.53			0.02	0.10	0.4				

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BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
Target Range - Lower Bound		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
Upper Bound		20	20	0.10	0.02	0.02	0.02	0.04	0.2	2	0.10	0.4	0.02	0.10	0.10	0.04
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL		<10	290	0.23	0.16	0.12	0.38	24.8	1.0	23	0.54	17.6	5.37	3.28	<0.05	0.22
DUP		<10	280	0.24	0.15	0.12	0.37	24.7	1.1	22	0.54	19.5	5.33	3.24	<0.05	0.20
Target Range - Lower Bound		<10	250	0.17	0.14	0.10	0.35	23.5	0.9	20	0.46	17.7	5.07	3.05	<0.05	0.18
Upper Bound		20	320	0.30	0.17	0.14	0.40	26.0	1.2	25	0.62	19.4	5.63	3.47	0.10	0.24
L1750666-3 117258																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1750666-10 117265																
DUP																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals
ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: +1 (604) 984 0221 Fax: +1 (604) 984 0218
www.alsglobal.com

To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Target Range - Lower Bound		<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Upper Bound		0.02	0.010	0.02	0.4	0.2	0.02	10	0.10	0.02	0.10	0.4	20	0.4	0.2	0.002
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL		0.21	0.036	0.33	13.8	1.7	0.03	41	18.95	0.01	<0.05	11.6	1140	42.2	7.7	<0.001
DUP		0.19	0.034	0.32	13.6	1.7	0.03	42	18.75	0.01	<0.05	11.8	1130	43.0	7.6	0.001
Target Range - Lower Bound		0.18	0.028	0.30	12.8	1.5	0.02	34	17.85	<0.01	<0.05	10.9	1070	40.3	7.2	<0.001
Upper Bound		0.23	0.042	0.35	14.6	1.9	0.04	49	19.85	0.02	0.10	12.5	1200	44.9	8.1	0.002
L1750666-3 117258																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1750666-10 117265																
DUP																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description / Method / Analyte / Units / LOR	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y
Units	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
LOR	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1	0.05	0.05
BLANKS															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Target Range - Lower Bound	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Upper Bound	0.02	0.10	0.2	0.4	0.4	0.4	0.02	0.02	0.4	0.010	0.04	0.10	2	0.10	0.10
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
DUPLICATES															
ORIGINAL	0.35	18.35	6.0	0.7	0.4	40.2	<0.01	0.06	2.7	0.005	0.28	2.42	69	1.69	2.44
DUP	0.35	19.15	6.0	0.9	0.4	40.1	<0.01	0.08	2.8	0.005	0.28	2.46	68	1.71	2.44
Target Range - Lower Bound	0.32	17.30	5.6	0.6	<0.2	37.9	<0.01	0.06	2.4	<0.005	0.24	2.27	64	1.52	2.27
Upper Bound	0.38	20.2	6.4	1.0	0.6	42.4	0.02	0.08	3.1	0.010	0.32	2.61	73	1.88	2.61
L1750666-3 117258															
DUP															
Target Range - Lower Bound															
Upper Bound															
L1750666-10 117265															
DUP															
Target Range - Lower Bound															
Upper Bound															

***** See Appendix Page for comments regarding this certificate *****

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
BLANKS			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK		<2	<0.5
Target Range - Lower Bound		<2	<0.5
Upper Bound		4	1.0
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
Target Range - Lower Bound			
Upper Bound			
DUPLICATES			
ORIGINAL		68	9.3
DUP		68	9.3
Target Range - Lower Bound		63	8.1
Upper Bound		73	10.5
L1750666-3 117258			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1750666-10 117265			
DUP			
Target Range - Lower Bound			
Upper Bound			

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Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
DUPLICATES																
ORIGINAL								<0.01								
DUP								<0.01								
Target Range - Lower Bound								<0.01								
Upper Bound								0.02								

***** See Appendix Page for comments regarding this certificate *****

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

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Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method Analyte Units LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
								DUPLICATES								
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
		DUPLICATES	
ORIGINAL			
DUP			
Target Range - Lower Bound			
Upper Bound			

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals

ALS Canada Ltd.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 15-APR-2016
Account: APN

Project: L1750666

QC CERTIFICATE OF ANALYSIS VA16050376

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	PUL-QC	S-CAL06
S-GRA06	S-GRA06a	S-IR08	SPL-21
WEI-21			

ALS

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Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1750666-COFC

COC Number: 2016-001

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals - Aqua regia digestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
1	124323	MARCH 15/16		WASTE	R	R	R	R	R	R	
2	124325										
3	117258										
4	117259										
5	117260	MARCH 22/16									
6	117261	MARCH 23/16									
7	117262	MARCH 23/16									
8	117263	MARCH 24/16									
9	117264	MARCH 25/16		WASTE							
10	~~117265~~	~~MARCH 25/16~~		~~WASTE~~							

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☒ Ice Cubes ☐ Custody seal intact Yes ☐ No ☒

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 8.9°C

FINAL COOLER TEMPERATURES °C: 4 4

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Phyllistine Hager	Date: Mar 28/16	Time:	Received by: [illegible]	Date: March 30-16	Time: 9:12am	Received by: Jean	Date: 31 Mar	Time: 13:50

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1 If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

OCTOBER 2015 FRONT

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 26-APR-16
Report Date: 17-MAY-16 14:35 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1760370

Project P.O. #: TBD

Job Reference:

C of C Numbers: 16-002

Legal Site Desc:

Comments: Please note, the ALS Minerals version of the finalized report and QC can be found at the end of the attachment.

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID / Description / Sampled Date / Sampled Time / Client ID		L1760370-1	L1760370-2	L1760370-3	L1760370-4	L1760370-5
Description		Composite	Tails	Tails	Waste	Waste
Sampled Date		03-APR-16	04-APR-16	04-APR-16	04-APR-16	10-APR-16
Sampled Time						
Client ID		117266	117267	TAILS - FEBRUARY	TAILS - MARCH	117270
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.6	8.6	8.5	8.6	8.6
Organic / Inorganic Carbon	Carbon (C) (%)	0.09	0.17	0.24	0.28	0.18
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	0.9	0.3	1.6	1.6	0.6
	Neutralization Potential (NP) (tCaCO3/1Kt)	17	23	25	26	24
	NNP (tCaCO3/1Kt)	16	23	23	24	23
	Ratio (NP/MPA) (Unity)	18.13	73.60	16.00	16.64	38.40
	Sulfate Sulfur (carbonate leach) (%)	0.01	<0.01	0.01	0.01	0.01
	Sulfate Sulfur (HCl leach) (%)	0.01	0.01	0.01	0.01	0.01
	Sulfide Sulfur (T minus carbonate leach) (%)	0.02	0.01	0.04	0.04	0.01
	Total Sulfur (combustion) (%)	0.03	0.01	0.05	0.05	0.02
Total Metals	Aluminum (Al) (%)	1.15	1.08	1.40	1.33	1.01
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	1.8	1.5	1.0	0.8	1.0
	Barium (Ba) (ppm)	180	130	220	210	90
	Beryllium (Be) (ppm)	0.28	0.36	0.24	0.26	0.35
	Bismuth (Bi) (ppm)	0.02	0.01	0.16	0.15	0.29
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.04	0.02	0.28	0.29	0.12
	Calcium (Ca) (%)	0.85	1.08	1.03	1.06	1.03
	Cerium (Ce) (ppm)	18.10	17.20	23.0	19.00	21.9
	Cesium (Cs) (ppm)	0.23	0.20	0.61	0.53	0.44
	Chromium (Cr) (ppm)	5	4	6	6	4
	Cobalt (Co) (ppm)	5.6	5.6	6.8	6.9	6.1
	Copper (Cu) (ppm)	163.5	26.6	688	743	394
	Gallium (Ga) (ppm)	5.44	5.25	8.00	7.72	5.15
	Germanium (Ge) (ppm)	0.07	0.07	0.09	0.09	0.08
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.07	0.07	0.05	0.04	0.10
	Indium (In) (ppm)	0.016	0.013	0.068	0.079	0.020
	Iron (Fe) (%)	2.09	2.09	3.23	3.48	2.14
	Lanthanum (La) (ppm)	10.4	9.4	12.1	9.8	13.3
	Lead (Pb) (ppm)	3.9	5.1	2.0	2.0	5.6
	Lithium (Li) (ppm)	6.1	5.7	6.7	6.4	4.8
	Magnesium (Mg) (%)	0.64	0.59	0.83	0.79	0.51
	Manganese (Mn) (ppm)	444	464	628	633	584

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1760370-6	L1760370-7	L1760370-8	L1760370-9	L1760370-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	10-APR-16	10-APR-16	12-APR-16	19-APR-16	19-APR-16
	Sampled Time					
	Client ID	117268	117269	117271	117273	117272
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.8	8.6	8.9	8.7	9.1
Organic / Inorganic Carbon	Carbon (C) (%)	0.18	0.18	0.09	0.15	0.08
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	6.6	0.6	0.9	1.3	0.6
	Neutralization Potential (NP) (tCaCO3/1Kt)	24	23	16	22	17
	NNP (tCaCO3/1Kt)	17	22	15	21	16
	Ratio (NP/MPA) (Unity)	3.66	36.80	17.07	17.60	27.20
	Sulfate Sulfur (carbonate leach) (%)	0.01	0.01	<0.01	0.01	0.01
	Sulfate Sulfur (HCl leach) (%)	0.01	0.01	0.01	0.01	0.01
	Sulfide Sulfur (T minus carbonate leach) (%)	0.20	0.01	0.03	0.03	0.01
	Total Sulfur (combustion) (%)	0.21	0.02	0.03	0.04	0.02
Total Metals	Aluminum (Al) (%)	1.17	1.21	1.12	1.31	1.09
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.4	1.3	2.0	3.8	2.3
	Barium (Ba) (ppm)	160	160	240	360	240
	Beryllium (Be) (ppm)	0.28	0.33	0.24	0.24	0.21
	Bismuth (Bi) (ppm)	0.61	0.03	0.01	0.03	0.02
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.30	0.04	0.02	0.04	0.04
	Calcium (Ca) (%)	0.98	1.13	0.70	0.92	0.77
	Cerium (Ce) (ppm)	18.00	22.3	14.15	24.8	18.15
	Cesium (Cs) (ppm)	0.34	0.21	0.31	0.42	0.32
	Chromium (Cr) (ppm)	4	4	5	5	4
	Cobalt (Co) (ppm)	6.2	6.4	6.2	6.1	5.8
	Copper (Cu) (ppm)	5060	324	148.5	378	166.0
	Gallium (Ga) (ppm)	6.31	5.96	5.20	5.44	4.87
	Germanium (Ge) (ppm)	0.08	0.08	0.08	0.08	0.09
	Gold (Au) (ppm)	<0.2	0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.04	0.05	0.06	0.06	0.08
	Indium (In) (ppm)	0.042	0.024	0.013	0.025	0.018
	Iron (Fe) (%)	2.54	2.27	2.24	2.44	2.18
	Lanthanum (La) (ppm)	9.7	12.5	7.7	14.9	10.4
	Lead (Pb) (ppm)	2.0	9.6	2.7	1.4	1.3
	Lithium (Li) (ppm)	6.7	6.6	6.1	5.9	5.2
	Magnesium (Mg) (%)	0.70	0.65	0.64	0.70	0.60
	Manganese (Mn) (ppm)	503	452	484	504	486

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1760370-11				
	Description	Waste				
	Sampled Date	19-APR-16				
	Sampled Time					
	Client ID	123696				
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.9				
Organic / Inorganic Carbon	Carbon (C) (%)	0.10				
Acid Base Accounting	FIZZ RATING (Unity)	2				
	MPA (tCaCO3/1Kt)	0.9				
	Neutralization Potential (NP) (tCaCO3/1Kt)	15				
	NNP (tCaCO3/1Kt)	14				
	Ratio (NP/MPA) (Unity)	16.00				
	Sulfate Sulfur (carbonate leach) (%)	0.01				
	Sulfate Sulfur (HCl leach) (%)	0.01				
	Sulfide Sulfur (T minus carbonate leach) (%)	0.02				
	Total Sulfur (combustion) (%)	0.03				
Total Metals	Aluminum (Al) (%)	1.16				
	Antimony (Sb) (ppm)	<0.05				
	Arsenic (As) (ppm)	0.2				
	Barium (Ba) (ppm)	270				
	Beryllium (Be) (ppm)	0.21				
	Bismuth (Bi) (ppm)	0.02				
	Boron (B) (ppm)	<10				
	Cadmium (Cd) (ppm)	0.06				
	Calcium (Ca) (%)	0.77				
	Cerium (Ce) (ppm)	20.6				
	Cesium (Cs) (ppm)	0.41				
	Chromium (Cr) (ppm)	11				
	Cobalt (Co) (ppm)	6.1				
	Copper (Cu) (ppm)	151.0				
	Gallium (Ga) (ppm)	5.37				
	Germanium (Ge) (ppm)	0.09				
	Gold (Au) (ppm)	<0.2				
	Hafnium (Hf) (ppm)	0.07				
	Indium (In) (ppm)	0.019				
	Iron (Fe) (%)	2.26				
	Lanthanum (La) (ppm)	11.7				
	Lead (Pb) (ppm)	4.1				
	Lithium (Li) (ppm)	4.8				
	Magnesium (Mg) (%)	0.68				
	Manganese (Mn) (ppm)	572				

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1760370-1	L1760370-2	L1760370-3	L1760370-4	L1760370-5
	Description	Composite	Tails	Tails	Waste	Waste
	Sampled Date	03-APR-16	04-APR-16	04-APR-16	04-APR-16	10-APR-16
	Sampled Time					
	Client ID	117266	117267	TAILS - FEBRUARY	TAILS - MARCH	117270
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	<0.01	0.01	0.01	<0.01
	Molybdenum (Mo) (ppm)	0.68	0.48	0.79	0.73	11.30
	Nickel (Ni) (ppm)	2.2	2.0	3.0	3.0	2.2
	Niobium (Nb) (ppm)	0.18	0.14	0.18	0.16	0.19
	Phosphorus (P) (ppm)	710	730	980	950	720
	Potassium (K) (%)	0.40	0.30	0.74	0.66	0.37
	Rhenium (Re) (ppm)	<0.001	<0.001	0.001	0.001	0.003
	Rubidium (Rb) (ppm)	19.5	15.1	41.7	35.7	24.1
	Scandium (Sc) (ppm)	2.8	3.5	4.2	3.8	3.4
	Selenium (Se) (ppm)	0.4	0.2	0.7	0.9	0.4
	Silver (Ag) (ppm)	0.05	0.03	0.47	0.49	0.25
	Sodium (Na) (%)	0.06	0.06	0.06	0.05	0.05
	Strontium (Sr) (ppm)	67.7	72.5	82.7	75.7	56.5
	Sulfur (S) (%)	0.02	<0.01	0.04	0.04	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.02	0.01	0.18	0.18	0.03
	Thallium (Tl) (ppm)	0.08	0.06	0.31	0.24	0.13
	Thorium (Th) (ppm)	2.1	2.0	5.0	4.2	3.9
	Tin (Sn) (ppm)	0.4	0.4	1.0	0.9	0.4
	Titanium (Ti) (%)	0.108	0.080	0.129	0.117	0.072
	Tungsten (W) (ppm)	0.26	0.23	0.07	0.06	0.36
	Uranium (U) (ppm)	0.22	0.33	0.31	0.53	0.67
	Vanadium (V) (ppm)	48	46	69	69	48
	Yttrium (Y) (ppm)	5.02	6.03	7.34	6.06	5.96
	Zinc (Zn) (ppm)	53	49	101	110	97
	Zirconium (Zr) (ppm)	1.3	1.1	1.2	1.0	1.6
Permanent Gases	Carbon Dioxide (CO2) (%)	0.3	0.6	0.9	1.0	0.7

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte					
	Sample ID	L1760370-6	L1760370-7	L1760370-8	L1760370-9	L1760370-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	10-APR-16	10-APR-16	12-APR-16	19-APR-16	19-APR-16
	Sampled Time					
	Client ID	117268	117269	117271	117273	117272
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	<0.01	<0.01	0.01	<0.01
	Molybdenum (Mo) (ppm)	0.43	1.40	0.44	1.89	0.51
	Nickel (Ni) (ppm)	2.2	2.1	2.4	3.3	2.0
	Niobium (Nb) (ppm)	0.17	0.11	0.17	0.18	0.23
	Phosphorus (P) (ppm)	690	730	660	710	770
	Potassium (K) (%)	0.50	0.33	0.57	0.76	0.60
	Rhenium (Re) (ppm)	<0.001	0.005	<0.001	0.001	<0.001
	Rubidium (Rb) (ppm)	27.5	16.9	27.2	37.3	28.1
	Scandium (Sc) (ppm)	3.1	3.3	3.5	3.6	3.2
	Selenium (Se) (ppm)	2.9	0.4	<0.2	0.3	0.3
	Silver (Ag) (ppm)	2.38	0.17	0.07	0.14	0.32
	Sodium (Na) (%)	0.06	0.06	0.08	0.08	0.09
	Strontium (Sr) (ppm)	77.0	88.0	38.1	40.4	53.4
	Sulfur (S) (%)	0.23	0.02	0.01	0.03	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.59	0.05	0.02	0.03	0.16
	Thallium (Tl) (ppm)	0.12	0.07	0.12	0.18	0.11
	Thorium (Th) (ppm)	3.0	2.5	1.3	2.9	2.6
	Tin (Sn) (ppm)	0.4	0.5	0.4	0.5	0.4
	Titanium (Ti) (%)	0.095	0.087	0.119	0.140	0.126
	Tungsten (W) (ppm)	0.24	0.26	0.25	0.61	0.49
	Uranium (U) (ppm)	0.28	0.24	0.19	0.29	0.33
	Vanadium (V) (ppm)	51	49	53	60	54
	Yttrium (Y) (ppm)	5.07	5.57	5.23	5.21	5.52
	Zinc (Zn) (ppm)	71	62	57	64	58
	Zirconium (Zr) (ppm)	0.7	0.8	1.0	0.9	1.3
Permanent Gases	Carbon Dioxide (CO_2) (%)	0.7	0.7	0.3	0.6	0.3

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1760370-11				
	Description	Waste				
	Sampled Date	19-APR-16				
	Sampled Time					
	Client ID	123696				
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01				
	Molybdenum (Mo) (ppm)	0.38				
	Nickel (Ni) (ppm)	2.2				
	Niobium (Nb) (ppm)	0.22				
	Phosphorus (P) (ppm)	770				
	Potassium (K) (%)	0.69				
	Rhenium (Re) (ppm)	0.001				
	Rubidium (Rb) (ppm)	33.2				
	Scandium (Sc) (ppm)	3.3				
	Selenium (Se) (ppm)	0.3				
	Silver (Ag) (ppm)	0.07				
	Sodium (Na) (%)	0.09				
	Strontium (Sr) (ppm)	52.5				
	Sulfur (S) (%)	0.03				
	Tantalum (Ta) (ppm)	<0.01				
	Tellurium (Te) (ppm)	0.03				
	Thallium (Tl) (ppm)	0.16				
	Thorium (Th) (ppm)	2.6				
	Tin (Sn) (ppm)	0.4				
	Titanium (Ti) (%)	0.144				
	Tungsten (W) (ppm)	0.11				
	Uranium (U) (ppm)	0.31				
	Vanadium (V) (ppm)	53				
	Yttrium (Y) (ppm)	5.58				
	Zinc (Zn) (ppm)	86				
	Zirconium (Zr) (ppm)	1.3				
Permanent Gases	Carbon Dioxide (CO_2) (%)	0.4				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ABA-OA-VOL08-AX	Soil	Acid Base Accounting	OA-VOL08
CARBON-C-GAS05-AX	Soil	Carbon, TOC and CO2	C-GAS05
ME-MS41-AX	Soil	Aqua Regia ICPMS	Aqua Regia ICPMS

A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-OA-ELE07-AX	Soil	pH	OA-ELE07
SULPHUR-S-CAL06-AX	Soil	Sulfide Sulfur Calc from Carbonate Leach	ALS Minerals S-CAL06

Sulfide Sulfur (as S) is calculated by subtracting the Carbonate Leachable Sulfate Sulfur (as S) from the Total Sulfur (as S) obtained from combustion.

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06-AX	Soil	Sulfate Sulfur in Soil (Carbonate Leach)	ALS Minerals S-GRA06

A prepared sample is boiled with a sodium carbonate solution for 30 minutes. Any insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06A-AX	Soil	Sulfate Sulfur in Soil (HCl Leach)	ALS Minerals S-GRA06A

A prepared sample is heated with dilute hydrochloric acid for 30 minutes. Silica and any acid-insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-IR08-AX	Soil	Total Sulfur in Soil by Combustion	ALS Minerals S-IR08

The sample is heated to approximately 1350 °C in an induction furnace while passing a stream of oxygen through the sample. Sulfur dioxide released from the sample is measured by an IR detection system and the Total Sulfur result is provided.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location

Chain of Custody Numbers:

16-002

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

CERTIFICATE VA16066460

Project: L1760370

P.O. No.: ALSM-CW16-102-APN

This report is for 11 Tailings samples submitted to our lab in Vancouver, BC, Canada on 29-APR-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method	WEI-21	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41
	Analyte	Recvd Wt.	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al
	Units	kg	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%
	LOR	0.02	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01
L1760370-1 117266		1.00	0.9	2	16	17	8.6	18.13	0.03	0.01	0.01	0.02	0.09	0.3	0.05	1.15
L1760370-2 117267		1.04	0.3	2	23	23	8.6	73.60	0.01	<0.01	0.01	0.01	0.17	0.6	0.03	1.08
L1760370-3 TAILS-FEBRUARY		1.04	1.6	2	23	25	8.5	16.00	0.05	0.01	0.01	0.04	0.24	0.9	0.47	1.40
L1760370-4 TAILS-MARCH		1.04	1.6	2	24	26	8.6	16.64	0.05	0.01	0.01	0.04	0.28	1.0	0.49	1.33
L1760370-5 117270		1.00	0.6	2	23	24	8.6	38.40	0.02	0.01	0.01	0.01	0.18	0.7	0.25	1.01
L1760370-6 117268		0.98	6.6	2	17	24	8.8	3.66	0.21	0.01	0.01	0.20	0.18	0.7	2.38	1.17
L1760370-7 117269		1.00	0.6	2	22	23	8.6	36.80	0.02	0.01	0.01	0.01	0.18	0.7	0.17	1.21
L1760370-8 117271		1.02	0.9	2	15	16	8.9	17.07	0.03	<0.01	0.01	0.03	0.09	0.3	0.07	1.12
L1760370-9 117273		0.92	1.3	2	21	22	8.7	17.60	0.04	0.01	0.01	0.03	0.15	0.6	0.14	1.31
L1760370-10 117272		0.94	0.6	2	16	17	9.1	27.20	0.02	0.01	0.01	0.01	0.08	0.3	0.32	1.09
L1760370-11 123696		1.24	0.9	2	14	15	8.9	16.00	0.03	0.01	0.01	0.02	0.10	0.4	0.07	1.16

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

CERTIFICATE OF ANALYSIS VA16066460

Sample Description / Method / Analyte / Units / LOR	ME-MS41 As ppm 0.1	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05
L1760370-1 117266	1.8	<0.2	<10	180	0.28	0.02	0.85	0.04	18.10	5.6	5	0.23	163.5	2.09	5.44
L1760370-2 117267	1.5	<0.2	<10	130	0.36	0.01	1.08	0.02	17.20	5.6	4	0.20	26.6	2.09	5.25
L1760370-3 TAILS-FEBRUARY	1.0	<0.2	<10	220	0.24	0.16	1.03	0.28	23.0	6.8	6	0.61	688	3.23	8.00
L1760370-4 TAILS-MARCH	0.8	<0.2	<10	210	0.26	0.15	1.06	0.29	19.00	6.9	6	0.53	743	3.48	7.72
L1760370-5 117270	1.0	<0.2	<10	90	0.35	0.29	1.03	0.12	21.9	6.1	4	0.44	394	2.14	5.15
L1760370-6 117268	0.4	<0.2	<10	160	0.28	0.61	0.98	0.30	18.00	6.2	4	0.34	5060	2.54	6.31
L1760370-7 117269	1.3	0.2	<10	160	0.33	0.03	1.13	0.04	22.3	6.4	4	0.21	324	2.27	5.96
L1760370-8 117271	2.0	<0.2	<10	240	0.24	0.01	0.70	0.02	14.15	6.2	5	0.31	148.5	2.24	5.20
L1760370-9 117273	3.8	<0.2	<10	360	0.24	0.03	0.92	0.04	24.8	6.1	5	0.42	378	2.44	5.44
L1760370-10 117272	2.3	<0.2	<10	240	0.21	0.02	0.77	0.04	18.15	5.8	4	0.32	166.0	2.18	4.87
L1760370-11 123696	0.2	<0.2	<10	270	0.21	0.02	0.77	0.06	20.6	6.1	11	0.41	151.0	2.26	5.37

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	Ge	Hf	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb
	Units	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm
	LOR	0.05	0.02	0.01	0.005	0.01	0.2	0.1	0.01	5	0.05	0.01	0.05	0.2	10	0.2
L1760370-1 117266		0.07	0.07	0.01	0.016	0.40	10.4	6.1	0.64	444	0.68	0.06	0.18	2.2	710	3.9
L1760370-2 117267		0.07	0.07	<0.01	0.013	0.30	9.4	5.7	0.59	464	0.48	0.06	0.14	2.0	730	5.1
L1760370-3 TAILS-FEBRUARY		0.09	0.05	0.01	0.068	0.74	12.1	6.7	0.83	628	0.79	0.06	0.18	3.0	980	2.0
L1760370-4 TAILS-MARCH		0.09	0.04	0.01	0.079	0.66	9.8	6.4	0.79	633	0.73	0.05	0.16	3.0	950	2.0
L1760370-5 117270		0.08	0.10	<0.01	0.020	0.37	13.3	4.8	0.51	584	11.30	0.05	0.19	2.2	720	5.6
L1760370-6 117268		0.08	0.04	0.01	0.042	0.50	9.7	6.7	0.70	503	0.43	0.06	0.17	2.2	690	2.0
L1760370-7 117269		0.08	0.05	<0.01	0.024	0.33	12.5	6.6	0.65	452	1.40	0.06	0.11	2.1	730	9.6
L1760370-8 117271		0.08	0.06	<0.01	0.013	0.57	7.7	6.1	0.64	484	0.44	0.08	0.17	2.4	660	2.7
L1760370-9 117273		0.08	0.06	0.01	0.025	0.76	14.9	5.9	0.70	504	1.89	0.08	0.18	3.3	710	1.4
L1760370-10 117272		0.09	0.08	<0.01	0.018	0.60	10.4	5.2	0.60	486	0.51	0.09	0.23	2.0	770	1.3
L1760370-11 123696		0.09	0.07	<0.01	0.019	0.69	11.7	4.8	0.68	572	0.38	0.09	0.22	2.2	770	4.1

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Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

CERTIFICATE OF ANALYSIS VA16066460

Sample Description / Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V
Units	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
LOR	0.1	0.001	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1
L1760370-1 117266	19.5	<0.001	0.02	<0.05	2.8	0.4	0.4	67.7	<0.01	0.02	2.1	0.108	0.08	0.22	48
L1760370-2 117267	15.1	<0.001	<0.01	<0.05	3.5	0.2	0.4	72.5	<0.01	0.01	2.0	0.080	0.06	0.33	46
L1760370-3 TAILS-FEBRUARY	41.7	0.001	0.04	<0.05	4.2	0.7	1.0	82.7	<0.01	0.18	5.0	0.129	0.31	0.31	69
L1760370-4 TAILS-MARCH	35.7	0.001	0.04	<0.05	3.8	0.9	0.9	75.7	<0.01	0.18	4.2	0.117	0.24	0.53	69
L1760370-5 117270	24.1	0.003	0.01	<0.05	3.4	0.4	0.4	56.5	<0.01	0.03	3.9	0.072	0.13	0.67	48
L1760370-6 117268	27.5	<0.001	0.23	<0.05	3.1	2.9	0.4	77.0	<0.01	0.59	3.0	0.095	0.12	0.28	51
L1760370-7 117269	16.9	0.005	0.02	<0.05	3.3	0.4	0.5	88.0	<0.01	0.05	2.5	0.087	0.07	0.24	49
L1760370-8 117271	27.2	<0.001	0.01	<0.05	3.5	<0.2	0.4	38.1	<0.01	0.02	1.3	0.119	0.12	0.19	53
L1760370-9 117273	37.3	0.001	0.03	<0.05	3.6	0.3	0.5	40.4	<0.01	0.03	2.9	0.140	0.18	0.29	60
L1760370-10 117272	28.1	<0.001	0.01	<0.05	3.2	0.3	0.4	53.4	<0.01	0.16	2.6	0.126	0.11	0.33	54
L1760370-11 123696	33.2	0.001	0.03	<0.05	3.3	0.3	0.4	52.5	<0.01	0.03	2.6	0.144	0.16	0.31	53

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BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method / Analyte / Units / LOR	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
L1760370-1 117266		0.26	5.02	53	1.3
L1760370-2 117267		0.23	6.03	49	1.1
L1760370-3 TAILS-FEBRUARY		0.07	7.34	101	1.2
L1760370-4 TAILS-MARCH		0.06	6.06	110	1.0
L1760370-5 117270		0.36	5.96	97	1.6
L1760370-6 117268		0.24	5.07	71	0.7
L1760370-7 117269		0.26	5.57	62	0.8
L1760370-8 117271		0.25	5.23	57	1.0
L1760370-9 117273		0.61	5.21	64	0.9
L1760370-10 117272		0.49	5.52	58	1.3
L1760370-11 123696		0.11	5.58	86	1.3

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BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

CERTIFICATE OF ANALYSIS VA16066460

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	S-CAL06	S-GRA06
S-GRA06a	S-IR08	SPL-21	WEI-21

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BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

QC CERTIFICATE VA16066460

Project: L1760370

P.O. No.: ALSM-CW16-102-APN

This report is for 11 Tailings samples submitted to our lab in Vancouver, BC, Canada on 29-APR-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Minerals

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BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
STANDARDS																
Buffer pH6						6.0										
Buffer pH6						6.0										
Target Range - Lower Bound						5.3										
Upper Bound						6.7										
CDN-CM-34													3.67	2.34	109.5	<0.2
Target Range - Lower Bound													3.17	2.14	100.5	<0.2
Upper Bound													3.89	2.64	123.5	0.4
CO-ASSAY											0.48	1.8				
Target Range - Lower Bound											0.42	1.5				
Upper Bound											0.64	2.4				
GS313-8								1.22								
Target Range - Lower Bound								1.19								
Upper Bound								1.29								
KZK-1		25.0	2	31	56		2.24									
Target Range - Lower Bound		22.9	<1	30	54		2.18									
Upper Bound		27.1	>4	38	64		2.53									
MA-2c											1.54	5.7				
Target Range - Lower Bound											1.50	5.5				
Upper Bound											1.84	6.8				
MRGeo08													4.32	2.48	33.0	<0.2
Target Range - Lower Bound													4.00	2.44	29.6	<0.2
Upper Bound													4.92	3.00	36.4	0.4
NBM-1		9.3	2	36	45		4.83									
Target Range - Lower Bound		8.4	<1	33	42		4.64									
Upper Bound		10.3	>4	42	51		5.37									
UTS-1									0.89							
Target Range - Lower Bound									0.83							
Upper Bound									0.93							
UTS-1										0.88						
Target Range - Lower Bound										0.81						
Upper Bound										0.95						
UTS-2								3.21								
Target Range - Lower Bound								3.11								
Upper Bound								3.35								
UTS-4									1.79							
Target Range - Lower Bound									1.64							
Upper Bound									1.84							
UTS-4										1.71						
Target Range - Lower Bound										1.61						
Upper Bound										1.87						

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description / Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
STANDARDS															
Buffer pH6															
Buffer pH6															
Target Range - Lower Bound															
Upper Bound															
CDN-CM-34	<10	100	0.37	3.55	1.33	0.96	20.9	40.0	176	2.13	5640	4.28	7.62	0.10	0.06
Target Range - Lower Bound	<10	70	0.29	3.14	1.20	0.89	19.05	37.3	164	1.79	5390	3.91	6.99	<0.05	<0.02
Upper Bound	30	140	0.53	3.86	1.49	1.11	23.3	45.8	202	2.29	6210	4.80	8.65	0.23	0.11
CO-ASSAY															
Target Range - Lower Bound															
Upper Bound															
GS313-8															
Target Range - Lower Bound															
Upper Bound															
KZK-1															
Target Range - Lower Bound															
Upper Bound															
MA-2c															
Target Range - Lower Bound															
Upper Bound															
MRGeo08	<10	430	0.73	0.66	1.01	2.14	72.0	18.8	87	10.50	597	3.49	9.08	0.16	0.66
Target Range - Lower Bound	<10	370	0.67	0.60	1.00	2.01	66.2	17.0	81	9.40	587	3.22	8.73	0.07	0.64
Upper Bound	20	530	0.95	0.76	1.24	2.47	81.0	21.0	102	11.60	675	3.96	10.80	0.29	0.83
NBM-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-2															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CDN-CM-34		0.15	0.118	1.19	9.2	6.2	2.45	288	252	0.10	0.11	220	1140	20.9	45.2	0.288
Target Range - Lower Bound		0.11	0.103	1.06	8.2	5.9	2.27	269	236	0.08	<0.05	205	1050	19.1	40.4	0.256
Upper Bound		0.18	0.137	1.32	10.4	7.4	2.80	340	288	0.13	0.22	251	1310	23.7	49.6	0.316
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.06	0.153	1.24	36.0	30.6	1.10	389	13.45	0.31	1.00	677	970	1010	145.0	0.007
Target Range - Lower Bound		0.04	0.137	1.12	33.2	29.6	1.03	378	13.10	0.30	0.79	622	900	959	132.0	0.006
Upper Bound		0.10	0.179	1.40	41.0	36.4	1.29	473	16.10	0.39	1.09	760	1130	1175	162.0	0.010
NBM-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																

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BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method / Analyte / Units / LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CDN-CM-34		2.94	4.13	9.4	4.3	0.7	101.0	<0.01	0.67	1.1	0.173	0.87	0.36	102	6.89	9.93
Target Range - Lower Bound		2.70	3.38	8.7	3.9	0.3	92.8	<0.01	0.55	0.7	0.157	0.76	0.25	95	6.36	8.93
Upper Bound		3.32	4.68	10.9	5.2	1.2	114.0	0.02	0.70	1.6	0.203	1.08	0.49	118	8.72	11.00
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.28	3.13	6.9	1.3	3.2	74.2	0.02	0.03	21.6	0.365	0.79	5.38	97	2.98	19.30
Target Range - Lower Bound		0.27	2.80	6.7	0.9	2.8	72.1	<0.01	<0.01	19.1	0.338	0.64	4.93	90	2.44	17.50
Upper Bound		0.35	3.90	8.4	1.9	4.0	88.5	0.03	0.04	23.7	0.424	0.92	6.13	112	3.42	21.5
NBM-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																

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Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
		STANDARDS	
Buffer pH6			
Buffer pH6			
Target Range - Lower Bound			
Upper Bound			
CDN-CM-34		166	1.2
Target Range - Lower Bound		159	<0.5
Upper Bound		199	2.4
CO-ASSAY			
Target Range - Lower Bound			
Upper Bound			
GS313-8			
Target Range - Lower Bound			
Upper Bound			
KZK-1			
Target Range - Lower Bound			
Upper Bound			
MA-2c			
Target Range - Lower Bound			
Upper Bound			
MRGeo08		735	21.7
Target Range - Lower Bound		708	18.1
Upper Bound		870	25.7
NBM-1			
Target Range - Lower Bound			
Upper Bound			
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-2			
Target Range - Lower Bound			
Upper Bound			
UTS-4			
Target Range - Lower Bound			
Upper Bound			
UTS-4			
Target Range - Lower Bound			
Upper Bound			

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals

ALS Canada Ltd.

2103 Dollarton Hwy
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Phone: +1 (604) 984 0221 Fax: +1 (604) 984 0218
www.alsglobal.com

To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Method / Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
BLANKS															
BLANK										<0.05	<0.2				
Target Range - Lower Bound										<0.05	<0.2				
Upper Bound										0.10	0.4				
BLANK												<0.01	<0.01	<0.1	<0.2
Target Range - Lower Bound												<0.01	<0.01	<0.1	<0.2
Upper Bound												0.02	0.02	0.2	0.4
BLANK					6.0										
Target Range - Lower Bound					5.5										
Upper Bound					6.9										
BLANK								<0.01							
Target Range - Lower Bound								<0.01							
Upper Bound								0.02							
BLANK									<0.01						
Target Range - Lower Bound									<0.01						
Upper Bound									0.02						
BLANK							0.01								
Target Range - Lower Bound							<0.01								
Upper Bound							0.02								
DUPLICATES															
ORIGINAL												0.15	1.23	85.2	<0.2
DUP												0.14	1.30	86.0	<0.2
Target Range - Lower Bound												0.13	1.19	81.2	<0.2
Upper Bound												0.16	1.34	90.0	0.4
L1760370-7 117269								0.01							
DUP								0.01							
Target Range - Lower Bound								<0.01							
Upper Bound								0.02							
L1760370-10 117272	0.6	2	16	17	9.1	27.20	0.02		0.01	0.08	0.3				
DUP	0.6	2	16	17	9.1	27.20	0.02		0.01	0.14	0.5				
Target Range - Lower Bound	<0.3	<1	14	15	8.5	25.83	<0.01		<0.01	<0.05	<0.2				
Upper Bound	0.9	3	18	19	9.7	28.57	0.03		0.02	0.17	0.6				

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
									BLANKS							
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
Target Range - Lower Bound		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
Upper Bound		20	20	0.10	0.02	0.02	0.02	0.04	0.2	2	0.10	0.4	0.02	0.10	0.10	0.04
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
									DUPLICATES							
ORIGINAL		10	150	0.83	0.13	5.01	9.39	47.5	5.1	24	17.60	21.2	1.48	2.75	0.08	0.05
DUP		10	160	0.91	0.14	5.19	9.76	49.6	5.3	26	18.55	21.7	1.52	2.88	0.08	0.05
Target Range - Lower Bound		<10	130	0.78	0.12	4.84	9.09	46.1	4.8	23	17.10	20.5	1.42	2.62	<0.05	0.03
Upper Bound		20	180	0.96	0.15	5.37	10.05	51.0	5.6	27	19.05	22.4	1.59	3.01	0.10	0.07
L1760370-7 117269																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1760370-10 117272																
DUP																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals

ALS Canada Ltd.

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www.alsglobal.com

To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.01	<0.005	<0.01	<0.2	0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Target Range - Lower Bound		<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Upper Bound		0.02	0.010	0.02	0.4	0.2	0.02	10	0.10	0.02	0.10	0.4	20	0.4	0.2	0.002
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL		0.43	0.028	0.36	29.5	13.7	0.52	145	6.11	0.07	<0.05	44.7	3180	8.8	23.3	0.001
DUP		0.44	0.027	0.39	30.6	14.0	0.54	151	6.39	0.07	<0.05	45.6	3300	8.8	24.6	0.001
Target Range - Lower Bound		0.39	0.021	0.35	28.3	13.1	0.49	136	5.89	0.06	<0.05	42.7	3070	8.2	22.7	<0.001
Upper Bound		0.48	0.034	0.40	31.8	14.6	0.57	160	6.61	0.08	0.10	47.6	3410	9.4	25.2	0.002
L1760370-7 117269																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1760370-10 117272																
DUP																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.

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www.alsglobal.com

To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y
	Units	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
	LOR	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1	0.05	0.05
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Target Range - Lower Bound		<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Upper Bound		0.02	0.10	0.2	0.4	0.4	0.4	0.02	0.02	0.4	0.010	0.04	0.10	2	0.10	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL		<0.01	4.70	3.4	1.6	0.3	237	<0.01	0.03	6.1	<0.005	0.33	1.84	81	0.09	20.5
DUP		<0.01	4.61	3.4	1.9	0.3	245	<0.01	0.04	6.3	<0.005	0.35	1.91	86	0.09	20.7
Target Range - Lower Bound		<0.01	4.26	3.1	1.5	<0.2	229	<0.01	0.02	5.7	<0.005	0.29	1.73	78	<0.05	19.50
Upper Bound		0.02	5.05	3.7	2.0	0.4	253	0.02	0.05	6.7	0.010	0.39	2.02	89	0.10	21.7
L1760370-7 117269																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1760370-10 117272																
DUP																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals
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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
BLANKS			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK		<2	<0.5
Target Range - Lower Bound		<2	<0.5
Upper Bound		4	1.0
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
Target Range - Lower Bound			
Upper Bound			
DUPLICATES			
ORIGINAL		292	2.2
DUP		305	2.1
Target Range - Lower Bound		282	1.5
Upper Bound		315	2.8
L1760370-7 117269			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1760370-10 117272			
DUP			
Target Range - Lower Bound			
Upper Bound			

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-MAY-2016
Account: APN

Project: L1760370

QC CERTIFICATE OF ANALYSIS VA16066460

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	S-CAL06	S-GRA06
S-GRA06a	S-IR08	SPL-21	WEI-21

Chain of Custody (COC) / Analytical Request Form

ALS

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1760370-COFC

COC Number: 16-002

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Dis

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

E&P TATs with your AM - surcharges will apply

AT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code Routing Code:

Requisitioner:

Location:

ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals - Aqua regia disgestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	117266	03-04-16		Composite	R	R	R	R	R	R	
	117267	04-04-16		Composite							
	Tails - Febuary	04-04-16		Tails							
	Tails - March	04-04-16		Tails							
	117270	08-04-16		waste							
	117268	10-04-16		waste							
	117269	10-04-16		waste							
	117271	12-04-16		waste							
	117273	19-04-16		waste							
	117272	19-04-16		waste							
	123696	19-04-16		waste							

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 2.5°C

FINAL COOLER TEMPERATURES °C: 6°C

SHIPMENT RELEASE (client use)		INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Phyllistine Hager	Date: April 21, 2016 Time:	Received by: Jeremy Murray	Date: April 26 16	Time: 12:55pm	Received By: Tady	Date: Apr. 27	Time: 2pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

OCTOBER 2015 FRONT

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 20-MAY-16
Report Date: 10-JUN-16 14:35 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1772159

Project P.O. #: TBD
Job Reference:
C of C Numbers: 16-003
Legal Site Desc:

Comments: Please note, the ALS Minerals version of the finalized report and QC can be found at the end of the attachment.

Ariel Tang, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1772159-1	L1772159-2	L1772159-3	L1772159-4	L1772159-5
	Description	Waste	Composite	Composite	Waste	Waste
	Sampled Date	13-APR-16	17-APR-16	18-APR-16	23-APR-16	19-APR-16
	Sampled Time					
	Client ID	117274	117275	117451	117453	117452
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.5	8.5	8.6	9.2	8.9
Organic / Inorganic Carbon	Carbon (C) (%)	0.37	0.25	0.23	0.07	0.12
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	3.8	1.3	5.9	0.6	0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	38	26	25	16	19
	NNP (tCaCO3/1Kt)	34	25	19	15	19
	Ratio (NP/MPA) (Unity)	10.13	20.80	4.21	25.60	60.80
	Sulfate Sulfur (carbonate leach) (%)	0.01	<0.01	<0.01	0.01	<0.01
	Sulfate Sulfur (HCl leach) (%)	0.01	<0.01	0.03	0.02	0.02
	Sulfide Sulfur (T minus carbonate leach) (%)	0.11	0.04	0.19	0.01	0.01
	Total Sulfur (combustion) (%)	0.12	0.04	0.19	0.02	0.01
Total Metals	Aluminum (Al) (%)	1.25	1.15	1.29	1.20	1.05
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.8	0.9	1.0	0.4	1.1
	Barium (Ba) (ppm)	140	200	220	270	160
	Beryllium (Be) (ppm)	0.34	0.32	0.22	0.21	0.28
	Bismuth (Bi) (ppm)	0.25	0.08	0.96	0.01	0.01
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.14	0.04	0.26	0.02	0.02
	Calcium (Ca) (%)	1.55	1.14	1.00	0.72	0.83
	Cerium (Ce) (ppm)	21.8	20.4	19.30	18.05	13.35
	Cesium (Cs) (ppm)	0.38	0.27	0.61	0.36	0.20
	Chromium (Cr) (ppm)	5	5	5	5	4
	Cobalt (Co) (ppm)	5.9	5.4	6.0	6.3	5.1
	Copper (Cu) (ppm)	1715	533	4180	40.5	27.1
	Gallium (Ga) (ppm)	6.33	5.62	6.47	5.67	4.66
	Germanium (Ge) (ppm)	0.14	0.14	0.15	0.15	0.14
	Gold (Au) (ppm)	<0.2	<0.2	0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.05	0.06	0.04	0.08	0.07
	Indium (In) (ppm)	0.049	0.023	0.043	0.021	0.012
	Iron (Fe) (%)	2.28	2.16	2.58	2.34	1.90
	Lanthanum (La) (ppm)	11.8	11.0	10.2	10.0	7.4
	Lead (Pb) (ppm)	2.3	2.3	2.3	1.0	1.6
	Lithium (Li) (ppm)	6.6	5.6	6.2	6.4	5.9
	Magnesium (Mg) (%)	0.63	0.54	0.66	0.68	0.60
	Manganese (Mn) (ppm)	557	486	514	517	451

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1772159-6	L1772159-7	L1772159-8	L1772159-9	L1772159-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	26-APR-16	26-APR-16	29-APR-16	07-MAY-16	07-MAY-16
	Sampled Time					
	Client ID	117454	123697	117455	117460	117458
SOIL						
Physical Tests	pH (Unity)	9.0	8.8	9.1	8.7	8.7
Organic / Inorganic Carbon	Carbon (C) (%)	0.06	0.06	0.10	0.24	0.23
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	0.9	0.3	0.3	0.3	0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	15	12	18	29	27
	NNP (tCaCO3/1Kt)	14	12	18	29	27
	Ratio (NP/MPA) (Unity)	16.00	38.40	57.60	92.80	86.40
	Sulfate Sulfur (carbonate leach) (%)	0.01	0.01	0.01	0.01	0.02
	Sulfate Sulfur (HCl leach) (%)	<0.01	0.01	0.01	0.02	0.03
	Sulfide Sulfur (T minus carbonate leach) (%)	0.02	<0.01	<0.01	<0.01	<0.01
	Total Sulfur (combustion) (%)	0.03	0.01	0.01	0.01	0.01
Total Metals	Aluminum (Al) (%)	1.30	1.02	1.07	1.30	1.21
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	1.9	0.2	0.4	0.9	0.8
	Barium (Ba) (ppm)	250	230	190	100	140
	Beryllium (Be) (ppm)	0.28	0.21	0.26	0.39	0.31
	Bismuth (Bi) (ppm)	0.02	0.01	0.01	0.01	0.01
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.02	0.02	0.01	0.03	0.02
	Calcium (Ca) (%)	0.79	0.61	0.82	1.37	1.26
	Cerium (Ce) (ppm)	18.95	18.05	14.90	16.45	13.40
	Cesium (Cs) (ppm)	0.33	0.31	0.24	0.16	0.19
	Chromium (Cr) (ppm)	4	8	4	4	3
	Cobalt (Co) (ppm)	7.2	5.0	5.2	5.6	5.3
	Copper (Cu) (ppm)	229	3.7	8.0	8.1	5.6
	Gallium (Ga) (ppm)	5.72	4.89	4.71	5.80	5.46
	Germanium (Ge) (ppm)	0.15	0.15	0.14	0.12	0.12
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.07	0.08	0.08	0.07	0.06
	Indium (In) (ppm)	0.018	0.020	0.013	0.014	0.014
	Iron (Fe) (%)	2.32	1.85	1.99	1.97	1.96
	Lanthanum (La) (ppm)	10.4	10.0	8.2	8.8	6.9
	Lead (Pb) (ppm)	2.4	1.2	1.1	5.8	2.9
	Lithium (Li) (ppm)	6.2	4.4	5.4	6.0	5.8
	Magnesium (Mg) (%)	0.71	0.57	0.60	0.63	0.57
	Manganese (Mn) (ppm)	454	474	453	471	445

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1772159-11	L1772159-12			
	Description	Waste	Waste			
	Sampled Date	07-MAY-16	07-MAY-16			
	Sampled Time					
	Client ID	117457	117456			
SOIL						
Physical Tests	pH (Unity)	8.6	8.8			
Organic / Inorganic Carbon	Carbon (C) (%)	0.42	0.23			
Acid Base Accounting	FIZZ RATING (Unity)	2	2			
	MPA (tCaCO3/1Kt)	1.3	0.3			
	Neutralization Potential (NP) (tCaCO3/1Kt)	40	25			
	NNP (tCaCO3/1Kt)	39	25			
	Ratio (NP/MPA) (Unity)	32.00	80.00			
	Sulfate Sulfur (carbonate leach) (%)	0.01	<0.01			
	Sulfate Sulfur (HCl leach) (%)	0.01	0.02			
	Sulfide Sulfur (T minus carbonate leach) (%)	0.03	0.01			
	Total Sulfur (combustion) (%)	0.04	0.01			
Total Metals	Aluminum (Al) (%)	1.16	1.16			
	Antimony (Sb) (ppm)	<0.05	<0.05			
	Arsenic (As) (ppm)	0.6	0.4			
	Barium (Ba) (ppm)	80	170			
	Beryllium (Be) (ppm)	0.43	0.34			
	Bismuth (Bi) (ppm)	0.08	0.01			
	Boron (B) (ppm)	<10	<10			
	Cadmium (Cd) (ppm)	0.06	0.02			
	Calcium (Ca) (%)	1.73	1.14			
	Cerium (Ce) (ppm)	13.00	13.45			
	Cesium (Cs) (ppm)	0.21	0.22			
	Chromium (Cr) (ppm)	3	4			
	Cobalt (Co) (ppm)	4.6	5.9			
	Copper (Cu) (ppm)	553	7.5			
	Gallium (Ga) (ppm)	5.27	5.44			
	Germanium (Ge) (ppm)	0.12	0.13			
	Gold (Au) (ppm)	<0.2	<0.2			
	Hafnium (Hf) (ppm)	0.04	0.07			
	Indium (In) (ppm)	0.018	0.015			
	Iron (Fe) (%)	1.86	2.13			
	Lanthanum (La) (ppm)	7.3	7.2			
	Lead (Pb) (ppm)	3.3	8.0			
	Lithium (Li) (ppm)	5.4	5.7			
	Magnesium (Mg) (%)	0.50	0.61			
	Manganese (Mn) (ppm)	498	494			

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1772159-1	L1772159-2	L1772159-3	L1772159-4	L1772159-5
	Description	Waste	Composite	Composite	Waste	Waste
	Sampled Date	13-APR-16	17-APR-16	18-APR-16	23-APR-16	19-APR-16
	Sampled Time					
	Client ID	117274	117275	117451	117453	117452
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	<0.01	0.03	0.01	0.01
	Molybdenum (Mo) (ppm)	1.34	1.11	0.63	0.63	0.53
	Nickel (Ni) (ppm)	2.3	4.4	2.5	2.2	2.2
	Niobium (Nb) (ppm)	0.22	0.21	0.26	0.24	0.21
	Phosphorus (P) (ppm)	720	620	800	800	650
	Potassium (K) (%)	0.39	0.43	0.80	0.67	0.39
	Rhenium (Re) (ppm)	0.001	<0.001	<0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	23.0	19.7	44.8	31.1	16.9
	Scandium (Sc) (ppm)	3.4	3.7	3.0	3.6	3.1
	Selenium (Se) (ppm)	1.7	0.5	4.2	0.2	0.2
	Silver (Ag) (ppm)	0.53	0.24	2.28	0.03	0.03
	Sodium (Na) (%)	0.06	0.06	0.05	0.09	0.06
	Strontium (Sr) (ppm)	108.0	80.5	75.6	45.9	57.8
	Sulfur (S) (%)	0.12	0.04	0.18	<0.01	<0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.16	0.03	0.93	<0.01	<0.01
	Thallium (Tl) (ppm)	0.11	0.11	0.22	0.15	0.07
	Thorium (Th) (ppm)	2.9	2.8	3.3	2.3	1.3
	Tin (Sn) (ppm)	0.5	0.5	0.5	0.5	0.3
	Titanium (Ti) (%)	0.077	0.084	0.143	0.146	0.103
	Tungsten (W) (ppm)	0.25	0.76	1.06	1.11	0.75
	Uranium (U) (ppm)	0.49	0.17	0.24	0.31	0.21
	Vanadium (V) (ppm)	46	44	58	58	45
	Yttrium (Y) (ppm)	8.00	5.82	4.53	5.78	4.89
	Zinc (Zn) (ppm)	75	65	76	65	52
	Zirconium (Zr) (ppm)	0.8	1.0	0.7	1.2	1.0
Permanent Gases	Carbon Dioxide (CO2) (%)	1.3	0.9	0.9	0.3	0.4

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1772159-6	L1772159-7	L1772159-8	L1772159-9	L1772159-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	26-APR-16	26-APR-16	29-APR-16	07-MAY-16	07-MAY-16
	Sampled Time					
	Client ID	117454	123697	117455	117460	117458
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	<0.01	<0.01	0.01	<0.01
	Molybdenum (Mo) (ppm)	1.58	0.10	0.82	0.18	0.24
	Nickel (Ni) (ppm)	2.4	1.7	2.0	1.8	1.6
	Niobium (Nb) (ppm)	0.32	0.20	0.27	0.14	0.16
	Phosphorus (P) (ppm)	790	630	640	630	600
	Potassium (K) (%)	0.60	0.59	0.47	0.22	0.27
	Rhenium (Re) (ppm)	<0.001	<0.001	<0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	29.3	27.2	20.3	10.0	12.2
	Scandium (Sc) (ppm)	3.7	3.4	3.3	3.4	3.1
	Selenium (Se) (ppm)	0.5	0.2	0.2	0.3	0.2
	Silver (Ag) (ppm)	0.08	0.01	0.02	0.02	0.01
	Sodium (Na) (%)	0.08	0.08	0.09	0.06	0.06
	Strontium (Sr) (ppm)	46.3	45.4	52.8	91.9	136.5
	Sulfur (S) (%)	0.03	0.01	<0.01	<0.01	<0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	<0.01	<0.01	<0.01	0.01	<0.01
	Thallium (Tl) (ppm)	0.13	0.14	0.09	0.04	0.05
	Thorium (Th) (ppm)	2.7	1.7	1.3	1.3	1.1
	Tin (Sn) (ppm)	0.6	0.4	0.4	0.4	0.4
	Titanium (Ti) (%)	0.151	0.123	0.108	0.058	0.069
	Tungsten (W) (ppm)	0.42	0.07	0.93	0.10	0.07
	Uranium (U) (ppm)	0.55	0.22	0.19	0.21	0.20
	Vanadium (V) (ppm)	60	44	47	41	41
	Yttrium (Y) (ppm)	6.07	5.78	5.79	6.47	5.52
	Zinc (Zn) (ppm)	59	67	50	58	56
	Zirconium (Zr) (ppm)	1.1	1.2	1.1	0.9	0.9
Permanent Gases	Carbon Dioxide (CO_2) (%)	0.2	0.2	0.4	0.9	0.8

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1772159-11 Waste 07-MAY-16 117457	L1772159-12 Waste 07-MAY-16 117456			
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01			
	Molybdenum (Mo) (ppm)	1.74	0.20			
	Nickel (Ni) (ppm)	6.4	1.9			
	Niobium (Nb) (ppm)	0.09	0.17			
	Phosphorus (P) (ppm)	470	710			
	Potassium (K) (%)	0.22	0.37			
	Rhenium (Re) (ppm)	<0.001	<0.001			
	Rubidium (Rb) (ppm)	10.4	16.0			
	Scandium (Sc) (ppm)	2.3	3.7			
	Selenium (Se) (ppm)	0.4	0.2			
	Silver (Ag) (ppm)	0.16	0.02			
	Sodium (Na) (%)	0.05	0.07			
	Strontium (Sr) (ppm)	111.0	108.0			
	Sulfur (S) (%)	0.04	<0.01			
	Tantalum (Ta) (ppm)	<0.01	<0.01			
	Tellurium (Te) (ppm)	0.03	<0.01			
	Thallium (Tl) (ppm)	0.05	0.06			
	Thorium (Th) (ppm)	1.2	1.0			
	Tin (Sn) (ppm)	0.3	0.4			
	Titanium (Ti) (%)	0.035	0.083			
	Tungsten (W) (ppm)	0.50	0.11			
	Uranium (U) (ppm)	0.17	0.20			
	Vanadium (V) (ppm)	36	46			
	Yttrium (Y) (ppm)	4.47	6.31			
	Zinc (Zn) (ppm)	51	58			
	Zirconium (Zr) (ppm)	0.7	1.1			
Permanent Gases	Carbon Dioxide (CO2) (%)	1.5	0.8			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ABA-OA-VOL08-AX	Soil	Acid Base Accounting	OA-VOL08
CARBON-C-GAS05-AX	Soil	Carbon, TOC and CO2	C-GAS05
ME-MS41-AX	Soil	Aqua Regia ICPMS	Aqua Regia ICPMS

A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-OA-ELE07-AX	Soil	pH	OA-ELE07
SULPHUR-S-CAL06-AX	Soil	Sulfide Sulfur Calc from Carbonate Leach	ALS Minerals S-CAL06

Sulfide Sulfur (as S) is calculated by subtracting the Carbonate Leachable Sulfate Sulfur (as S) from the Total Sulfur (as S) obtained from combustion.

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06-AX	Soil	Sulfate Sulfur in Soil (Carbonate Leach)	ALS Minerals S-GRA06

A prepared sample is boiled with a sodium carbonate solution for 30 minutes. Any insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06A-AX	Soil	Sulfate Sulfur in Soil (HCl Leach)	ALS Minerals S-GRA06A

A prepared sample is heated with dilute hydrochloric acid for 30 minutes. Silica and any acid-insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-IR08-AX	Soil	Total Sulfur in Soil by Combustion	ALS Minerals S-IR08

The sample is heated to approximately 1350 °C in an induction furnace while passing a stream of oxygen through the sample. Sulfur dioxide released from the sample is measured by an IR detection system and the Total Sulfur result is provided.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
AX	ALS MINERALS - VANCOUVER, B.C., CANADA

Chain of Custody Numbers:

16-003

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Minerals

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

CERTIFICATE VA16082648

Project: L1772159

P.O. No.: ALSM-CW16-102-APN

This report is for 12 Other samples submitted to our lab in Vancouver, BC, Canada on 25-MAY-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
PUL-QC	Pulverizing QC Test
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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100 - 8081 LOUGHEED HWY.
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Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method Analyte Units LOR	WEI-21 Recvd Wt. kg 0.02	OA-VOL08m MPA tCaCO3/1Kt 0.3	OA-VOL08m FIZZ RAT Unity 1	OA-VOL08m NNP tCaCO3/1Kt 1	OA-VOL08m NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08m Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	S-CAL06 S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2	ME-MS41 Ag ppm 0.01	ME-MS41 Al % 0.01
L1772159-1 117274		1.06	3.8	2	34	38	8.5	10.13	0.12	0.01	0.01	0.11	0.37	1.3	0.53	1.25
L1772159-2 117275		1.02	1.3	2	25	26	8.5	20.80	0.04	<0.01	<0.01	0.04	0.25	0.9	0.24	1.15
L1772159-3 117451		1.06	5.9	2	19	25	8.6	4.21	0.19	<0.01	0.03	0.19	0.23	0.9	2.28	1.29
L1772159-4 117453		1.06	0.6	2	15	16	9.2	25.60	0.02	0.01	0.02	0.01	0.07	0.3	0.03	1.20
L1772159-5 117452		0.96	0.3	2	19	19	8.9	60.80	0.01	<0.01	0.02	0.01	0.12	0.4	0.03	1.05
L1772159-6 117454		1.14	0.9	2	14	15	9.0	16.00	0.03	0.01	<0.01	0.02	0.06	0.2	0.08	1.30
L1772159-7 123697		1.02	0.3	2	12	12	8.8	38.40	0.01	0.01	0.01	<0.01	0.06	0.2	0.01	1.02
L1772159-8 117455		1.04	0.3	2	18	18	9.1	57.60	0.01	0.01	0.01	<0.01	0.10	0.4	0.02	1.07
L1772159-9 117460		0.98	0.3	2	29	29	8.7	92.80	0.01	0.01	0.02	<0.01	0.24	0.9	0.02	1.30
L1772159-10 117458		1.00	0.3	2	27	27	8.7	86.40	0.01	0.02	0.03	<0.01	0.23	0.8	0.01	1.21
L1772159-11 117457		0.98	1.3	2	39	40	8.6	32.00	0.04	0.01	0.01	0.03	0.42	1.5	0.16	1.16
L1772159-12 117456		0.98	0.3	2	25	25	8.8	80.00	0.01	<0.01	0.02	0.01	0.23	0.8	0.02	1.16

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 As ppm 0.1	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05
L1772159-1 117274		0.8	<0.2	<10	140	0.34	0.25	1.55	0.14	21.8	5.9	5	0.38	1715	2.28	6.33
L1772159-2 117275		0.9	<0.2	<10	200	0.32	0.08	1.14	0.04	20.4	5.4	5	0.27	533	2.16	5.62
L1772159-3 117451		1.0	0.2	<10	220	0.22	0.96	1.00	0.26	19.30	6.0	5	0.61	4180	2.58	6.47
L1772159-4 117453		0.4	<0.2	<10	270	0.21	0.01	0.72	0.02	18.05	6.3	5	0.36	40.5	2.34	5.67
L1772159-5 117452		1.1	<0.2	<10	160	0.28	0.01	0.83	0.02	13.35	5.1	4	0.20	27.1	1.90	4.66
L1772159-6 117454		1.9	<0.2	<10	250	0.28	0.02	0.79	0.02	18.95	7.2	4	0.33	229	2.32	5.72
L1772159-7 123697		0.2	<0.2	<10	230	0.21	0.01	0.61	0.02	18.05	5.0	8	0.31	3.7	1.85	4.89
L1772159-8 117455		0.4	<0.2	<10	190	0.26	0.01	0.82	0.01	14.90	5.2	4	0.24	8.0	1.99	4.71
L1772159-9 117460		0.9	<0.2	<10	100	0.39	0.01	1.37	0.03	16.45	5.6	4	0.16	8.1	1.97	5.80
L1772159-10 117458		0.8	<0.2	<10	140	0.31	0.01	1.26	0.02	13.40	5.3	3	0.19	5.6	1.96	5.46
L1772159-11 117457		0.6	<0.2	<10	80	0.43	0.08	1.73	0.06	13.00	4.6	3	0.21	553	1.86	5.27
L1772159-12 117456		0.4	<0.2	<10	170	0.34	0.01	1.14	0.02	13.45	5.9	4	0.22	7.5	2.13	5.44

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2
L1772159-1 117274		0.14	0.05	0.01	0.049	0.39	11.8	6.6	0.63	557	1.34	0.06	0.22	2.3	720	2.3
L1772159-2 117275		0.14	0.06	<0.01	0.023	0.43	11.0	5.6	0.54	486	1.11	0.06	0.21	4.4	620	2.3
L1772159-3 117451		0.15	0.04	0.03	0.043	0.80	10.2	6.2	0.66	514	0.63	0.05	0.26	2.5	800	2.3
L1772159-4 117453		0.15	0.08	0.01	0.021	0.67	10.0	6.4	0.68	517	0.63	0.09	0.24	2.2	800	1.0
L1772159-5 117452		0.14	0.07	0.01	0.012	0.39	7.4	5.9	0.60	451	0.53	0.06	0.21	2.2	650	1.6
L1772159-6 117454		0.15	0.07	0.01	0.018	0.60	10.4	6.2	0.71	454	1.58	0.08	0.32	2.4	790	2.4
L1772159-7 123697		0.15	0.08	<0.01	0.020	0.59	10.0	4.4	0.57	474	0.10	0.08	0.20	1.7	630	1.2
L1772159-8 117455		0.14	0.08	<0.01	0.013	0.47	8.2	5.4	0.60	453	0.82	0.09	0.27	2.0	640	1.1
L1772159-9 117460		0.12	0.07	0.01	0.014	0.22	8.8	6.0	0.63	471	0.18	0.06	0.14	1.8	630	5.8
L1772159-10 117458		0.12	0.06	<0.01	0.014	0.27	6.9	5.8	0.57	445	0.24	0.06	0.16	1.6	600	2.9
L1772159-11 117457		0.12	0.04	<0.01	0.018	0.22	7.3	5.4	0.50	498	1.74	0.05	0.09	6.4	470	3.3
L1772159-12 117456		0.13	0.07	<0.01	0.015	0.37	7.2	5.7	0.61	494	0.20	0.07	0.17	1.9	710	8.0

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Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1
L1772159-1 117274		23.0	0.001	0.12	<0.05	3.4	1.7	0.5	108.0	<0.01	0.16	2.9	0.077	0.11	0.49	46
L1772159-2 117275		19.7	<0.001	0.04	<0.05	3.7	0.5	0.5	80.5	<0.01	0.03	2.8	0.084	0.11	0.17	44
L1772159-3 117451		44.8	<0.001	0.18	<0.05	3.0	4.2	0.5	75.6	<0.01	0.93	3.3	0.143	0.22	0.24	58
L1772159-4 117453		31.1	<0.001	<0.01	<0.05	3.6	0.2	0.5	45.9	<0.01	<0.01	2.3	0.146	0.15	0.31	58
L1772159-5 117452		16.9	<0.001	<0.01	<0.05	3.1	0.2	0.3	57.8	<0.01	<0.01	1.3	0.103	0.07	0.21	45
L1772159-6 117454		29.3	<0.001	0.03	<0.05	3.7	0.5	0.6	46.3	<0.01	<0.01	2.7	0.151	0.13	0.55	60
L1772159-7 123697		27.2	<0.001	0.01	<0.05	3.4	0.2	0.4	45.4	<0.01	<0.01	1.7	0.123	0.14	0.22	44
L1772159-8 117455		20.3	<0.001	<0.01	<0.05	3.3	0.2	0.4	52.8	<0.01	<0.01	1.3	0.108	0.09	0.19	47
L1772159-9 117460		10.0	<0.001	<0.01	<0.05	3.4	0.3	0.4	91.9	<0.01	0.01	1.3	0.058	0.04	0.21	41
L1772159-10 117458		12.2	<0.001	<0.01	<0.05	3.1	0.2	0.4	136.5	<0.01	<0.01	1.1	0.069	0.05	0.20	41
L1772159-11 117457		10.4	<0.001	0.04	<0.05	2.3	0.4	0.3	111.0	<0.01	0.03	1.2	0.035	0.05	0.17	36
L1772159-12 117456		16.0	<0.001	<0.01	<0.05	3.7	0.2	0.4	108.0	<0.01	<0.01	1.0	0.083	0.06	0.20	46

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method Analyte Units LOR	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
L1772159-1 117274		0.25	8.00	75	0.8
L1772159-2 117275		0.76	5.82	65	1.0
L1772159-3 117451		1.06	4.53	76	0.7
L1772159-4 117453		1.11	5.78	65	1.2
L1772159-5 117452		0.75	4.89	52	1.0
L1772159-6 117454		0.42	6.07	59	1.1
L1772159-7 123697		0.07	5.78	67	1.2
L1772159-8 117455		0.93	5.79	50	1.1
L1772159-9 117460		0.10	6.47	58	0.9
L1772159-10 117458		0.07	5.52	56	0.9
L1772159-11 117457		0.50	4.47	51	0.7
L1772159-12 117456		0.11	6.31	58	1.1

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BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

CERTIFICATE OF ANALYSIS VA16082648

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	PUL-QC	S-CAL06
S-GRA06	S-GRA06a	S-IR08	SPL-21
WEI-21			

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BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

QC CERTIFICATE VA16082648

Project: L1772159
P.O. No.: ALSM-CW16-102-APN
This report is for 12 Other samples submitted to our lab in Vancouver, BC, Canada on 25-MAY-2016.
The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
PUL-QC	Pulverizing QC Test
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
STANDARDS															
Buffer pH6					6.1										
Buffer pH6					6.1										
Target Range - Lower Bound					5.3										
Upper Bound					6.7										
CO-ASSAY											0.47	1.7			
Target Range - Lower Bound											0.42	1.5			
Upper Bound											0.64	2.4			
GS313-8							1.26								
Target Range - Lower Bound							1.19								
Upper Bound							1.29								
KZK-1	25.0	2	33	58		2.32									
KZK-1	25.0	2	33	58		2.32									
Target Range - Lower Bound	22.9	<1	30	54		2.18									
Upper Bound	27.1	>4	38	64		2.53									
MA-2c											1.53	5.6			
Target Range - Lower Bound											1.50	5.5			
Upper Bound											1.84	6.8			
MA-3a											2.39	8.8			
Target Range - Lower Bound											2.31	8.4			
Upper Bound											2.77	10.2			
OGGeo08													19.80	2.20	116.0
Target Range - Lower Bound													18.15	2.05	107.0
Upper Bound													22.2	2.53	131.0
OREAS-45d													0.12	4.82	6.4
Target Range - Lower Bound													0.10	4.36	5.8
Upper Bound													0.15	5.36	7.3
SY-4											0.87	3.2			
Target Range - Lower Bound											0.84	3.0			
Upper Bound											1.08	4.0			
UTS-1								0.89							
Target Range - Lower Bound								0.83							
Upper Bound								0.93							
UTS-1									0.88						
Target Range - Lower Bound									0.81						
Upper Bound									0.95						
UTS-2							3.35								
Target Range - Lower Bound							3.11								
Upper Bound							3.35								
UTS-4								1.76							

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description / Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge
Units	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
LOR	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05	0.05
STANDARDS															
Buffer pH6															
Buffer pH6															
Target Range - Lower Bound															
Upper Bound															
CO-ASSAY															
Target Range - Lower Bound															
Upper Bound															
GS313-8															
Target Range - Lower Bound															
Upper Bound															
KZK-1															
KZK-1															
Target Range - Lower Bound															
Upper Bound															
MA-2c															
Target Range - Lower Bound															
Upper Bound															
MA-3a															
Target Range - Lower Bound															
Upper Bound															
OGGeo08	<0.2	<10	110	0.73	10.65	0.85	18.55	60.7	94.5	77	9.13	8320	4.92	8.46	0.22
Target Range - Lower Bound	<0.2	<10	60	0.61	9.44	0.82	16.75	56.7	87.2	75	8.68	7800	4.51	8.05	0.21
Upper Bound	0.4	30	110	0.89	11.55	1.02	20.5	69.3	107.0	93	10.70	8980	5.53	9.95	0.45
OREAS-45d	<0.2	10	80	0.58	0.27	0.09	0.02	25.0	26.5	442	2.43	338	13.50	16.95	0.13
Target Range - Lower Bound	<0.2	<10	50	0.42	0.26	0.06	<0.01	22.3	23.5	419	2.09	321	12.30	16.05	<0.05
Upper Bound	0.4	30	110	0.68	0.34	0.11	0.05	27.3	28.9	515	2.67	369	15.05	19.75	0.23
SY-4															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-2															
Target Range - Lower Bound															
Upper Bound															
UTS-4															

***** See Appendix Page for comments regarding this certificate *****

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100 - 8081 LOUGHEED HWY.
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Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
OGGeo08		0.85	0.45	1.405	1.04	29.9	31.3	0.91	369	847	0.29	1.06	8790	760	6940	119.5
Target Range - Lower Bound		0.72	0.41	1.335	0.94	27.7	29.8	0.84	350	811	0.26	0.97	7760	700	6520	109.5
Upper Bound		0.92	0.57	1.645	1.18	34.3	36.6	1.05	438	991	0.34	1.29	9480	880	7970	134.5
OREAS-45d		0.51	0.04	0.079	0.10	10.9	12.3	0.13	352	1.60	0.03	0.36	184.5	320	16.6	20.0
Target Range - Lower Bound		0.40	0.02	0.071	0.07	8.8	10.6	0.12	328	1.45	<0.01	0.27	158.0		15.1	18.7
Upper Bound		0.54	0.06	0.099	0.12	11.2	13.2	0.17	412	1.89	0.05	0.51	194.0		18.9	23.1
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																

***** See Appendix Page for comments regarding this certificate *****

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BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05
								STANDARDS								
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
OGGeo08		1.350	2.65	19.75	6.1	10.2	12.7	64.5	<0.01	0.15	17.0	0.299	1.40	4.92	76	3.19
Target Range - Lower Bound		1.295	2.51	17.70	6.0	9.7	12.0	59.6	<0.01	0.14	15.6	0.279	1.14	4.45	70	2.58
Upper Bound		1.585	3.09	24.1	7.6	12.3	15.1	73.2	0.03	0.20	19.6	0.353	1.58	5.55	88	3.60
OREAS-45d		<0.001	0.04	0.34	44.9	1.3	1.8	11.2	<0.01	0.03	10.6	0.081	0.13	1.63	193	0.05
Target Range - Lower Bound		<0.001	0.02	0.22	37.3	0.7	1.3	9.7	<0.01	0.02	10.0	0.068	0.07	1.43	180	<0.05
Upper Bound		0.003	0.07	0.49	45.8	1.7	2.3	12.3	0.03	0.06	12.6	0.096	0.17	1.85	222	0.16
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description / Method / Analyte / Units / LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
STANDARDS			
Buffer pH6			
Buffer pH6			
Target Range - Lower Bound			
Upper Bound			
CO-ASSAY			
Target Range - Lower Bound			
Upper Bound			
GS313-8			
Target Range - Lower Bound			
Upper Bound			
KZK-1			
KZK-1			
Target Range - Lower Bound			
Upper Bound			
MA-2c			
Target Range - Lower Bound			
Upper Bound			
MA-3a			
Target Range - Lower Bound			
Upper Bound			
OGGeo08	16.50	6990	22.0
Target Range - Lower Bound	15.35	6500	19.5
Upper Bound	18.85	7950	27.5
OREAS-45d	4.82	28	20.0
Target Range - Lower Bound	4.52	25	16.2
Upper Bound	5.64	36	23.2
SY-4			
Target Range - Lower Bound			
Upper Bound			
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-2			
Target Range - Lower Bound			
Upper Bound			
UTS-4			

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
Method / Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
STANDARDS															
Target Range - Lower Bound								1.64							
Upper Bound								1.84							
UTS-4									1.76						
Target Range - Lower Bound									1.61						
Upper Bound									1.87						
BLANKS															
BLANK											<0.05	<0.2			
BLANK											<0.05	<0.2			
Target Range - Lower Bound											<0.05	<0.2			
Upper Bound											0.10	0.4			
BLANK													<0.01	<0.01	<0.1
Target Range - Lower Bound													<0.01	<0.01	<0.1
Upper Bound													0.02	0.02	0.2
BLANK					6.1										
Target Range - Lower Bound					5.5										
Upper Bound					6.9										
BLANK								<0.01							
Target Range - Lower Bound								<0.01							
Upper Bound								0.02							
BLANK									<0.01						
Target Range - Lower Bound									<0.01						
Upper Bound									0.02						
BLANK							0.01								
Target Range - Lower Bound							<0.01								
Upper Bound							0.02								

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QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05
STANDARDS																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.2	<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	0.07
Target Range - Lower Bound		<0.2	<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05
Upper Bound		0.4	20	20	0.10	0.02	0.02	0.02	0.04	0.2	2	0.10	0.4	0.02	0.10	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																

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Project: L1772159

QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1
		STANDARDS														
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
		BLANKS														
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.02	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
Target Range - Lower Bound		<0.02	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
Upper Bound		0.04	0.02	0.010	0.02	0.4	0.2	0.02	10	0.10	0.02	0.10	0.4	20	0.4	0.2
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 9-JUN-2016
Account: APN

Project: L1772159

QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05
STANDARDS																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
Target Range - Lower Bound		<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
Upper Bound		0.002	0.02	0.10	0.2	0.4	0.4	0.4	0.02	0.02	0.4	0.010	0.04	0.10	2	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
STANDARDS				
Target Range - Lower Bound				
Upper Bound				
UTS-4				
Target Range - Lower Bound				
Upper Bound				
BLANKS				
BLANK				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK		<0.05	<2	<0.5
Target Range - Lower Bound		<0.05	<2	<0.5
Upper Bound		0.10	4	1.0
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
Target Range - Lower Bound				
Upper Bound				

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QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
DUPLICATES																
ORIGINAL										0.01						
DUP										<0.01						
Target Range - Lower Bound										<0.01						
Upper Bound										0.02						
L1772159-4 117453								0.02	0.01		0.01					
DUP								0.02	0.01		0.01					
Target Range - Lower Bound								<0.01	<0.01		<0.01					
Upper Bound								0.03	0.02		0.02					
L1772159-6 117454														0.08	1.30	1.9
DUP														0.09	1.37	6.0
Target Range - Lower Bound														0.07	1.26	3.7
Upper Bound														0.10	1.41	4.2
L1772159-10 117458		0.3	2	27	27	8.7	86.40					0.23	0.8			
DUP		0.3	2	28	28	8.7	89.60					0.23	0.9			
Target Range - Lower Bound		<0.3	<1	25	25	8.2	83.59					0.17	0.6			
Upper Bound		0.6	3	30	30	9.2	92.41					0.29	1.1			
L1772159-12 117456												0.23	0.8			
DUP												0.22	0.8			
Target Range - Lower Bound												0.16	0.6			
Upper Bound												0.29	1.0			

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QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge
	Units	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
	LOR	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05	0.05
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1772159-4 117453																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1772159-6 117454		<0.2	<10	250	0.28	0.02	0.79	0.02	18.95	7.2	4	0.33	229	2.32	5.72	0.15
DUP		<0.2	<10	260	0.27	0.01	0.82	0.03	20.3	7.6	4	0.39	232	2.43	6.35	0.15
Target Range - Lower Bound		<0.2	<10	230	0.21	<0.01	0.75	<0.01	18.60	6.9	3	0.29	222	2.25	5.68	0.09
Upper Bound		0.4	20	280	0.34	0.02	0.86	0.04	20.6	7.9	5	0.43	239	2.50	6.39	0.21
L1772159-10 117458																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1772159-12 117456																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1772159-4 117453																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1772159-6 117454		0.07	0.01	0.018	0.60	10.4	6.2	0.71	454	1.58	0.08	0.32	2.4	790	2.4	29.3
DUP		0.07	0.02	0.021	0.63	11.0	6.4	0.74	470	1.72	0.09	0.33	2.5	810	2.6	30.2
Target Range - Lower Bound		0.05	<0.01	0.014	0.57	10.0	5.9	0.68	434	1.52	0.07	0.26	2.1	750	2.2	28.2
Upper Bound		0.09	0.02	0.025	0.66	11.4	6.7	0.77	490	1.78	0.10	0.39	2.8	850	2.8	31.3
L1772159-10 117458																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1772159-12 117456																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1772159-4 117453																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1772159-6 117454		<0.001	0.03	<0.05	3.7	0.5	0.6	46.3	<0.01	<0.01	2.7	0.151	0.13	0.55	60	0.42
DUP		<0.001	0.03	0.08	3.9	0.3	0.6	48.5	<0.01	0.01	2.9	0.157	0.15	0.62	63	0.40
Target Range - Lower Bound		<0.001	0.02	<0.05	3.5	<0.2	0.4	44.8	<0.01	<0.01	2.5	0.141	0.11	0.51	57	0.33
Upper Bound		0.002	0.04	0.10	4.1	0.6	0.8	50.0	0.02	0.02	3.1	0.167	0.17	0.66	66	0.49
L1772159-10 117458																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1772159-12 117456																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16082648

Sample Description	Method Analyte Units LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
DUPLICATES				
ORIGINAL				
DUP				
Target Range - Lower Bound				
Upper Bound				
L1772159-4 117453				
DUP				
Target Range - Lower Bound				
Upper Bound				
L1772159-6 117454		6.07	59	1.1
DUP		6.40	62	1.2
Target Range - Lower Bound		5.87	55	0.6
Upper Bound		6.60	66	1.7
L1772159-10 117458				
DUP				
Target Range - Lower Bound				
Upper Bound				
L1772159-12 117456				
DUP				
Target Range - Lower Bound				
Upper Bound				

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QC CERTIFICATE OF ANALYSIS VA16082648

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	PUL-QC	S-CAL06
S-GRA06	S-GRA06a	S-IR08	SPL-21
WEI-21			

ALS Environmental
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Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1772159-COFC

COC Number: 16 - 003

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Service Level Request

…if E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals- Aqua regia disgestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	117274	13-04-16		Composite	R	R	R	R	R	R	
	117275	17-04-16		Composite							
	117451	18-04-16		Composite							
	117453	23-04-16		waste							
	117452	19-04-16		waste							
	117454	26-04-16		waste							
	123697	APR 26/16		waste							
	117455	APR 29/16		waste							
	117460	May 7/16		waste							
	117458	May 7/16		waste							
	117457	May 7/16		waste							
	117456	May 7/16		waste							

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C	FINAL COOLER TEMPERATURES °C
19.1	19.4

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Phyllistine Harper	Date: May 19/16	Time:	Received by: [signature]	Date: 20-May-16	Time: 3:50	Received by: Shayan	Date: May. 21	Time: 1400

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form

OCTOBER 2015 FRONT

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 27-MAY-16
Report Date: 29-JUN-16 17:12 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1775359
Project P.O. #: TBD
Job Reference:
C of C Numbers: 15-004
Legal Site Desc:

Comments: Please note, the ALS Minerals version of the finalized report and QC can be found at the end of the attachment.

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1775359-1	L1775359-2	L1775359-3	L1775359-4	L1775359-5
	Description	Composite	Waste	Waste	Waste	Waste
	Sampled Date	07-MAY-16	10-MAY-16	10-MAY-16	12-MAY-16	15-MAY-16
	Sampled Time					
	Client ID	117459	117462	117461	117463	123698
SOIL						
Physical Tests	pH (Unity)	8.8	8.9	8.6	8.9	8.3
Organic / Inorganic Carbon	Carbon (C) (%)	0.20	0.15	0.33	0.17	0.11
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	<0.3	0.3	2.8	0.6	10.9
	Neutralization Potential (NP) (tCaCO3/1Kt)	24	23	29	23	16
	NNP (tCaCO3/1Kt)	24	23	26	22	5
	Ratio (NP/MPA) (Unity)	153.60	73.60	10.31	36.80	1.46
	Sulfate Sulfur (carbonate leach) (%)	0.01	0.01	0.02	0.02	0.20
	Sulfate Sulfur (HCl leach) (%)	<0.01	0.03	0.01	0.01	0.27
	Sulfide Sulfur (T minus carbonate leach) (%)	<0.01	<0.01	0.07	<0.01	0.15
	Total Sulfur (combustion) (%)	<0.01	0.01	0.09	0.02	0.35
Total Metals	Aluminum (Al) (%)	1.24	1.33	1.08	1.26	1.20
	Antimony (Sb) (ppm)	<0.05	0.05	0.12	<0.05	<0.05
	Arsenic (As) (ppm)	0.5	1.4	4.5	1.5	0.7
	Barium (Ba) (ppm)	200	140	120	110	170
	Beryllium (Be) (ppm)	0.34	0.35	0.30	0.38	0.33
	Bismuth (Bi) (ppm)	0.02	0.01	0.20	0.02	0.10
	Boron (B) (ppm)	<10	<10	<10	<10	10
	Cadmium (Cd) (ppm)	0.02	0.02	0.14	0.03	0.06
	Calcium (Ca) (%)	1.07	1.21	1.30	1.33	1.26
	Cerium (Ce) (ppm)	19.05	16.30	19.95	17.35	21.6
	Cesium (Cs) (ppm)	0.25	0.18	0.22	0.15	0.36
	Chromium (Cr) (ppm)	6	5	5	6	9
	Cobalt (Co) (ppm)	6.0	6.2	4.9	5.8	5.7
	Copper (Cu) (%)					
	Copper (Cu) (ppm)	68.7	26.1	1390	55.3	761
	Gallium (Ga) (ppm)	6.06	6.44	5.45	6.22	6.27
	Germanium (Ge) (ppm)	0.13	0.13	0.11	0.14	0.13
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.06	0.08	0.05	0.08	0.05
	Indium (In) (ppm)	0.015	0.016	0.057	0.016	0.024
	Iron (Fe) (%)	2.20	2.28	2.10	2.14	2.34
	Lanthanum (La) (ppm)	10.4	8.7	10.7	9.3	12.4
	Lead (Pb) (ppm)	2.1	4.7	3.2	2.7	2.7
	Lithium (Li) (ppm)	6.8	7.2	5.1	6.4	5.5
	Magnesium (Mg) (%)	0.66	0.74	0.54	0.71	0.70

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1775359-6	L1775359-7	L1775359-8	L1775359-9	L1775359-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	21-MAY-16	21-MAY-16	22-MAY-16	22-MAY-16	22-MAY-16
	Sampled Time					
	Client ID	117465	117464	117469	117468	117467
SOIL						
Physical Tests	pH (Unity)	8.8	9.0	8.9	9.3	8.9
Organic / Inorganic Carbon	Carbon (C) (%)	0.16	0.15	0.25	0.08	0.22
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	1.6	<0.3	<0.3	<0.3	0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	21	21	25	17	28
	NNP (tCaCO3/1Kt)	19	21	25	17	28
	Ratio (NP/MPA) (Unity)	13.44	134.40	160.00	108.80	89.60
	Sulfate Sulfur (carbonate leach) (%)	0.01	<0.01	0.02	0.01	0.02
	Sulfate Sulfur (HCl leach) (%)	0.01	<0.01	0.02	0.01	0.02
	Sulfide Sulfur (T minus carbonate leach) (%)	0.04	<0.01	<0.01	<0.01	<0.01
	Total Sulfur (combustion) (%)	0.05	<0.01	<0.01	<0.01	0.01
Total Metals	Aluminum (Al) (%)	1.24	1.08	1.11	1.16	1.52
	Antimony (Sb) (ppm)	<0.05	<0.05	0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.9	0.5	0.6	0.5	1.0
	Barium (Ba) (ppm)	320	210	170	180	150
	Beryllium (Be) (ppm)	0.29	0.28	0.35	0.29	0.42
	Bismuth (Bi) (ppm)	0.09	0.02	0.01	0.01	0.02
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.04	0.02	0.02	0.02	0.04
	Calcium (Ca) (%)	0.95	1.04	1.19	0.93	1.45
	Cerium (Ce) (ppm)	25.4	18.70	18.05	16.70	22.3
	Cesium (Cs) (ppm)	0.37	0.31	0.23	0.22	0.40
	Chromium (Cr) (ppm)	4	5	5	5	5
	Cobalt (Co) (ppm)	7.0	5.8	5.7	6.0	6.1
	Copper (Cu) (%)					
	Copper (Cu) (ppm)	534	29.5	7.3	17.2	59.1
	Gallium (Ga) (ppm)	5.80	5.36	5.37	5.72	6.72
	Germanium (Ge) (ppm)	0.14	0.14	0.12	0.13	0.14
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.07	0.09	0.10	0.11	0.09
	Indium (In) (ppm)	0.020	0.018	0.020	0.014	0.016
	Iron (Fe) (%)	2.36	2.11	2.22	2.31	2.42
	Lanthanum (La) (ppm)	15.4	10.0	9.6	9.5	12.4
	Lead (Pb) (ppm)	1.3	1.1	3.2	1.5	3.5
	Lithium (Li) (ppm)	5.6	5.1	5.4	6.1	7.0
	Magnesium (Mg) (%)	0.61	0.55	0.56	0.70	0.77

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1775359-11				
	Description	Waste				
	Sampled Date	21-MAY-16				
	Sampled Time					
	Client ID	117466				
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.3				
Organic / Inorganic Carbon	Carbon (C) (%)	0.55				
Acid Base Accounting	FIZZ RATING (Unity)	2				
	MPA (tCaCO3/1Kt)	23.8				
	Neutralization Potential (NP) (tCaCO3/1Kt)	50				
	NNP (tCaCO3/1Kt)	26				
	Ratio (NP/MPA) (Unity)	2.11				
	Sulfate Sulfur (carbonate leach) (%)	0.01				
	Sulfate Sulfur (HCl leach) (%)	0.01				
	Sulfide Sulfur (T minus carbonate leach) (%)	0.75				
	Total Sulfur (combustion) (%)	0.76				
Total Metals	Aluminum (Al) (%)	1.63				
	Antimony (Sb) (ppm)	0.07				
	Arsenic (As) (ppm)	430				
	Barium (Ba) (ppm)	250				
	Beryllium (Be) (ppm)	0.26				
	Bismuth (Bi) (ppm)	2.81				
	Boron (B) (ppm)	<10				
	Cadmium (Cd) (ppm)	0.72				
	Calcium (Ca) (%)	2.08				
	Cerium (Ce) (ppm)	20.1				
	Cesium (Cs) (ppm)	0.43				
	Chromium (Cr) (ppm)	4				
	Cobalt (Co) (ppm)	9.9				
	Copper (Cu) (%)	1.565				
	Copper (Cu) (ppm)	>10000				
	Gallium (Ga) (ppm)	9.46				
	Germanium (Ge) (ppm)	0.17				
	Gold (Au) (ppm)	0.4				
	Hafnium (Hf) (ppm)	0.04				
	Indium (In) (ppm)	0.120				
	Iron (Fe) (%)	4.45				
	Lanthanum (La) (ppm)	11.2				
	Lead (Pb) (ppm)	5.2				
	Lithium (Li) (ppm)	7.0				
	Magnesium (Mg) (%)	0.66				

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1775359-1	L1775359-2	L1775359-3	L1775359-4	L1775359-5
	Description	Composite	Waste	Waste	Waste	Waste
	Sampled Date	07-MAY-16	10-MAY-16	10-MAY-16	12-MAY-16	15-MAY-16
	Sampled Time					
	Client ID	117459	117462	117461	117463	123698
Grouping	**Analyte**					
SOIL						
Total Metals	Manganese (Mn) (ppm)	491	523	514	480	530
	Mercury (Hg) (ppm)	<0.01	0.01	0.03	0.01	<0.01
	Molybdenum (Mo) (ppm)	0.89	0.26	0.34	0.78	5.00
	Nickel (Ni) (ppm)	2.5	2.2	1.7	2.2	2.1
	Niobium (Nb) (ppm)	0.20	0.24	0.17	0.29	0.24
	Phosphorus (P) (ppm)	650	720	650	720	750
	Potassium (K) (%)	0.43	0.32	0.28	0.24	0.50
	Rhenium (Re) (ppm)	<0.001	<0.001	<0.001	<0.001	0.006
	Rubidium (Rb) (ppm)	20.5	13.0	14.2	9.9	24.8
	Scandium (Sc) (ppm)	3.5	4.3	3.6	3.9	4.0
	Selenium (Se) (ppm)	0.2	<0.2	0.9	<0.2	0.4
	Silver (Ag) (ppm)	0.03	0.02	0.47	0.04	0.21
	Sodium (Na) (%)	0.08	0.09	0.07	0.10	0.11
	Strontium (Sr) (ppm)	128.0	82.5	132.0	85.6	80.1
	Sulfur (S) (%)	0.01	0.01	0.10	0.03	0.36
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.01	<0.01	0.12	0.03	0.03
	Thallium (Tl) (ppm)	0.10	0.06	0.08	0.05	0.17
	Thorium (Th) (ppm)	2.1	1.4	2.6	1.5	3.1
	Tin (Sn) (ppm)	0.5	0.5	0.5	0.5	0.6
	Titanium (Ti) (%)	0.092	0.112	0.051	0.118	0.132
	Tungsten (W) (ppm)	0.15	0.25	0.17	0.40	0.07
	Uranium (U) (ppm)	0.22	0.21	0.29	0.26	0.46
	Vanadium (V) (ppm)	48	52	38	49	54
	Yttrium (Y) (ppm)	6.11	6.69	6.10	7.11	6.28
	Zinc (Zn) (ppm)	58	60	72	54	68
	Zirconium (Zr) (ppm)	1.2	1.4	0.9	1.4	1.1
Permanent Gases	Carbon Dioxide (CO2) (%)	0.7	0.6	1.2	0.6	0.4

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1775359-6	L1775359-7	L1775359-8	L1775359-9	L1775359-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	21-MAY-16	21-MAY-16	22-MAY-16	22-MAY-16	22-MAY-16
	Sampled Time					
	Client ID	117465	117464	117469	117468	117467
Grouping	**Analyte**					
SOIL						
Total Metals	Manganese (Mn) (ppm)	465	470	473	497	530
	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	2.52	0.69	0.46	1.23	0.75
	Nickel (Ni) (ppm)	2.1	2.3	2.2	2.2	2.0
	Niobium (Nb) (ppm)	0.20	0.31	0.23	0.27	0.20
	Phosphorus (P) (ppm)	740	740	720	750	800
	Potassium (K) (%)	0.68	0.51	0.39	0.43	0.46
	Rhenium (Re) (ppm)	0.004	<0.001	<0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	34.7	24.1	17.1	18.6	26.0
	Scandium (Sc) (ppm)	3.8	4.6	4.4	3.9	4.2
	Selenium (Se) (ppm)	0.6	0.4	0.2	0.4	0.5
	Silver (Ag) (ppm)	0.27	0.03	0.02	0.02	0.05
	Sodium (Na) (%)	0.08	0.12	0.10	0.12	0.10
	Strontium (Sr) (ppm)	53.4	49.1	88.7	60.8	96.2
	Sulfur (S) (%)	0.06	<0.01	0.01	<0.01	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.05	0.01	0.01	0.01	0.02
	Thallium (Tl) (ppm)	0.17	0.12	0.09	0.09	0.13
	Thorium (Th) (ppm)	3.1	1.7	2.0	1.8	3.2
	Tin (Sn) (ppm)	0.5	0.6	0.6	0.5	0.5
	Titanium (Ti) (%)	0.129	0.120	0.094	0.131	0.114
	Tungsten (W) (ppm)	0.44	0.52	0.33	0.69	0.34
	Uranium (U) (ppm)	0.27	0.29	0.40	0.33	0.81
	Vanadium (V) (ppm)	57	50	50	56	57
	Yttrium (Y) (ppm)	5.12	7.63	7.50	6.24	7.45
	Zinc (Zn) (ppm)	62	53	51	54	67
	Zirconium (Zr) (ppm)	1.1	1.6	1.6	1.8	1.7
Permanent Gases	Carbon Dioxide (CO2) (%)	0.6	0.6	0.9	0.3	0.8

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1775359-11				
	Description	Waste				
	Sampled Date	21-MAY-16				
	Sampled Time					
	Client ID	117466				
Grouping	**Analyte**					
SOIL						
Total Metals	Manganese (Mn) (ppm)	711				
	Mercury (Hg) (ppm)	0.06				
	Molybdenum (Mo) (ppm)	0.68				
	Nickel (Ni) (ppm)	2.8				
	Niobium (Nb) (ppm)	0.28				
	Phosphorus (P) (ppm)	860				
	Potassium (K) (%)	0.85				
	Rhenium (Re) (ppm)	0.002				
	Rubidium (Rb) (ppm)	41.9				
	Scandium (Sc) (ppm)	5.2				
	Selenium (Se) (ppm)	7.7				
	Silver (Ag) (ppm)	6.23				
	Sodium (Na) (%)	0.06				
	Strontium (Sr) (ppm)	57.9				
	Sulfur (S) (%)	0.78				
	Tantalum (Ta) (ppm)	<0.01				
	Tellurium (Te) (ppm)	0.57				
	Thallium (Tl) (ppm)	0.36				
	Thorium (Th) (ppm)	3.9				
	Tin (Sn) (ppm)	1.2				
	Titanium (Ti) (%)	0.149				
	Tungsten (W) (ppm)	0.53				
	Uranium (U) (ppm)	0.58				
	Vanadium (V) (ppm)	73				
	Yttrium (Y) (ppm)	5.20				
	Zinc (Zn) (ppm)	172				
	Zirconium (Zr) (ppm)	1.2				
Permanent Gases	Carbon Dioxide (CO2) (%)	2.0				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ABA-OA-VOL08-AX	Soil	Acid Base Accounting	OA-VOL08
CARBON-C-GAS05-AX	Soil	Carbon, TOC and CO2	C-GAS05
CU-OG46-AX	Soil	Ore Grade Cu - AquaRegia	Aqua Regia ICPMS

A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.

ME-MS41-AX	Soil	Aqua Regia ICPMS	Aqua Regia ICPMS

A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.

PH-OA-ELE07-AX	Soil	pH	OA-ELE07
SULPHUR-S-CAL06-AX	Soil	Sulfide Sulfur Calc from Carbonate Leach	ALS Minerals S-CAL06

Sulfide Sulfur (as S) is calculated by subtracting the Carbonate Leachable Sulfate Sulfur (as S) from the Total Sulfur (as S) obtained from combustion.

SULPHUR-S-GRA06-AX	Soil	Sulfate Sulfur in Soil (Carbonate Leach)	ALS Minerals S-GRA06

A prepared sample is boiled with a sodium carbonate solution for 30 minutes. Any insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

SULPHUR-S-GRA06A-AX	Soil	Sulfate Sulfur in Soil (HCl Leach)	ALS Minerals S-GRA06A

A prepared sample is heated with dilute hydrochloric acid for 30 minutes. Silica and any acid-insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

SULPHUR-S-IR08-AX	Soil	Total Sulfur in Soil by Combustion	ALS Minerals S-IR08

The sample is heated to approximately 1350 °C in an induction furnace while passing a stream of oxygen through the sample. Sulfur dioxide released from the sample is measured by an IR detection system and the Total Sulfur result is provided.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
AX	ALS MINERALS - VANCOUVER, B.C., CANADA

Chain of Custody Numbers:

15-004

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

CERTIFICATE VA16087264

Project: L1775359

P.O. No.: ALSM-CW16-102-APN

This report is for 11 Crushed Rock samples submitted to our lab in Vancouver, BC, Canada on 1-JUN-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
ME-OG46	Ore Grade Elements - AquaRegia	ICP-AES
Cu-OG46	Ore Grade Cu - Aqua Regia	VARIABLE
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Minerals

ALS Canada Ltd.

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www.alsglobal.com

To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	OA-VOL08m MPA tCaCO3/1Kt 0.3	OA-VOL08m FIZZ RAT Unity 1	OA-VOL08m NNP tCaCO3/1Kt 1	OA-VOL08m NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08m Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	S-CAL06 S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2	ME-MS41 Ag ppm 0.01	ME-MS41 Al % 0.01
L1775359-1 117459		0.98	<0.3	2	24	24	8.8	153.60	<0.01	0.01	<0.01	<0.01	0.20	0.7	0.03	1.24
L1775359-2 117462		0.88	0.3	2	23	23	8.9	73.60	0.01	0.01	0.03	<0.01	0.15	0.6	0.02	1.33
L1775359-3 117461		0.86	2.8	2	26	29	8.6	10.31	0.09	0.02	0.01	0.07	0.33	1.2	0.47	1.08
L1775359-4 117463		0.94	0.6	2	22	23	8.9	36.80	0.02	0.02	0.01	<0.01	0.17	0.6	0.04	1.26
L1775359-5 123698		0.94	10.9	2	5	16	8.3	1.46	0.35	0.20	0.27	0.15	0.11	0.4	0.21	1.20
L1775359-6 117465		1.72	1.6	2	19	21	8.8	13.44	0.05	0.01	0.01	0.04	0.16	0.6	0.27	1.24
L1775359-7 117464		1.66	<0.3	2	21	21	9.0	134.40	<0.01	<0.01	<0.01	<0.01	0.15	0.6	0.03	1.08
L1775359-8 117469		1.08	<0.3	2	25	25	8.9	160.00	<0.01	0.02	0.02	<0.01	0.25	0.9	0.02	1.11
L1775359-9 117468		1.08	<0.3	2	17	17	9.3	108.80	<0.01	0.01	0.01	<0.01	0.08	0.3	0.02	1.16
L1775359-10 117467		1.08	0.3	2	28	28	8.9	89.60	0.01	0.02	0.02	<0.01	0.22	0.8	0.05	1.52
L1775359-11 117466		0.88	23.8	2	26	50	8.3	2.11	0.76	0.01	0.01	0.75	0.55	2.0	6.23	1.63

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	As	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga
	Units	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm
	LOR	0.1	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05
L1775359-1 117459		0.5	<0.2	<10	200	0.34	0.02	1.07	0.02	19.05	6.0	6	0.25	68.7	2.20	6.06
L1775359-2 117462		1.4	<0.2	<10	140	0.35	0.01	1.21	0.02	16.30	6.2	5	0.18	26.1	2.28	6.44
L1775359-3 117461		4.5	<0.2	<10	120	0.30	0.20	1.30	0.14	19.95	4.9	5	0.22	1390	2.10	5.45
L1775359-4 117463		1.5	<0.2	<10	110	0.38	0.02	1.33	0.03	17.35	5.8	6	0.15	55.3	2.14	6.22
L1775359-5 123698		0.7	<0.2	10	170	0.33	0.10	1.26	0.06	21.6	5.7	9	0.36	761	2.34	6.27
L1775359-6 117465		0.9	<0.2	<10	320	0.29	0.09	0.95	0.04	25.4	7.0	4	0.37	534	2.36	5.80
L1775359-7 117464		0.5	<0.2	<10	210	0.28	0.02	1.04	0.02	18.70	5.8	5	0.31	29.5	2.11	5.36
L1775359-8 117469		0.6	<0.2	<10	170	0.35	0.01	1.19	0.02	18.05	5.7	5	0.23	7.3	2.22	5.37
L1775359-9 117468		0.5	<0.2	<10	180	0.29	0.01	0.93	0.02	16.70	6.0	5	0.22	17.2	2.31	5.72
L1775359-10 117467		1.0	<0.2	<10	150	0.42	0.02	1.45	0.04	22.3	6.1	5	0.40	59.1	2.42	6.72
L1775359-11 117466		430	0.4	<10	250	0.26	2.81	2.08	0.72	20.1	9.9	4	0.43	>10000	4.45	9.46

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method Analyte Units LOR	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2
L1775359-1 117459		0.13	0.06	<0.01	0.015	0.43	10.4	6.8	0.66	491	0.89	0.08	0.20	2.5	650	2.1
L1775359-2 117462		0.13	0.08	0.01	0.016	0.32	8.7	7.2	0.74	523	0.26	0.09	0.24	2.2	720	4.7
L1775359-3 117461		0.11	0.05	0.03	0.057	0.28	10.7	5.1	0.54	514	0.34	0.07	0.17	1.7	650	3.2
L1775359-4 117463		0.14	0.08	0.01	0.016	0.24	9.3	6.4	0.71	480	0.78	0.10	0.29	2.2	720	2.7
L1775359-5 123698		0.13	0.05	<0.01	0.024	0.50	12.4	5.5	0.70	530	5.00	0.11	0.24	2.1	750	2.7
L1775359-6 117465		0.14	0.07	<0.01	0.020	0.68	15.4	5.6	0.61	465	2.52	0.08	0.20	2.1	740	1.3
L1775359-7 117464		0.14	0.09	<0.01	0.018	0.51	10.0	5.1	0.55	470	0.69	0.12	0.31	2.3	740	1.1
L1775359-8 117469		0.12	0.10	<0.01	0.020	0.39	9.6	5.4	0.56	473	0.46	0.10	0.23	2.2	720	3.2
L1775359-9 117468		0.13	0.11	<0.01	0.014	0.43	9.5	6.1	0.70	497	1.23	0.12	0.27	2.2	750	1.5
L1775359-10 117467		0.14	0.09	<0.01	0.016	0.46	12.4	7.0	0.77	530	0.75	0.10	0.20	2.0	800	3.5
L1775359-11 117466		0.17	0.04	0.06	0.120	0.85	11.2	7.0	0.66	711	0.68	0.06	0.28	2.8	860	5.2

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1
L1775359-1 117459		20.5	<0.001	0.01	<0.05	3.5	0.2	0.5	128.0	<0.01	0.01	2.1	0.092	0.10	0.22	48
L1775359-2 117462		13.0	<0.001	0.01	0.05	4.3	<0.2	0.5	82.5	<0.01	<0.01	1.4	0.112	0.06	0.21	52
L1775359-3 117461		14.2	<0.001	0.10	0.12	3.6	0.9	0.5	132.0	<0.01	0.12	2.6	0.051	0.08	0.29	38
L1775359-4 117463		9.9	<0.001	0.03	<0.05	3.9	<0.2	0.5	85.6	<0.01	0.03	1.5	0.118	0.05	0.26	49
L1775359-5 123698		24.8	0.006	0.36	<0.05	4.0	0.4	0.6	80.1	<0.01	0.03	3.1	0.132	0.17	0.46	54
L1775359-6 117465		34.7	0.004	0.06	<0.05	3.8	0.6	0.5	53.4	<0.01	0.05	3.1	0.129	0.17	0.27	57
L1775359-7 117464		24.1	<0.001	<0.01	<0.05	4.6	0.4	0.6	49.1	<0.01	0.01	1.7	0.120	0.12	0.29	50
L1775359-8 117469		17.1	<0.001	0.01	0.05	4.4	0.2	0.6	88.7	<0.01	0.01	2.0	0.094	0.09	0.40	50
L1775359-9 117468		18.6	<0.001	<0.01	<0.05	3.9	0.4	0.5	60.8	<0.01	0.01	1.8	0.131	0.09	0.33	56
L1775359-10 117467		26.0	<0.001	0.01	<0.05	4.2	0.5	0.5	96.2	<0.01	0.02	3.2	0.114	0.13	0.81	57
L1775359-11 117466		41.9	0.002	0.78	0.07	5.2	7.7	1.2	57.9	<0.01	0.57	3.9	0.149	0.36	0.58	73

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5	Cu-OG46 Cu % 0.001
L1775359-1 117459		0.15	6.11	58	1.2	
L1775359-2 117462		0.25	6.69	60	1.4	
L1775359-3 117461		0.17	6.10	72	0.9	
L1775359-4 117463		0.40	7.11	54	1.4	
L1775359-5 123698		0.07	6.28	68	1.1	
L1775359-6 117465		0.44	5.12	62	1.1	
L1775359-7 117464		0.52	7.63	53	1.6	
L1775359-8 117469		0.33	7.50	51	1.6	
L1775359-9 117468		0.69	6.24	54	1.8	
L1775359-10 117467		0.34	7.45	67	1.7	
L1775359-11 117466		0.53	5.20	172	1.2	1.565

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BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

CERTIFICATE OF ANALYSIS VA16087264

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	Cu-OG46	LOG-22	ME-MS41
ME-OG46	OA-ELE07	OA-VOL08m	PUL-31
S-CAL06	S-GRA06	S-GRA06a	S-IR08
SPL-21	WEI-21		

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BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

QC CERTIFICATE VA16087264

Project: L1775359

P.O. No.: ALSM-CW16-102-APN

This report is for 11 Crushed Rock samples submitted to our lab in Vancouver, BC, Canada on 1-JUN-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
ME-OG46	Ore Grade Elements - AquaRegia	ICP-AES
Cu-OG46	Ore Grade Cu - Aqua Regia	VARIABLE
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
STANDARDS																
Buffer pH6						6.0										
Buffer pH6						6.0										
Target Range - Lower Bound						5.3										
Upper Bound						6.7										
CCU-1d																
Target Range - Lower Bound																
Upper Bound																
DS-1								2.67								
Target Range - Lower Bound								2.51								
Upper Bound								2.71								
GS310-10								0.28								
Target Range - Lower Bound								0.25								
Upper Bound								0.29								
GS313-8								1.27								
Target Range - Lower Bound								1.19								
Upper Bound								1.29								
KZK-1		25.0	2	31	56		2.24									
KZK-1		25.0	2	31	56		2.24									
Target Range - Lower Bound		22.9	<1	30	54		2.18									
Upper Bound		27.1	>4	38	64		2.53									
MA-3a											2.39	8.8				
Target Range - Lower Bound											2.31	8.4				
Upper Bound											2.77	10.2				
MP-1b																
Target Range - Lower Bound																
Upper Bound																
OGGeo08																
Target Range - Lower Bound																
Upper Bound																
OGGeo08													19.40	2.24	121.0	<0.2
Target Range - Lower Bound													18.15	2.05	107.0	<0.2
Upper Bound													22.2	2.53	131.0	0.4

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Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CCU-1d																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
MP-1b																
Target Range - Lower Bound																
Upper Bound																
OGGeo08																
Target Range - Lower Bound																
Upper Bound																
OGGeo08		10	80	0.71	10.05	0.92	19.05	59.7	93.6	80	9.19	8470	5.05	8.74	0.22	0.79
Target Range - Lower Bound		<10	60	0.61	9.44	0.82	16.75	56.7	87.2	75	8.68	7800	4.51	8.05	0.21	0.72
Upper Bound		30	110	0.89	11.55	1.02	20.5	69.3	107.0	93	10.70	8980	5.53	9.95	0.45	0.92

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Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method Analyte Units LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CCU-1d																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
MP-1b																
Target Range - Lower Bound																
Upper Bound																
OGGeo08																
Target Range - Lower Bound																
Upper Bound																
OGGeo08		0.48	1.455	1.06	29.7	28.8	0.97	383	862	0.31	1.10	8710	780	7120	115.0	1.390
Target Range - Lower Bound		0.41	1.335	0.94	27.7	29.8	0.84	350	811	0.26	0.97	7760	700	6520	109.5	1.295
Upper Bound		0.57	1.645	1.18	34.3	36.6	1.05	438	991	0.34	1.29	9480	880	7970	134.5	1.585

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method Analyte Units LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CCU-1d																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
MP-1b																
Target Range - Lower Bound																
Upper Bound																
OGGeo08																
Target Range - Lower Bound																
Upper Bound																
OGGeo08		2.75	19.45	6.2	11.2	13.7	64.6	0.01	0.15	16.6	0.303	1.42	4.74	79	3.35	16.75
Target Range - Lower Bound		2.51	17.70	6.0	9.7	12.0	59.6	<0.01	0.14	15.6	0.279	1.14	4.45	70	2.58	15.35
Upper Bound		3.09	24.1	7.6	12.3	15.1	73.2	0.03	0.20	19.6	0.353	1.58	5.55	88	3.60	18.85

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Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5	Cu-OG46 Cu % 0.001
STANDARDS				
Buffer pH6				
Buffer pH6				
Target Range - Lower Bound				
Upper Bound				
CCU-1d				23.6
Target Range - Lower Bound				23.1
Upper Bound				24.8
DS-1				
Target Range - Lower Bound				
Upper Bound				
GS310-10				
Target Range - Lower Bound				
Upper Bound				
GS313-8				
Target Range - Lower Bound				
Upper Bound				
KZK-1				
KZK-1				
Target Range - Lower Bound				
Upper Bound				
MA-3a				
Target Range - Lower Bound				
Upper Bound				
MP-1b				3.01
Target Range - Lower Bound				2.96
Upper Bound				3.18
OGGeo08				0.840
Target Range - Lower Bound				0.809
Upper Bound				0.869
OGGeo08		7100	23.8	
Target Range - Lower Bound		6500	19.5	
Upper Bound		7950	27.5	

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QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
STANDARDS															
OREAS 932															
Target Range - Lower Bound															
Upper Bound															
OREAS-133b															
Target Range - Lower Bound															
Upper Bound															
OREAS-134b															
Target Range - Lower Bound															
Upper Bound															
OREAS-45d												0.11	4.84	7.2	<0.2
Target Range - Lower Bound												0.10	4.36	5.8	<0.2
Upper Bound												0.15	5.36	7.3	0.4
SY-4										0.89	3.3				
Target Range - Lower Bound										0.84	3.0				
Upper Bound										1.08	4.0				
UTS-1								0.88							
UTS-1								0.83							
Target Range - Lower Bound								0.83							
Upper Bound								0.93							
UTS-1									0.89						
Target Range - Lower Bound									0.81						
Upper Bound									0.95						
UTS-1							1.03								
Target Range - Lower Bound							0.95								
Upper Bound							1.05								
UTS-4								1.69							
UTS-4								1.74							
Target Range - Lower Bound								1.64							
Upper Bound								1.84							
UTS-4									1.74						
Target Range - Lower Bound									1.61						
Upper Bound									1.87						

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QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method Analyte Units LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
STANDARDS																
OREAS 932																
Target Range - Lower Bound																
Upper Bound																
OREAS-133b																
Target Range - Lower Bound																
Upper Bound																
OREAS-134b																
Target Range - Lower Bound																
Upper Bound																
OREAS-45d		10	80	0.51	0.26	0.10	0.02	25.0	26.7	467	2.45	341	13.45	17.20	0.14	0.47
Target Range - Lower Bound		<10	50	0.42	0.26	0.06	<0.01	22.3	23.5	419	2.09	321	12.30	16.05	<0.05	0.40
Upper Bound		30	110	0.68	0.34	0.11	0.05	27.3	28.9	515	2.67	369	15.05	19.75	0.23	0.54
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description / Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
STANDARDS															
OREAS 932															
Target Range - Lower Bound															
Upper Bound															
OREAS-133b															
Target Range - Lower Bound															
Upper Bound															
OREAS-134b															
Target Range - Lower Bound															
Upper Bound															
OREAS-45d	0.05	0.083	0.10	11.3	12.8	0.14	371	1.70	0.03	0.42	185.0	340	16.4	20.4	<0.001
Target Range - Lower Bound	0.02	0.071	0.07	8.8	10.6	0.12	328	1.45	<0.01	0.27	158.0		15.1	18.7	<0.001
Upper Bound	0.06	0.099	0.12	11.2	13.2	0.17	412	1.89	0.05	0.51	194.0		18.9	23.1	0.003
SY-4															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															

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QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
STANDARDS																
OREAS 932																
Target Range - Lower Bound																
Upper Bound																
OREAS-133b																
Target Range - Lower Bound																
Upper Bound																
OREAS-134b																
Target Range - Lower Bound																
Upper Bound																
OREAS-45d		0.05	0.40	44.9	1.9	1.9	10.9	<0.01	0.08	10.5	0.088	0.16	1.64	202	0.07	4.91
Target Range - Lower Bound		0.02	0.22	37.3	0.7	1.3	9.7	<0.01	0.02	10.0	0.068	0.07	1.43	180	<0.05	4.52
Upper Bound		0.07	0.49	45.8	1.7	2.3	12.3	0.03	0.06	12.6	0.096	0.17	1.85	222	0.16	5.64
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5	Cu-OG46 Cu % 0.001
STANDARDS				
OREAS 932				6.15
Target Range - Lower Bound				5.90
Upper Bound				6.32
OREAS-133b				0.032
Target Range - Lower Bound				0.031
Upper Bound				0.035
OREAS-134b				0.138
Target Range - Lower Bound				0.131
Upper Bound				0.142
OREAS-45d		30	21.9	
Target Range - Lower Bound		25	16.2	
Upper Bound		36	23.2	
SY-4				
Target Range - Lower Bound				
Upper Bound				
UTS-1				
UTS-1				
Target Range - Lower Bound				
Upper Bound				
UTS-1				
Target Range - Lower Bound				
Upper Bound				
UTS-1				
Target Range - Lower Bound				
Upper Bound				
UTS-4				
UTS-4				
Target Range - Lower Bound				
Upper Bound				
UTS-4				
Target Range - Lower Bound				
Upper Bound				

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QC CERTIFICATE OF ANALYSIS VA16087264

BLANKS

Sample Description	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
BLANK										<0.05	<0.2				
Target Range - Lower Bound										<0.05	<0.2				
Upper Bound										0.10	0.4				
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK												<0.01	<0.01	0.1	<0.2
Target Range - Lower Bound												<0.01	<0.01	<0.1	<0.2
Upper Bound												0.02	0.02	0.2	0.4
BLANK					6.0										
Target Range - Lower Bound					5.5										
Upper Bound					6.9										
BLANK								<0.01							
BLANK								<0.01							
Target Range - Lower Bound								<0.01							
Upper Bound								0.02							
BLANK									<0.01						
Target Range - Lower Bound									<0.01						
Upper Bound									0.02						
BLANK							<0.01								
BLANK							<0.01								
Target Range - Lower Bound							<0.01								
Upper Bound							0.02								

DUPLICATES

Sample Description	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
ORIGINAL								7.96							
DUP								7.77							
Target Range - Lower Bound								7.58							
Upper Bound								8.15							
ORIGINAL							1.55								
DUP							1.53								
Target Range - Lower Bound							1.49								
Upper Bound							1.59								

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QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	0.05	<0.02
Target Range - Lower Bound		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
Upper Bound		20	20	0.10	0.02	0.02	0.02	0.04	0.2	2	0.10	0.4	0.02	0.10	0.10	0.04
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method Analyte Units LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.01	<0.005	<0.01	<0.2	0.1	<0.01	<5	<0.05	0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Target Range - Lower Bound		<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Upper Bound		0.02	0.010	0.02	0.4	0.2	0.02	10	0.10	0.02	0.10	0.4	20	0.4	0.2	0.002
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y
	Units	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
	LOR	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1	0.05	0.05
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Target Range - Lower Bound		<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Upper Bound		0.02	0.10	0.2	0.4	0.4	0.4	0.02	0.02	0.4	0.010	0.04	0.10	2	0.10	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals
ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: +1 (604) 984 0221 Fax: +1 (604) 984 0218
www.alsglobal.com

To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method	ME-MS41	ME-MS41	Cu-OG46
	Analyte	Zn	Zr	Cu
	Units	ppm	ppm	%
	LOR	2	0.5	0.001
BLANKS				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				<0.001
Target Range - Lower Bound				<0.001
Upper Bound				0.002
BLANK		<2	<0.5	
Target Range - Lower Bound		<2	<0.5	
Upper Bound		4	1.0	
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
BLANK				
Target Range - Lower Bound				
Upper Bound				
DUPLICATES				
ORIGINAL				
DUP				
Target Range - Lower Bound				
Upper Bound				
ORIGINAL				
DUP				
Target Range - Lower Bound				
Upper Bound				

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
							DUPLICATES									
L1775359-2 117462								0.01								
DUP								0.01								
Target Range - Lower Bound								<0.01								
Upper Bound								0.02								
L1775359-5 123698						8.3				0.27						
DUP						8.3				0.27						
Target Range - Lower Bound						7.8				0.25						
Upper Bound						8.8				0.29						
L1775359-9 117468		<0.3	2	17	17		108.80				0.08	0.3				
DUP		<0.3	2	16	16		102.40				0.10	0.4				
Target Range - Lower Bound		<0.3	<1	15	15		100.31				<0.05	<0.2				
Upper Bound		0.6	3	18	18		110.89				0.10	0.4				
ORIGINAL									1.06							
DUP									1.01							
Target Range - Lower Bound									0.99							
Upper Bound									1.08							
ORIGINAL													0.24	1.70	1.3	<0.2
DUP													0.26	1.69	1.4	<0.2
Target Range - Lower Bound													0.23	1.60	1.2	<0.2
Upper Bound													0.27	1.79	1.5	0.4

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
DUPLICATES																
L1775359-2 117462																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1775359-5 123698																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1775359-9 117468																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL		<10	150	0.41	0.57	1.34	0.08	47.7	19.7	147	1.64	47.6	3.39	7.94	0.18	0.84
DUP		<10	150	0.40	0.57	1.36	0.08	48.6	19.8	149	1.67	48.2	3.38	8.21	0.18	0.75
Target Range - Lower Bound		<10	130	0.33	0.53	1.27	0.07	45.7	18.7	140	1.52	46.0	3.21	7.62	0.12	0.74
Upper Bound		20	170	0.48	0.61	1.43	0.09	50.6	20.8	156	1.79	49.8	3.56	8.53	0.24	0.85

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
DUPLICATES																
L1775359-2 117462																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1775359-5 123698																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1775359-9 117468																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL		0.01	0.021	1.07	24.1	18.7	1.55	436	6.20	0.03	0.14	72.3	630	8.1	46.7	0.002
DUP		<0.01	0.020	1.09	24.3	18.2	1.54	446	6.97	0.03	0.14	72.3	630	8.7	46.5	0.001
Target Range - Lower Bound		<0.01	0.014	1.02	22.8	17.4	1.46	414	6.21	0.02	0.08	68.5	590	7.8	44.2	<0.001
Upper Bound		0.02	0.027	1.14	25.6	19.5	1.63	468	6.96	0.04	0.20	76.1	670	9.0	49.0	0.002

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
DUPLICATES																
L1775359-2 117462																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1775359-5 123698																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1775359-9 117468																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL		1.05	0.10	6.9	1.0	0.4	70.2	<0.01	1.36	5.3	0.177	0.32	1.27	65	4.88	7.58
DUP		1.06	0.09	7.0	0.3	0.5	72.3	<0.01	1.48	5.5	0.182	0.33	1.31	66	5.06	7.92
Target Range - Lower Bound		0.99	<0.05	6.5	0.4	<0.2	67.5	<0.01	1.34	4.9	0.166	0.28	1.18	61	4.55	7.31
Upper Bound		1.12	0.10	7.4	0.9	0.7	75.0	0.02	1.50	5.9	0.193	0.37	1.40	70	5.39	8.19

***** See Appendix Page for comments regarding this certificate *****

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5	Cu-OG46 Cu % 0.001
		DUPLICATES		
L1775359-2 117462				
DUP				
Target Range - Lower Bound				
Upper Bound				
L1775359-5 123698				
DUP				
Target Range - Lower Bound				
Upper Bound				
L1775359-9 117468				
DUP				
Target Range - Lower Bound				
Upper Bound				
ORIGINAL				
DUP				
Target Range - Lower Bound				
Upper Bound				
ORIGINAL		77	27.8	
DUP		81	28.6	
Target Range - Lower Bound		73	25.6	
Upper Bound		85	30.8	

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 25-JUN-2016
Account: APN

Project: L1775359

QC CERTIFICATE OF ANALYSIS VA16087264

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	Cu-OG46	LOG-22	ME-MS41
ME-OG46	OA-ELE07	OA-VOL08m	PUL-31
S-CAL06	S-GRA06	S-GRA06a	S-IR08
SPL-21	WEI-21		

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1775359-COFC

COC Number: 15 - 004

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☑ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax minto_environment@mintomine.com
Email 2
Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax ap@mintomine.com
Email 2

... confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:
Job #:
PO / AFE: TBD
LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#
Major/Minor Code: | Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only)

ALS Contact:

Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals- Aqua regia disgestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	117459	07-05-16		Composite	R	R	R	R	R	R	
	117462	10-05/16		waste							
	117461	10-05/16		waste							
	117463	12-05-16		waste							
	123698	13-05-16		waste							
	117465	may 21/16		waste							
	117464	may 21/16		waste							
	117469	May 22/16		waste							
	117468	May 22 16		waste							
	117469	May 22/16		waste							
	117466	May 21/16		waste							

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ | SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ | Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C: 5.6

FINAL COOLER TEMPERATURES °C: 8/9/20°C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	~~Received by:~~	Date: 27 May 16	Time: 4:50	Received by: lady	Date: May 31	Time: 4 pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

OCTOBER 2015 FRONT

Minto Explorations Ltd.
ATTN: Minto Environment
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 22-JUN-16
Report Date: 19-JUL-16 15:04 (MT)
Version: FINAL

Client Phone: 604-759-0860

Certificate of Analysis

Lab Work Order #: L1787168
Project P.O. #: TBD
Job Reference:
C of C Numbers: 15-005
Legal Site Desc:

Comments: Please note, the ALS Minerals version of the finalized report and QC can be found at the end of the attachment.

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1787168-1 Waste 22-MAY-16 117470	L1787168-2 Waste 22-MAY-16 117471	L1787168-3 Waste 22-MAY-16 117472	L1787168-5 Waste 24-MAY-16 117473	L1787168-6 Waste 21-MAY-16 123699
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.7	8.7	8.5	9.3	8.7
Organic / Inorganic Carbon	Carbon (C) (%)	0.33	0.27	0.41	0.14	0.22
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	1	2
	MPA (tCaCO3/1Kt)	0.3	0.3	2.2	0.3	1.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	28	26	37	14	16
	NNP (tCaCO3/1Kt)	28	26	35	14	15
	Ratio (NP/MPA) (Unity)	89.60	83.20	16.91	44.80	12.80
	Sulfate Sulfur (carbonate leach) (%)	0.02	<0.01	0.01	0.01	0.01
	Sulfate Sulfur (HCl leach) (%)	0.03	0.01	0.02	0.01	<0.01
	Sulfide Sulfur (T minus carbonate leach) (%)	<0.01	0.01	0.06	<0.01	0.03
	Total Sulfur (combustion) (%)	0.01	0.01	0.07	0.01	0.04
Total Metals	Aluminum (Al) (%)	1.19	1.38	1.89	1.27	1.18
	Antimony (Sb) (ppm)	0.09	0.08	0.07	0.05	0.05
	Arsenic (As) (ppm)	1.6	1.8	2.3	1.2	0.8
	Barium (Ba) (ppm)	160	130	40	290	370
	Beryllium (Be) (ppm)	0.34	0.43	0.68	0.27	0.19
	Bismuth (Bi) (ppm)	0.02	0.01	0.16	0.03	0.16
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.03	0.02	0.03	0.03	0.07
	Calcium (Ca) (%)	1.36	1.41	2.11	0.84	0.69
	Cerium (Ce) (ppm)	18.60	16.55	19.80	21.4	21.2
	Cesium (Cs) (ppm)	0.22	0.17	0.21	0.31	0.35
	Chromium (Cr) (ppm)	5	5	4	10	9
	Cobalt (Co) (ppm)	5.8	5.9	6.2	6.3	5.3
	Copper (Cu) (ppm)	95.4	19.4	684	205	550
	Gallium (Ga) (ppm)	5.64	6.51	8.37	5.64	5.66
	Germanium (Ge) (ppm)	0.06	0.06	0.07	0.09	0.07
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.08	0.08	0.05	0.09	0.05
	Indium (In) (ppm)	0.015	0.015	0.014	0.020	0.024
	Iron (Fe) (%)	2.17	2.12	2.09	2.39	2.31
	Lanthanum (La) (ppm)	10.1	8.7	10.6	11.9	11.6
	Lead (Pb) (ppm)	3.7	4.1	5.4	1.5	2.0
	Lithium (Li) (ppm)	6.0	7.0	8.1	6.2	5.3
	Magnesium (Mg) (%)	0.61	0.70	0.80	0.70	0.62
	Manganese (Mn) (ppm)	504	503	494	513	475

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1787168-7	L1787168-8	L1787168-9	L1787168-10	L1787168-11
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	09-JUN-16	09-JUN-16	09-JUN-16	09-JUN-16	09-JUN-16
	Sampled Time					
	Client ID	119329	119333	119332	119330	119331
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.8	8.9	9.1	8.7	9.0
Organic / Inorganic Carbon	Carbon (C) (%)	0.31	0.37	0.26	0.35	0.27
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	1
	MPA (tCaCO3/1Kt)	<0.3	0.3	0.9	0.6	<0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	27	24	20	26	19
	NNP (tCaCO3/1Kt)	27	24	19	25	19
	Ratio (NP/MPA) (Unity)	172.80	76.80	21.33	41.60	121.60
	Sulfate Sulfur (carbonate leach) (%)	0.01	0.01	<0.01	0.01	<0.01
	Sulfate Sulfur (HCl leach) (%)	0.01	0.01	0.01	0.01	0.02
	Sulfide Sulfur (T minus carbonate leach) (%)	<0.01	<0.01	0.03	0.01	<0.01
	Total Sulfur (combustion) (%)	<0.01	0.01	0.03	0.02	<0.01
Total Metals	Aluminum (Al) (%)	1.38	1.11	1.29	1.40	1.16
	Antimony (Sb) (ppm)	<0.05	0.05	<0.05	<0.05	0.06
	Arsenic (As) (ppm)	1.7	0.8	1.0	1.0	1.0
	Barium (Ba) (ppm)	120	210	210	130	240
	Beryllium (Be) (ppm)	0.50	0.33	0.35	0.43	0.34
	Bismuth (Bi) (ppm)	0.01	0.02	0.01	0.09	0.02
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.02	0.02	0.02	0.04	0.02
	Calcium (Ca) (%)	1.52	1.15	1.10	1.36	0.97
	Cerium (Ce) (ppm)	16.75	18.65	21.2	18.20	19.85
	Cesium (Cs) (ppm)	0.17	0.29	0.25	0.18	0.29
	Chromium (Cr) (ppm)	5	6	5	5	5
	Cobalt (Co) (ppm)	5.7	5.5	6.8	6.0	6.1
	Copper (Cu) (ppm)	19.6	57.9	74.2	307	70.5
	Gallium (Ga) (ppm)	6.55	5.35	6.16	6.94	5.82
	Germanium (Ge) (ppm)	0.06	0.07	0.08	0.08	0.10
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.07	0.08	0.12	0.06	0.10
	Indium (In) (ppm)	0.012	0.015	0.017	0.017	0.017
	Iron (Fe) (%)	2.08	2.12	2.38	2.34	2.34
	Lanthanum (La) (ppm)	9.2	9.9	11.7	9.3	10.5
	Lead (Pb) (ppm)	3.1	2.0	2.2	5.3	1.5
	Lithium (Li) (ppm)	7.3	5.5	6.4	7.4	6.4
	Magnesium (Mg) (%)	0.66	0.55	0.71	0.71	0.65
	Manganese (Mn) (ppm)	493	491	521	537	479

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1787168-12	L1787168-13	L1787168-14	L1787168-15	L1787168-16
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	09-JUN-16	09-JUN-16	09-JUN-16	09-JUN-16	09-JUN-16
	Sampled Time					
	Client ID	119334	119328	119327	117474	119326
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.8	9.0	9.2	9.1	9.0
Organic / Inorganic Carbon	Carbon (C) (%)	0.41	0.20	0.19	0.20	0.27
Acid Base Accounting	FIZZ RATING (Unity)	2	1	1	1	2
	MPA (tCaCO3/1Kt)	<0.3	0.9	<0.3	9.4	0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	31	16	15	17	22
	NNP (tCaCO3/1Kt)	31	15	15	8	22
	Ratio (NP/MPA) (Unity)	198.40	17.07	96.00	1.81	70.40
	Sulfate Sulfur (carbonate leach) (%)	<0.01	0.01	0.02	<0.01	0.02
	Sulfate Sulfur (HCl leach) (%)	0.01	0.03	0.02	0.02	0.03
	Sulfide Sulfur (T minus carbonate leach) (%)	<0.01	0.02	<0.01	0.30	<0.01
	Total Sulfur (combustion) (%)	<0.01	0.03	<0.01	0.30	0.01
Total Metals	Aluminum (Al) (%)	1.28	1.40	1.30	1.52	1.41
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	1.2	2.4	4.3	2.0	1.3
	Barium (Ba) (ppm)	180	310	240	170	100
	Beryllium (Be) (ppm)	0.40	0.30	0.28	0.35	0.47
	Bismuth (Bi) (ppm)	0.01	0.02	0.02	0.02	0.01
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.03	0.13	0.02	0.02	0.03
	Calcium (Ca) (%)	1.45	0.90	1.02	1.07	1.34
	Cerium (Ce) (ppm)	15.45	17.05	18.65	23.0	12.65
	Cesium (Cs) (ppm)	0.23	0.41	0.29	0.38	0.17
	Chromium (Cr) (ppm)	5	6	5	4	5
	Cobalt (Co) (ppm)	6.0	6.7	6.7	7.5	5.9
	Copper (Cu) (ppm)	17.1	178.5	16.7	138.5	8.2
	Gallium (Ga) (ppm)	6.40	6.21	6.02	7.11	6.71
	Germanium (Ge) (ppm)	0.07	0.07	0.08	0.09	0.07
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.07	0.08	0.11	0.07	0.08
	Indium (In) (ppm)	0.017	0.020	0.016	0.017	0.013
	Iron (Fe) (%)	2.28	2.61	2.47	2.69	2.18
	Lanthanum (La) (ppm)	7.8	9.2	10.1	12.9	6.3
	Lead (Pb) (ppm)	3.1	6.4	1.6	5.1	3.3
	Lithium (Li) (ppm)	6.5	7.3	6.8	7.8	7.9
	Magnesium (Mg) (%)	0.63	0.74	0.74	0.86	0.76
	Manganese (Mn) (ppm)	539	634	582	470	525

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1787168-17	L1787168-18	L1787168-19	L1787168-20	
	Description	Waste	Waste	Waste	Waste	
	Sampled Date	09-JUN-16	09-JUN-16	25-APR-16	09-MAY-16	
	Sampled Time					
	Client ID	117475	119335	U/F TAILS	U/F TAILS	
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	9.3	9.0	8.8	8.8	
Organic / Inorganic Carbon	Carbon (C) (%)	0.08	0.19	0.24	0.27	
Acid Base Accounting	FIZZ RATING (Unity)	1	2	2	2	
	MPA (tCaCO3/1Kt)	<0.3	0.3	1.3	1.3	
	Neutralization Potential (NP) (tCaCO3/1Kt)	15	24	22	22	
	NNP (tCaCO3/1Kt)	15	24	21	21	
	Ratio (NP/MPA) (Unity)	96.00	76.80	17.60	17.60	
	Sulfate Sulfur (carbonate leach) (%)	0.01	0.02	<0.01	0.01	
	Sulfate Sulfur (HCl leach) (%)	0.01	0.02	0.02	0.02	
	Sulfide Sulfur (T minus carbonate leach) (%)	<0.01	<0.01	0.04	0.03	
	Total Sulfur (combustion) (%)	<0.01	0.01	0.04	0.04	
Total Metals	Aluminum (Al) (%)	1.30	1.40	1.46	1.33	
	Antimony (Sb) (ppm)	0.05	<0.05	0.05	<0.05	
	Arsenic (As) (ppm)	1.6	1.1	1.3	1.6	
	Barium (Ba) (ppm)	100	140	190	170	
	Beryllium (Be) (ppm)	0.46	0.42	0.26	0.19	
	Bismuth (Bi) (ppm)	0.01	0.06	0.16	0.15	
	Boron (B) (ppm)	<10	<10	<10	<10	
	Cadmium (Cd) (ppm)	0.02	0.03	0.20	0.19	
	Calcium (Ca) (%)	1.20	1.35	0.98	0.94	
	Cerium (Ce) (ppm)	14.30	17.85	17.50	14.00	
	Cesium (Cs) (ppm)	0.11	0.17	0.56	0.51	
	Chromium (Cr) (ppm)	5	5	7	7	
	Cobalt (Co) (ppm)	5.2	6.4	7.1	6.7	
	Copper (Cu) (ppm)	10.7	203	692	686	
	Gallium (Ga) (ppm)	6.38	6.64	9.85	8.92	
	Germanium (Ge) (ppm)	0.10	0.08	0.10	0.09	
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	
	Hafnium (Hf) (ppm)	0.08	0.09	0.05	0.05	
	Indium (In) (ppm)	0.010	0.016	0.101	0.096	
	Iron (Fe) (%)	1.93	2.42	4.28	4.22	
	Lanthanum (La) (ppm)	7.4	9.5	9.1	7.2	
	Lead (Pb) (ppm)	4.0	3.8	2.7	2.2	
	Lithium (Li) (ppm)	6.5	7.0	7.1	5.5	
	Magnesium (Mg) (%)	0.64	0.73	0.76	0.68	
	Manganese (Mn) (ppm)	450	548	630	587	

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1787168-1	L1787168-2	L1787168-3	L1787168-5	L1787168-6
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	22-MAY-16	22-MAY-16	22-MAY-16	24-MAY-16	21-MAY-16
	Sampled Time					
	Client ID	117470	117471	117472	117473	123699
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.40	0.21	0.18	5.20	0.18
	Nickel (Ni) (ppm)	2.3	2.2	2.1	5.3	1.9
	Niobium (Nb) (ppm)	0.18	0.21	0.10	0.22	0.18
	Phosphorus (P) (ppm)	730	680	730	790	670
	Potassium (K) (%)	0.35	0.22	0.14	0.68	0.76
	Rhenium (Re) (ppm)	<0.001	<0.001	0.002	0.003	<0.001
	Rubidium (Rb) (ppm)	15.4	10.0	7.3	28.4	32.3
	Scandium (Sc) (ppm)	4.3	3.9	3.6	4.0	4.1
	Selenium (Se) (ppm)	<0.2	0.2	0.5	0.3	0.6
	Silver (Ag) (ppm)	0.04	0.01	0.36	0.08	0.34
	Sodium (Na) (%)	0.08	0.08	0.04	0.13	0.12
	Strontium (Sr) (ppm)	126.0	170.5	186.5	63.8	60.6
	Sulfur (S) (%)	0.01	0.01	0.08	0.02	0.04
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.03	<0.01	0.11	0.01	0.13
	Thallium (Tl) (ppm)	0.08	0.05	0.03	0.13	0.19
	Thorium (Th) (ppm)	1.8	1.5	2.5	2.7	2.5
	Tin (Sn) (ppm)	0.5	0.5	0.4	0.6	0.5
	Titanium (Ti) (%)	0.084	0.086	0.051	0.152	0.143
	Tungsten (W) (ppm)	0.18	0.17	0.09	0.55	<0.05
	Uranium (U) (ppm)	0.27	0.25	0.23	0.28	0.19
	Vanadium (V) (ppm)	47	45	42	58	53
	Yttrium (Y) (ppm)	7.25	7.25	6.82	6.88	5.20
	Zinc (Zn) (ppm)	56	58	63	60	72
	Zirconium (Zr) (ppm)	1.2	1.1	1.0	1.4	0.9
Permanent Gases	Carbon Dioxide (CO2) (%)	1.2	1.0	1.5	0.5	0.8

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1787168-7	L1787168-8	L1787168-9	L1787168-10	L1787168-11
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	09-JUN-16	09-JUN-16	09-JUN-16	09-JUN-16	09-JUN-16
	Sampled Time					
	Client ID	119329	119333	119332	119330	119331
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.31	0.76	0.49	0.53	0.82
	Nickel (Ni) (ppm)	2.1	2.3	2.5	2.4	3.4
	Niobium (Nb) (ppm)	0.15	0.22	0.24	0.14	0.24
	Phosphorus (P) (ppm)	680	630	790	720	760
	Potassium (K) (%)	0.24	0.48	0.50	0.27	0.56
	Rhenium (Re) (ppm)	<0.001	0.001	0.001	0.001	0.001
	Rubidium (Rb) (ppm)	10.4	21.9	21.8	13.2	25.7
	Scandium (Sc) (ppm)	3.9	4.2	4.0	4.1	4.3
	Selenium (Se) (ppm)	<0.2	<0.2	<0.2	0.2	<0.2
	Silver (Ag) (ppm)	0.06	0.03	0.04	0.17	0.05
	Sodium (Na) (%)	0.08	0.09	0.11	0.08	0.10
	Strontium (Sr) (ppm)	136.5	76.0	77.2	128.0	80.5
	Sulfur (S) (%)	0.01	0.01	0.04	0.02	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.01	0.01	<0.01	0.10	0.02
	Thallium (Tl) (ppm)	0.05	0.12	0.11	0.08	0.12
	Thorium (Th) (ppm)	1.5	2.3	3.1	2.3	2.9
	Tin (Sn) (ppm)	0.4	0.5	0.5	0.5	0.5
	Titanium (Ti) (%)	0.073	0.102	0.130	0.074	0.121
	Tungsten (W) (ppm)	0.20	0.56	0.62	0.13	0.59
	Uranium (U) (ppm)	0.21	0.27	0.55	0.26	0.50
	Vanadium (V) (ppm)	44	47	56	46	56
	Yttrium (Y) (ppm)	6.94	6.65	6.98	6.93	7.13
	Zinc (Zn) (ppm)	54	54	61	67	53
	Zirconium (Zr) (ppm)	1.1	1.2	1.6	0.9	1.4
Permanent Gases	Carbon Dioxide (CO2) (%)	1.1	1.3	1.0	1.3	1.0

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1787168-12	L1787168-13	L1787168-14	L1787168-15	L1787168-16
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	09-JUN-16	09-JUN-16	09-JUN-16	09-JUN-16	09-JUN-16
	Sampled Time					
	Client ID	119334	119328	119327	117474	119326
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.82	1.80	0.60	1.55	0.32
	Nickel (Ni) (ppm)	2.7	2.9	2.8	2.3	2.2
	Niobium (Nb) (ppm)	0.15	0.23	0.29	0.27	0.22
	Phosphorus (P) (ppm)	750	770	830	760	680
	Potassium (K) (%)	0.37	0.69	0.56	0.47	0.23
	Rhenium (Re) (ppm)	<0.001	<0.001	0.001	0.001	<0.001
	Rubidium (Rb) (ppm)	15.9	30.8	23.2	24.9	10.1
	Scandium (Sc) (ppm)	4.9	4.2	4.4	4.1	4.1
	Selenium (Se) (ppm)	<0.2	<0.2	<0.2	0.2	<0.2
	Silver (Ag) (ppm)	0.01	0.09	0.02	0.06	0.01
	Sodium (Na) (%)	0.09	0.11	0.13	0.10	0.10
	Strontium (Sr) (ppm)	97.4	56.0	51.8	130.0	107.0
	Sulfur (S) (%)	0.01	0.04	0.01	0.34	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	<0.01	0.01	<0.01	0.03	<0.01
	Thallium (Tl) (ppm)	0.08	0.19	0.11	0.14	0.04
	Thorium (Th) (ppm)	1.2	2.5	2.0	4.1	1.1
	Tin (Sn) (ppm)	0.5	0.6	0.5	0.6	0.5
	Titanium (Ti) (%)	0.089	0.151	0.153	0.152	0.125
	Tungsten (W) (ppm)	0.27	0.64	0.57	0.57	0.23
	Uranium (U) (ppm)	0.22	0.34	0.41	0.79	0.26
	Vanadium (V) (ppm)	51	62	60	62	50
	Yttrium (Y) (ppm)	7.47	6.32	6.95	6.39	6.43
	Zinc (Zn) (ppm)	60	141	67	52	60
	Zirconium (Zr) (ppm)	1.2	1.3	1.7	1.4	1.3
Permanent Gases	Carbon Dioxide (CO_2) (%)	1.5	0.7	0.7	0.7	1.0

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID / Description / Sampled Date / Sampled Time / Client ID	L1787168-17 Waste 09-JUN-16 117475	L1787168-18 Waste 09-JUN-16 119335	L1787168-19 Waste 25-APR-16 U/F TAILS	L1787168-20 Waste 09-MAY-16 U/F TAILS	
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	
	Molybdenum (Mo) (ppm)	0.39	1.71	0.65	0.51	
	Nickel (Ni) (ppm)	2.2	4.7	3.1	2.7	
	Niobium (Nb) (ppm)	0.24	0.24	0.24	0.27	
	Phosphorus (P) (ppm)	630	820	890	820	
	Potassium (K) (%)	0.20	0.32	0.71	0.66	
	Rhenium (Re) (ppm)	<0.001	0.001	0.001	<0.001	
	Rubidium (Rb) (ppm)	8.9	13.3	38.8	36.5	
	Scandium (Sc) (ppm)	3.5	4.2	4.6	4.0	
	Selenium (Se) (ppm)	<0.2	0.4	0.7	0.7	
	Silver (Ag) (ppm)	0.01	0.15	0.47	0.48	
	Sodium (Na) (%)	0.11	0.10	0.07	0.07	
	Strontium (Sr) (ppm)	89.1	122.5	78.1	70.8	
	Sulfur (S) (%)	0.01	0.02	0.05	0.05	
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	
	Tellurium (Te) (ppm)	0.01	0.06	0.21	0.20	
	Thallium (Tl) (ppm)	0.05	0.07	0.29	0.24	
	Thorium (Th) (ppm)	1.3	2.2	5.0	4.3	
	Tin (Sn) (ppm)	0.5	0.5	1.1	0.9	
	Titanium (Ti) (%)	0.125	0.116	0.130	0.117	
	Tungsten (W) (ppm)	0.52	0.19	<0.05	0.07	
	Uranium (U) (ppm)	0.22	0.31	0.32	0.30	
	Vanadium (V) (ppm)	45	54	76	74	
	Yttrium (Y) (ppm)	6.00	7.14	6.23	5.65	
	Zinc (Zn) (ppm)	52	69	117	114	
	Zirconium (Zr) (ppm)	1.3	1.4	1.1	1.2	
Permanent Gases	Carbon Dioxide (CO2) (%)	0.3	0.7	0.9	1.0	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ABA-OA-VOL08-AX	Soil	Acid Base Accounting	OA-VOL08
CARBON-C-GAS05-AX	Soil	Carbon, TOC and CO2	C-GAS05
ME-MS41-AX	Soil	Aqua Regia ICPMS	Aqua Regia ICPMS

A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-OA-ELE07-AX	Soil	pH	OA-ELE07
SULPHUR-S-CAL06-AX	Soil	Sulfide Sulfur Calc from Carbonate Leach	ALS Minerals S-CAL06

Sulfide Sulfur (as S) is calculated by subtracting the Carbonate Leachable Sulfate Sulfur (as S) from the Total Sulfur (as S) obtained from combustion.

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06-AX	Soil	Sulfate Sulfur in Soil (Carbonate Leach)	ALS Minerals S-GRA06

A prepared sample is boiled with a sodium carbonate solution for 30 minutes. Any insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06A-AX	Soil	Sulfate Sulfur in Soil (HCl Leach)	ALS Minerals S-GRA06A

A prepared sample is heated with dilute hydrochloric acid for 30 minutes. Silica and any acid-insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-IR08-AX	Soil	Total Sulfur in Soil by Combustion	ALS Minerals S-IR08

The sample is heated to approximately 1350 °C in an induction furnace while passing a stream of oxygen through the sample. Sulfur dioxide released from the sample is measured by an IR detection system and the Total Sulfur result is provided.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
AX	ALS MINERALS - VANCOUVER, B.C., CANADA

Chain of Custody Numbers:

15-005

GLOSSARY OF REPORT TERMS
Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Canada Ltd.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

CERTIFICATE VA16101612

Project: L1787168

P.O. No.: ALSM-CW16-102-APN

This report is for 19 Other samples submitted to our lab in Vancouver, BC, Canada on 24-JUN-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Colin Ramshaw, Vancouver Laboratory Manager

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www.alsglobal.com

To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	OA-VOL08m MPA tCaCO3/1Kt 0.3	OA-VOL08m FIZZ RAT Unity 1	OA-VOL08m NNP tCaCO3/1Kt 1	OA-VOL08m NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08m Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	S-CAL06 S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2	ME-MS41 Ag ppm 0.01	ME-MS41 Al % 0.01
L1787168-1 117470		1.12	0.3	2	28	28	8.7	89.60	0.01	0.02	0.03	<0.01	0.33	1.2	0.04	1.19
L1787168-2 117471		1.10	0.3	2	26	26	8.7	83.20	0.01	<0.01	0.01	0.01	0.27	1.0	0.01	1.38
L1787168-3 117472		1.80	2.2	2	35	37	8.5	16.91	0.07	0.01	0.02	0.06	0.41	1.5	0.36	1.89
L1787168-5 117473		1.04	0.3	1	14	14	9.3	44.80	0.01	0.01	0.01	<0.01	0.14	0.5	0.08	1.27
L1787168-6 123699		1.16	1.3	2	15	16	8.7	12.80	0.04	0.01	<0.01	0.03	0.22	0.8	0.34	1.18
L1787168-7 119329		0.94	<0.3	2	27	27	8.8	172.80	<0.01	0.01	0.01	<0.01	0.31	1.1	0.06	1.38
L1787168-8 119333		0.94	0.3	2	24	24	8.9	76.80	0.01	0.01	0.01	<0.01	0.37	1.3	0.03	1.11
L1787168-9 119332		0.94	0.9	2	19	20	9.1	21.33	0.03	<0.01	0.01	0.03	0.26	1.0	0.04	1.29
L1787168-10 119330		0.94	0.6	2	25	26	8.7	41.60	0.02	0.01	0.01	0.01	0.35	1.3	0.17	1.40
L1787168-11 119331		0.96	<0.3	1	19	19	9.0	121.60	<0.01	<0.01	0.02	<0.01	0.27	1.0	0.05	1.16
L1787168-12 119334		0.94	<0.3	2	31	31	8.8	198.40	<0.01	<0.01	0.01	<0.01	0.41	1.5	0.01	1.28
L1787168-13 119328		0.88	0.9	1	15	16	9.0	17.07	0.03	0.01	0.03	0.02	0.20	0.7	0.09	1.40
L1787168-14 119327		0.94	<0.3	1	15	15	9.2	96.00	<0.01	0.02	0.02	<0.01	0.19	0.7	0.02	1.30
L1787168-15 117474		0.92	9.4	1	8	17	9.1	1.81	0.30	<0.01	0.02	0.30	0.20	0.7	0.06	1.52
L1787168-16 119326		0.90	0.3	2	22	22	9.0	70.40	0.01	0.02	0.03	<0.01	0.27	1.0	0.01	1.41
L1787168-17 117475		0.92	<0.3	1	15	15	9.3	96.00	<0.01	0.01	0.01	<0.01	0.08	0.3	0.01	1.30
L1787168-18 119335		0.96	0.3	2	24	24	9.0	76.80	0.01	0.02	0.02	<0.01	0.19	0.7	0.15	1.40
L1787168-19 U/F TAILS		1.10	1.3	2	21	22	8.8	17.60	0.04	<0.01	0.02	0.04	0.24	0.9	0.47	1.46
L1787168-20 U/F TAILS		1.12	1.3	2	21	22	8.8	17.60	0.04	0.01	0.02	0.03	0.27	1.0	0.48	1.33

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 As ppm 0.1	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05
L1787168-1 117470		1.6	<0.2	<10	160	0.34	0.02	1.36	0.03	18.60	5.8	5	0.22	95.4	2.17	5.64
L1787168-2 117471		1.8	<0.2	<10	130	0.43	0.01	1.41	0.02	16.55	5.9	5	0.17	19.4	2.12	6.51
L1787168-3 117472		2.3	<0.2	<10	40	0.68	0.16	2.11	0.03	19.80	6.2	4	0.21	684	2.09	8.37
L1787168-5 117473		1.2	<0.2	<10	290	0.27	0.03	0.84	0.03	21.4	6.3	10	0.31	205	2.39	5.64
L1787168-6 123699		0.8	<0.2	<10	370	0.19	0.16	0.69	0.07	21.2	5.3	9	0.35	550	2.31	5.66
L1787168-7 119329		1.7	<0.2	<10	120	0.50	0.01	1.52	0.02	16.75	5.7	5	0.17	19.6	2.08	6.55
L1787168-8 119333		0.8	<0.2	<10	210	0.33	0.02	1.15	0.02	18.65	5.5	6	0.29	57.9	2.12	5.35
L1787168-9 119332		1.0	<0.2	<10	210	0.35	0.01	1.10	0.02	21.2	6.8	5	0.25	74.2	2.38	6.16
L1787168-10 119330		1.0	<0.2	<10	130	0.43	0.09	1.36	0.04	18.20	6.0	5	0.18	307	2.34	6.94
L1787168-11 119331		1.0	<0.2	<10	240	0.34	0.02	0.97	0.02	19.85	6.1	5	0.29	70.5	2.34	5.82
L1787168-12 119334		1.2	<0.2	<10	180	0.40	0.01	1.45	0.03	15.45	6.0	5	0.23	17.1	2.28	6.40
L1787168-13 119328		2.4	<0.2	<10	310	0.30	0.02	0.90	0.13	17.05	6.7	6	0.41	178.5	2.61	6.21
L1787168-14 119327		4.3	<0.2	<10	240	0.28	0.02	1.02	0.02	18.65	6.7	5	0.29	16.7	2.47	6.02
L1787168-15 117474		2.0	<0.2	<10	170	0.35	0.02	1.07	0.02	23.0	7.5	4	0.38	138.5	2.69	7.11
L1787168-16 119326		1.3	<0.2	<10	100	0.47	0.01	1.34	0.03	12.65	5.9	5	0.17	8.2	2.18	6.71
L1787168-17 117475		1.6	<0.2	<10	100	0.46	0.01	1.20	0.02	14.30	5.2	5	0.11	10.7	1.93	6.38
L1787168-18 119335		1.1	<0.2	<10	140	0.42	0.06	1.35	0.03	17.85	6.4	5	0.17	203	2.42	6.64
L1787168-19 U/F TAILS		1.3	<0.2	<10	190	0.26	0.16	0.98	0.20	17.50	7.1	7	0.56	692	4.28	9.85
L1787168-20 U/F TAILS		1.6	<0.2	<10	170	0.19	0.15	0.94	0.19	14.00	6.7	7	0.51	686	4.22	8.92

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	Ge	Hf	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb
	Units	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm
	LOR	0.05	0.02	0.01	0.005	0.01	0.2	0.1	0.01	5	0.05	0.01	0.05	0.2	10	0.2
L1787168-1 117470		0.06	0.08	<0.01	0.015	0.35	10.1	6.0	0.61	504	0.40	0.08	0.18	2.3	730	3.7
L1787168-2 117471		0.06	0.08	<0.01	0.015	0.22	8.7	7.0	0.70	503	0.21	0.08	0.21	2.2	680	4.1
L1787168-3 117472		0.07	0.05	<0.01	0.014	0.14	10.6	8.1	0.80	494	0.18	0.04	0.10	2.1	730	5.4
L1787168-5 117473		0.09	0.09	<0.01	0.020	0.68	11.9	6.2	0.70	513	5.20	0.13	0.22	5.3	790	1.5
L1787168-6 123699		0.07	0.05	<0.01	0.024	0.76	11.6	5.3	0.62	475	0.18	0.12	0.18	1.9	670	2.0
L1787168-7 119329		0.06	0.07	<0.01	0.012	0.24	9.2	7.3	0.66	493	0.31	0.08	0.15	2.1	680	3.1
L1787168-8 119333		0.07	0.08	<0.01	0.015	0.48	9.9	5.5	0.55	491	0.76	0.09	0.22	2.3	630	2.0
L1787168-9 119332		0.08	0.12	<0.01	0.017	0.50	11.7	6.4	0.71	521	0.49	0.11	0.24	2.5	790	2.2
L1787168-10 119330		0.08	0.06	<0.01	0.017	0.27	9.3	7.4	0.71	537	0.53	0.08	0.14	2.4	720	5.3
L1787168-11 119331		0.10	0.10	<0.01	0.017	0.56	10.5	6.4	0.65	479	0.82	0.10	0.24	3.4	760	1.5
L1787168-12 119334		0.07	0.07	<0.01	0.017	0.37	7.8	6.5	0.63	539	0.82	0.09	0.15	2.7	750	3.1
L1787168-13 119328		0.07	0.08	<0.01	0.020	0.69	9.2	7.3	0.74	634	1.80	0.11	0.23	2.9	770	6.4
L1787168-14 119327		0.08	0.11	<0.01	0.016	0.56	10.1	6.8	0.74	582	0.60	0.13	0.29	2.8	830	1.6
L1787168-15 117474		0.09	0.07	<0.01	0.017	0.47	12.9	7.8	0.86	470	1.55	0.10	0.27	2.3	760	5.1
L1787168-16 119326		0.07	0.08	<0.01	0.013	0.23	6.3	7.9	0.76	525	0.32	0.10	0.22	2.2	680	3.3
L1787168-17 117475		0.10	0.08	<0.01	0.010	0.20	7.4	6.5	0.64	450	0.39	0.11	0.24	2.2	630	4.0
L1787168-18 119335		0.08	0.09	<0.01	0.016	0.32	9.5	7.0	0.73	548	1.71	0.10	0.24	4.7	820	3.8
L1787168-19 U/F TAILS		0.10	0.05	<0.01	0.101	0.71	9.1	7.1	0.76	630	0.65	0.07	0.24	3.1	890	2.7
L1787168-20 U/F TAILS		0.09	0.05	<0.01	0.096	0.66	7.2	5.5	0.68	587	0.51	0.07	0.27	2.7	820	2.2

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1
L1787168-1 117470		15.4	<0.001	0.01	0.09	4.3	<0.2	0.5	126.0	<0.01	0.03	1.8	0.084	0.08	0.27	47
L1787168-2 117471		10.0	<0.001	0.01	0.08	3.9	0.2	0.5	170.5	<0.01	<0.01	1.5	0.086	0.05	0.25	45
L1787168-3 117472		7.3	0.002	0.08	0.07	3.6	0.5	0.4	186.5	<0.01	0.11	2.5	0.051	0.03	0.23	42
L1787168-5 117473		28.4	0.003	0.02	0.05	4.0	0.3	0.6	63.8	<0.01	0.01	2.7	0.152	0.13	0.28	58
L1787168-6 123699		32.3	<0.001	0.04	0.05	4.1	0.6	0.5	60.6	<0.01	0.13	2.5	0.143	0.19	0.19	53
L1787168-7 119329		10.4	<0.001	0.01	<0.05	3.9	<0.2	0.4	136.5	<0.01	0.01	1.5	0.073	0.05	0.21	44
L1787168-8 119333		21.9	0.001	0.01	0.05	4.2	<0.2	0.5	76.0	<0.01	0.01	2.3	0.102	0.12	0.27	47
L1787168-9 119332		21.8	0.001	0.04	<0.05	4.0	<0.2	0.5	77.2	<0.01	<0.01	3.1	0.130	0.11	0.55	56
L1787168-10 119330		13.2	0.001	0.02	<0.05	4.1	0.2	0.5	128.0	<0.01	0.10	2.3	0.074	0.08	0.26	46
L1787168-11 119331		25.7	0.001	0.01	0.06	4.3	<0.2	0.5	80.5	<0.01	0.02	2.9	0.121	0.12	0.50	56
L1787168-12 119334		15.9	<0.001	0.01	<0.05	4.9	<0.2	0.5	97.4	<0.01	<0.01	1.2	0.089	0.08	0.22	51
L1787168-13 119328		30.8	<0.001	0.04	<0.05	4.2	<0.2	0.6	56.0	<0.01	0.01	2.5	0.151	0.19	0.34	62
L1787168-14 119327		23.2	0.001	0.01	<0.05	4.4	<0.2	0.5	51.8	<0.01	<0.01	2.0	0.153	0.11	0.41	60
L1787168-15 117474		24.9	0.001	0.34	<0.05	4.1	0.2	0.6	130.0	<0.01	0.03	4.1	0.152	0.14	0.79	62
L1787168-16 119326		10.1	<0.001	0.01	<0.05	4.1	<0.2	0.5	107.0	<0.01	<0.01	1.1	0.125	0.04	0.26	50
L1787168-17 117475		8.9	<0.001	0.01	0.05	3.5	<0.2	0.5	89.1	<0.01	0.01	1.3	0.125	0.05	0.22	45
L1787168-18 119335		13.3	0.001	0.02	<0.05	4.2	0.4	0.5	122.5	<0.01	0.06	2.2	0.116	0.07	0.31	54
L1787168-19 U/F TAILS		38.8	0.001	0.05	0.05	4.6	0.7	1.1	78.1	<0.01	0.21	5.0	0.130	0.29	0.32	76
L1787168-20 U/F TAILS		36.5	<0.001	0.05	<0.05	4.0	0.7	0.9	70.8	<0.01	0.20	4.3	0.117	0.24	0.30	74

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BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
L1787168-1 117470		0.18	7.25	56	1.2
L1787168-2 117471		0.17	7.25	58	1.1
L1787168-3 117472		0.09	6.82	63	1.0
L1787168-5 117473		0.55	6.88	60	1.4
L1787168-6 123699		<0.05	5.20	72	0.9
L1787168-7 119329		0.20	6.94	54	1.1
L1787168-8 119333		0.56	6.65	54	1.2
L1787168-9 119332		0.62	6.98	61	1.6
L1787168-10 119330		0.13	6.93	67	0.9
L1787168-11 119331		0.59	7.13	53	1.4
L1787168-12 119334		0.27	7.47	60	1.2
L1787168-13 119328		0.64	6.32	141	1.3
L1787168-14 119327		0.57	6.95	67	1.7
L1787168-15 117474		0.57	6.39	52	1.4
L1787168-16 119326		0.23	6.43	60	1.3
L1787168-17 117475		0.52	6.00	52	1.3
L1787168-18 119335		0.19	7.14	69	1.4
L1787168-19 U/F TAILS		<0.05	6.23	117	1.1
L1787168-20 U/F TAILS		0.07	5.65	114	1.2

***** See Appendix Page for comments regarding this certificate *****

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Finalized Date: 16-JUL-2016
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Project: L1787168

CERTIFICATE OF ANALYSIS VA16101612

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	S-CAL06	S-GRA06
S-GRA06a	S-IR08	SPL-21	WEI-21

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Finalized Date: 16-JUL-2016
Account: APN

QC CERTIFICATE VA16101612

Project: L1787168

P.O. No.: ALSM-CW16-102-APN

This report is for 19 Other samples submitted to our lab in Vancouver, BC, Canada on 24-JUN-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	SOFTWARE DEVELOPMENT GROUP	ARIEL TANG

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL TANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Minerals

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Account: APN

Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description / Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
STANDARDS															
Buffer pH6					6.1										
Buffer pH6					6.0										
Target Range - Lower Bound					5.3										
Upper Bound					6.7										
CO-ASSAY											0.50	1.8			
Target Range - Lower Bound											0.42	1.5			
Upper Bound											0.64	2.4			
DS-1							2.63								
Target Range - Lower Bound							2.51								
Upper Bound							2.71								
GS310-10							0.28								
Target Range - Lower Bound							0.25								
Upper Bound							0.29								
GS313-8							1.25								
Target Range - Lower Bound							1.19								
Upper Bound							1.29								
KZK-1	25.0	2	31	56		2.24									
KZK-1	25.0	2	30	55		2.20									
Target Range - Lower Bound	22.9	<1	30	54		2.18									
Upper Bound	27.1	>4	38	64		2.53									
MA-2c											1.51	5.5			
Target Range - Lower Bound											1.50	5.5			
Upper Bound											1.84	6.8			
MA-3a											2.60	9.5			
Target Range - Lower Bound											2.31	8.4			
Upper Bound											2.77	10.2			
MRGeo08													4.36	2.67	33.2
Target Range - Lower Bound													4.00	2.44	29.6
Upper Bound													4.92	3.00	36.4
OGGeo08													19.60	2.27	118.0
Target Range - Lower Bound													18.15	2.05	107.0
Upper Bound													22.2	2.53	131.0

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge
	Units	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
	LOR	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05	0.05
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		<0.2	<10	440	0.89	0.68	1.09	2.10	69.9	17.7	89	10.25	604	3.54	10.05	0.19
Target Range - Lower Bound		<0.2	<10	370	0.67	0.60	1.00	2.01	66.2	17.0	81	9.40	587	3.22	8.73	0.07
Upper Bound		0.4	20	530	0.95	0.76	1.24	2.47	81.0	21.0	102	11.60	675	3.96	10.80	0.29
OGGeo08		<0.2	<10	70	0.79	10.00	0.93	18.40	59.7	94.4	82	9.57	8450	5.13	8.51	0.18
Target Range - Lower Bound		<0.2	<10	60	0.61	9.44	0.82	16.75	56.7	87.2	75	8.68	7800	4.51	8.05	0.21
Upper Bound		0.4	30	110	0.89	11.55	1.02	20.5	69.3	107.0	93	10.70	8980	5.53	9.95	0.45

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Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.81	0.09	0.149	1.26	35.0	32.3	1.15	407	13.95	0.34	0.74	689	980	1055	137.5
Target Range - Lower Bound		0.64	0.04	0.137	1.12	33.2	29.6	1.03	378	13.10	0.30	0.79	622	900	959	132.0
Upper Bound		0.83	0.10	0.179	1.40	41.0	36.4	1.29	473	16.10	0.39	1.09	760	1130	1175	162.0
OGGeo08		0.84	0.48	1.425	1.07	28.4	32.9	0.98	396	904	0.30	0.98	8990	800	7270	124.0
Target Range - Lower Bound		0.72	0.41	1.335	0.94	27.7	29.8	0.84	350	811	0.26	0.97	7760	700	6520	109.5
Upper Bound		0.92	0.57	1.645	1.18	34.3	36.6	1.05	438	991	0.34	1.29	9480	880	7970	134.5

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Account: APN

Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W
	Units	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
	LOR	0.001	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1	0.05
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.008	0.32	3.42	7.7	1.2	3.3	83.1	0.01	0.02	20.9	0.375	0.81	5.59	98	2.92
Target Range - Lower Bound		0.006	0.27	2.80	6.7	0.9	2.8	72.1	<0.01	<0.01	19.1	0.338	0.64	4.93	90	2.44
Upper Bound		0.010	0.35	3.90	8.4	1.9	4.0	88.5	0.03	0.04	23.7	0.424	0.92	6.13	112	3.42
OGGeo08		1.350	2.86	21.2	6.7	10.3	13.4	63.5	0.04	0.15	16.6	0.317	1.42	5.18	80	3.14
Target Range - Lower Bound		1.295	2.51	17.70	6.0	9.7	12.0	59.6	<0.01	0.14	15.6	0.279	1.14	4.45	70	2.58
Upper Bound		1.585	3.09	24.1	7.6	12.3	15.1	73.2	0.03	0.20	19.6	0.353	1.58	5.55	88	3.60

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BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
STANDARDS				
Buffer pH6				
Buffer pH6				
Target Range - Lower Bound				
Upper Bound				
CO-ASSAY				
Target Range - Lower Bound				
Upper Bound				
DS-1				
Target Range - Lower Bound				
Upper Bound				
GS310-10				
Target Range - Lower Bound				
Upper Bound				
GS313-8				
Target Range - Lower Bound				
Upper Bound				
KZK-1				
KZK-1				
Target Range - Lower Bound				
Upper Bound				
MA-2c				
Target Range - Lower Bound				
Upper Bound				
MA-3a				
Target Range - Lower Bound				
Upper Bound				
MRGeo08		19.00	760	20.9
Target Range - Lower Bound		17.50	708	18.1
Upper Bound		21.5	870	25.7
OGGeo08		16.90	7080	28.1
Target Range - Lower Bound		15.35	6500	19.5
Upper Bound		18.85	7950	27.5

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QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description / Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
STANDARDS															
OREAS 905													0.52	0.79	33.6
Target Range - Lower Bound													0.45	0.73	28.4
Upper Bound													0.58	0.91	35.0
OREAS 920													0.10	2.24	4.7
Target Range - Lower Bound													0.07	2.18	3.8
Upper Bound													0.12	2.68	4.9
SY-4											1.03	3.8			
Target Range - Lower Bound											0.84	3.0			
Upper Bound											1.08	4.0			
UTS-1								0.90							
UTS-1								0.90							
Target Range - Lower Bound								0.83							
Upper Bound								0.93							
UTS-1									0.88						
Target Range - Lower Bound									0.81						
Upper Bound									0.95						
UTS-1							1.01								
Target Range - Lower Bound							0.95								
Upper Bound							1.05								
UTS-4								1.79							
UTS-4								1.75							
Target Range - Lower Bound								1.64							
Upper Bound								1.84							
UTS-4									1.72						
Target Range - Lower Bound									1.61						
Upper Bound									1.87						
BLANKS															
BLANK											<0.05	<0.2			
BLANK											<0.05	<0.2			
Target Range - Lower Bound											<0.05	<0.2			
Upper Bound											0.10	0.4			

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QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge
	Units	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
	LOR	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05	0.05
STANDARDS																
OREAS 905		0.4	<10	240	0.98	5.78	0.34	0.34	75.8	13.0	17	1.25	1525	3.35	6.28	0.10
Target Range - Lower Bound		<0.2	<10	200	0.78	5.16	0.29	<0.01	72.0	12.4	<1	1.14	1450	3.14	5.74	<0.05
Upper Bound		0.8	20	300	1.08	6.32	0.38	0.02	88.0	15.4	2	1.50	1670	3.86	7.12	0.10
OREAS 920		<0.2	<10	70	0.68	0.81	0.29	0.06	67.8	13.9	39	1.89	107.5	3.38	6.36	0.09
Target Range - Lower Bound		<0.2	<10	50	0.59	0.60	0.28	0.04	64.8	13.4	37	1.84	102.0	3.26	6.12	<0.05
Upper Bound		0.4	20	110	0.87	0.76	0.37	0.09	79.2	16.6	48	2.36	118.0	4.00	7.60	0.10
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description / Method / Analyte / Units / LOR	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1
STANDARDS															
OREAS 905	1.11	0.03	0.547	0.31	38.2	5.1	0.15	337	2.91	0.09	0.30	8.5	240	16.8	18.1
Target Range - Lower Bound	1.08	<0.01	0.517	0.28	35.6	4.3	0.13	310	2.65	0.07	<0.05	7.8		15.2	17.3
Upper Bound	1.36	0.02	0.643	0.36	44.0	5.5	0.19	390	3.35	0.12	0.10	10.0		19.0	21.3
OREAS 920	0.54	<0.01	0.030	0.37	33.4	21.6	1.05	494	0.36	0.02	0.28	36.2	680	21.3	22.6
Target Range - Lower Bound	0.53	<0.01	0.019	0.39	33.3	19.0	0.98	<5	0.29	<0.01	0.31	34.4		19.2	22.2
Upper Bound	0.69	0.02	0.043	0.50	41.1	23.4	1.22	10	0.53	0.02	0.55	42.4		23.9	27.4
SY-4															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
BLANKS															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															

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QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05
STANDARDS																
OREAS 905		<0.001	0.07	1.33	1.7	2.4	1.3	12.7	<0.01	0.05	8.8	0.020	0.12	2.29	6	0.60
Target Range - Lower Bound		<0.001	0.04	0.90	1.6	1.8	0.8	10.9	<0.01	0.04	7.8	0.008	0.06	2.08	4	<0.05
Upper Bound		0.002	0.09	1.34	2.2	2.8	1.7	13.7	0.02	0.09	10.0	0.030	0.16	2.66	8	0.10
OREAS 920		<0.001	0.03	0.67	2.6	0.7	1.0	15.8	<0.01	0.02	14.8	0.104	0.14	2.00	23	0.66
Target Range - Lower Bound		<0.001	<0.01	0.45	2.5	0.4	0.7	15.0	<0.01	<0.01	13.6	0.106	0.07	1.89	23	<0.05
Upper Bound		0.002	0.05	0.77	3.3	1.3	1.7	18.8	0.02	0.02	17.0	0.140	0.18	2.42	30	0.10
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
STANDARDS				
OREAS 905		7.02	63	43.3
Target Range - Lower Bound		6.32	58	39.9
Upper Bound		7.84	76	55.1
OREAS 920		16.85	102	17.9
Target Range - Lower Bound		16.85	93	17.6
Upper Bound		20.7	119	25.0
SY-4				
Target Range - Lower Bound				
Upper Bound				
UTS-1				
UTS-1				
Target Range - Lower Bound				
Upper Bound				
UTS-1				
Target Range - Lower Bound				
Upper Bound				
UTS-1				
Target Range - Lower Bound				
Upper Bound				
UTS-4				
UTS-4				
Target Range - Lower Bound				
Upper Bound				
UTS-4				
Target Range - Lower Bound				
Upper Bound				
BLANKS				
BLANK				
BLANK				
Target Range - Lower Bound				
Upper Bound				

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2103 Dollarton Hwy
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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description / Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
BLANKS															
BLANK													<0.01	<0.01	0.1
BLANK													<0.01	<0.01	<0.1
Target Range - Lower Bound													<0.01	<0.01	<0.1
Upper Bound													0.02	0.02	0.2
BLANK					6.0										
Target Range - Lower Bound					5.5										
Upper Bound					6.9										
BLANK								<0.01							
BLANK								<0.01							
Target Range - Lower Bound								<0.01							
Upper Bound								0.02							
BLANK									<0.01						
Target Range - Lower Bound									<0.01						
Upper Bound									0.02						
BLANK							<0.01								
BLANK							0.01								
Target Range - Lower Bound							<0.01								
Upper Bound							0.02								
DUPLICATES															
ORIGINAL													0.09	0.08	73.7
DUP													0.11	0.09	72.4
Target Range - Lower Bound													0.09	0.07	69.3
Upper Bound													0.12	0.10	76.8
ORIGINAL													1.05	0.45	2380
DUP													1.07	0.45	2320
Target Range - Lower Bound													1.00	0.42	2230
Upper Bound													1.12	0.48	2470
ORIGINAL											0.38	1.4			
DUP											0.37	1.4			
Target Range - Lower Bound											0.31	1.1			
Upper Bound											0.44	1.7			

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Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description / Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge
Units	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
LOR	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05	0.05
BLANKS															
BLANK	<0.2	<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05
BLANK	<0.2	<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05
Target Range - Lower Bound	<0.2	<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05
Upper Bound	0.4	20	20	0.10	0.02	0.02	0.02	0.04	0.2	2	0.10	0.4	0.02	0.10	0.10
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															
DUPLICATES															
ORIGINAL	<0.2	<10	20	0.37	0.30	>25.0	1.45	7.72	0.8	6	1.23	6.8	0.63	0.41	<0.05
DUP	<0.2	<10	20	0.38	0.12	>25.0	1.46	7.76	0.9	6	1.31	6.9	0.62	0.41	<0.05
Target Range - Lower Bound	<0.2	<10	<10	0.31	0.19	23.7	1.37	7.33	0.7	5	1.16	6.4	0.58	0.34	<0.05
Upper Bound	0.4	20	30	0.44	0.23	>25.0	1.54	8.15	1.0	7	1.38	7.3	0.67	0.48	0.10
ORIGINAL	<0.2	10	10	0.38	1.33	0.38	6.34	21.6	34.3	16	7.95	29.4	9.76	1.60	0.10
DUP	<0.2	10	10	0.41	1.78	0.37	6.27	21.7	36.2	15	8.27	29.7	9.48	1.93	0.15
Target Range - Lower Bound	<0.2	<10	<10	0.33	1.47	0.35	5.98	20.5	33.4	14	7.65	28.3	9.13	1.63	0.07
Upper Bound	0.4	20	20	0.46	1.64	0.40	6.63	22.8	37.1	17	8.57	30.8	10.10	1.90	0.18
ORIGINAL															
DUP															
Target Range - Lower Bound															
Upper Bound															

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	Hf	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb
Units	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
LOR	0.02	0.01	0.005	0.01	0.2	0.1	0.01	5	0.05	0.01	0.05	0.2	10	0.2	0.1
BLANKS															
BLANK	<0.02	<0.01	<0.005	<0.01	<0.2	0.2	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
BLANK	<0.02	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	0.05	<0.2	<10	<0.2	<0.1
Target Range - Lower Bound	<0.02	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
Upper Bound	0.04	0.02	0.010	0.02	0.4	0.2	0.02	10	0.10	0.02	0.10	0.4	20	0.4	0.2
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															
DUPLICATES															
ORIGINAL	0.02	6.22	0.020	0.04	5.9	0.8	0.13	638	0.26	<0.01	0.06	4.5	130	44.9	2.1
DUP	0.03	5.76	0.027	0.04	5.9	0.7	0.12	633	0.25	<0.01	0.06	4.6	130	44.9	2.3
Target Range - Lower Bound	<0.02	5.53	0.017	0.03	5.4	0.6	0.11	599	0.19	<0.01	<0.05	4.1	110	42.5	2.0
Upper Bound	0.04	6.45	0.030	0.05	6.4	0.9	0.14	672	0.32	0.02	0.10	5.0	150	47.3	2.4
ORIGINAL	0.07	51.5	0.221	0.18	8.8	3.8	0.05	9	2.37	<0.01	0.08	107.0	1460	234	12.1
DUP	0.13	49.8	0.220	0.18	9.0	5.2	0.05	13	2.32	<0.01	0.07	105.5	1450	238	13.7
Target Range - Lower Bound	0.08	46.8	0.204	0.16	8.3	4.2	0.04	<5	2.18	<0.01	<0.05	100.5	1370	224	12.2
Upper Bound	0.13	54.5	0.237	0.20	9.5	4.8	0.06	17	2.51	0.02	0.10	112.0	1540	248	13.6
ORIGINAL															
DUP															
Target Range - Lower Bound															
Upper Bound															

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description — Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W
Units	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
LOR	0.001	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1	0.05
BLANKS															
BLANK	<0.001	<0.01	0.12	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
BLANK	<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
Target Range - Lower Bound	<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
Upper Bound	0.002	0.02	0.10	0.2	0.4	0.4	0.4	0.02	0.02	0.4	0.010	0.04	0.10	2	0.10
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															
DUPLICATES															
ORIGINAL	<0.001	0.01	20.1	3.0	2.3	0.5	90.6	<0.01	0.10	0.6	<0.005	0.04	1.90	9	10.95
DUP	<0.001	0.02	19.85	3.1	1.9	0.5	90.4	<0.01	0.03	0.6	<0.005	0.04	1.88	9	10.90
Target Range - Lower Bound	<0.001	<0.01	18.45	2.8	1.8	0.3	85.8	<0.01	0.05	0.4	<0.005	<0.02	1.75	8	10.05
Upper Bound	0.002	0.02	21.5	3.3	2.4	0.7	95.2	0.02	0.08	0.8	0.010	0.06	2.03	10	11.80
ORIGINAL	0.007	>10.0	335	4.2	1.1	0.6	12.1	<0.01	0.04	1.3	<0.005	3.25	7.53	42	6.50
DUP	0.007	>10.0	331	4.5	1.2	0.6	12.7	<0.01	0.03	1.3	<0.005	3.18	7.51	42	6.95
Target Range - Lower Bound	0.006	9.49	308	4.0	0.9	0.4	11.6	<0.01	0.02	1.0	<0.005	2.95	7.09	39	6.17
Upper Bound	0.008	10.00	358	4.7	1.4	0.8	13.2	0.02	0.05	1.6	0.010	3.48	7.95	45	7.28
ORIGINAL															
DUP															
Target Range - Lower Bound															
Upper Bound															

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 16-JUL-2016
Account: APN

Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
BLANKS				
BLANK		<0.05	<2	<0.5
BLANK		<0.05	<2	<0.5
Target Range - Lower Bound		<0.05	<2	<0.5
Upper Bound		0.10	4	1.0
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
BLANK				
Target Range - Lower Bound				
Upper Bound				
DUPLICATES				
ORIGINAL		19.05	102	0.8
DUP		19.25	100	1.0
Target Range - Lower Bound		18.15	94	<0.5
Upper Bound		20.2	108	1.0
ORIGINAL		11.80	948	3.2
DUP		12.05	925	3.2
Target Range - Lower Bound		11.30	888	2.5
Upper Bound		12.55	985	3.9
ORIGINAL				
DUP				
Target Range - Lower Bound				
Upper Bound				

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QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
DUPLICATES															
ORIGINAL											5.06	18.6			
DUP											5.03	18.5			
Target Range - Lower Bound											4.74	17.4			
Upper Bound											5.35	19.7			
L1787168-8 119333					8.9		0.01	0.01		<0.01					
DUP					9.0		<0.01	0.01		<0.01					
Target Range - Lower Bound					8.4		<0.01	<0.01		<0.01					
Upper Bound					9.5		0.02	0.02		0.02					
L1787168-9 119332	0.9	2	19	20		21.33									
DUP	0.9	2	20	21		22.40									
Target Range - Lower Bound	0.6	<1	18	18		20.76									
Upper Bound	1.2	3	21	23		22.97									
L1787168-11 119331								<0.01	0.02						
DUP								0.01	<0.01						
Target Range - Lower Bound								<0.01	<0.01						
Upper Bound								0.02	0.02						
L1787168-16 119326							0.01								
DUP							0.01								
Target Range - Lower Bound							<0.01								
Upper Bound							0.02								

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QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-8 119333																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-9 119332																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-11 119331																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-16 119326																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-8 119333																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-9 119332																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-11 119331																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-16 119326																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05
								DUPLICATES								
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-8 119333																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-9 119332																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-11 119331																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1787168-16 119326																
DUP																
Target Range - Lower Bound																
Upper Bound																

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Finalized Date: 16-JUL-2016
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Project: L1787168

QC CERTIFICATE OF ANALYSIS VA16101612

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5

DUPLICATES

Sample Description	Y	Zn	Zr
ORIGINAL			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1787168-8 119333			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1787168-9 119332			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1787168-11 119331			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1787168-16 119326			
DUP			
Target Range - Lower Bound			
Upper Bound			

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Finalized Date: 16-JUL-2016
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QC CERTIFICATE OF ANALYSIS VA16101612

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:			
C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	S-CAL06	S-GRA06
S-GRA06a	S-IR08	SPL-21	WEI-21

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

L1787168-COFC

COC Number: 15 - 005

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals- Aqua regia disgestion (ICP)	Paste pH	% Inorganic Carbonate	Total Corbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	117470	may 22		Composite	R	R	R	R	R	R	
	117471	may 22									
	117472	may 22/16		waste							
	123699	may 22/16		waste							
	117473	may 21/16		SAT							
	123699	may 24 16		waste							
		may 21/16		waste							
	119329	June 9/16		waste							
	119333	June 9/16		waste							
	119332	June 9/16		waste							
	119330	June 9/16		waste							
	119331	June 9/16		waste							
	119334	June 9/16		waste							

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 17.7

FINAL COOLER TEMPERATURES °C: 6.8 °C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Phyllistine Hager	Date: June 21 2016	Time:	Received by:	Date: 22-JUN-16	Time: 11:00	Received by:	Date: Jun. 23	Time: 4pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy

1. If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

OCTOBER 2015 FRONT

ALS

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Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1787168-COFC

COC Number: 15 -

Page of

Report To — Contact and company name below will appear on the final report

Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: minto_environment@mintomine.com

Email 2

Email 3

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Invoice To

Same as Report To	☐ YES ☑ NO
Copy of Invoice with Report	☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: ap@mintomine.com

Email 2

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#

Major/Minor Code: | Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact:

Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals- Aqua regia digestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	119328	09/06/16		Composite	R	R	R	R	R	R	
	119327	June 9/16									
	117474	June 9/16									
	119326	June 9/16									
	117475	June 9/16									
	119335	June 9/16									
	UG Tails	June 14									
	UG Tails	June 14									

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 17.9

FINAL COOLER TEMPERATURES °C: 6/8°C

SHIPMENT RELEASE (client use)

Released by: | Date: | Time:

INITIAL SHIPMENT RECEPTION (lab use only)

Received by: | Date: 22-JUN-16 | Time: 11:00

FINAL SHIPMENT RECEPTION (lab use only)

Received by: | Date: June 23 | Time: 4pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

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1. If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

OCTOBER 2015 FRONT

Minto Explorations Ltd.
ATTN: Minto Environment
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 21-JUL-16
Report Date: 23-AUG-16 14:51 (MT)
Version: FINAL

Client Phone: 604-759-0860

Certificate of Analysis

Lab Work Order #: L1802714
Project P.O. #: 220826
Job Reference:
C of C Numbers: 15-007
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1802714-1 Composite 27-JUN-16 119336	L1802714-2 Waste 27-JUN-16 119337	L1802714-3 Sat 28-JUN-16 119338	L1802714-4 Waste 27-JUN-16 119340	L1802714-5 Waste 28-JUN-16 119341
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.6	8.8	8.6	8.9	8.9
Organic / Inorganic Carbon	Carbon (C) (%)	0.19	0.15	0.12	0.13	0.16
Acid Base Accounting	FIZZ RATING (Unity)	2	2	1	1	1
	MPA (tCaCO3/1Kt)	0.9	1.6	2.2	0.3	0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	24	20	18	18	19
	NNP (tCaCO3/1Kt)	23	18	16	18	19
	Ratio (NP/MPA) (Unity)	25.60	12.80	8.23	57.60	60.80
	Sulfate Sulfur (carbonate leach) (%)	0.02	0.02	0.02	0.01	0.01
	Sulfate Sulfur (HCl leach) (%)	0.02	<0.01	0.04	<0.01	0.02
	Sulfide Sulfur (T minus carbonate leach) (%)	0.01	0.03	0.05	<0.01	<0.01
	Total Sulfur (combustion) (%)	0.03	0.05	0.07	0.01	0.01
Total Metals	Aluminum (Al) (%)	1.16	1.20	1.81	1.20	1.17
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	2.4	0.7	1.6	0.6	0.6
	Barium (Ba) (ppm)	120	210	80	210	170
	Beryllium (Be) (ppm)	0.42	0.24	0.69	0.30	0.30
	Bismuth (Bi) (ppm)	0.11	0.18	0.25	0.01	0.01
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.03	0.05	0.07	0.02	0.03
	Calcium (Ca) (%)	1.13	0.92	1.36	0.92	1.04
	Cerium (Ce) (ppm)	20.7	19.15	13.75	16.55	16.25
	Cesium (Cs) (ppm)	0.18	0.31	0.10	0.26	0.19
	Chromium (Cr) (ppm)	4	5	5	5	5
	Cobalt (Co) (ppm)	5.9	6.4	6.4	6.6	5.9
	Copper (Cu) (ppm)	371	624	970	29.7	33.2
	Gallium (Ga) (ppm)	6.05	6.12	8.39	5.88	5.45
	Germanium (Ge) (ppm)	0.07	0.08	0.07	0.08	0.07
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.06	0.07	0.02	0.09	0.08
	Indium (In) (ppm)	0.017	0.025	0.016	0.016	0.015
	Iron (Fe) (%)	2.12	2.54	2.44	2.25	2.18
	Lanthanum (La) (ppm)	11.1	10.0	6.7	9.1	8.7
	Lead (Pb) (ppm)	3.2	1.9	6.5	5.7	2.1
	Lithium (Li) (ppm)	5.1	5.3	8.9	5.5	4.8
	Magnesium (Mg) (%)	0.62	0.66	0.93	0.70	0.63
	Manganese (Mn) (ppm)	520	539	530	511	477

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1802714-6	L1802714-7	L1802714-8	L1802714-9	L1802714-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	28-JUN-16	28-JUN-16	01-JUL-16	06-JUL-16	06-JUL-16
	Sampled Time					
	Client ID	119342	119343	119339	119345	119344
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.6	8.8	8.6	8.5	8.9
Organic / Inorganic Carbon	Carbon (C) (%)	0.26	0.24	0.22	0.09	0.19
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	1	2
	MPA (tCaCO3/1Kt)	0.6	1.6	0.3	19.4	<0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	27	25	32	16	23
	NNP (tCaCO3/1Kt)	26	23	32	-3	23
	Ratio (NP/MPA) (Unity)	43.20	16.00	102.40	0.83	147.20
	Sulfate Sulfur (carbonate leach) (%)	<0.01	0.02	0.01	0.02	<0.01
	Sulfate Sulfur (HCl leach) (%)	0.02	0.02	<0.01	0.01	<0.01
	Sulfide Sulfur (T minus carbonate leach) (%)	0.02	0.03	<0.01	0.60	<0.01
	Total Sulfur (combustion) (%)	0.02	0.05	0.01	0.62	<0.01
Total Metals	Aluminum (Al) (%)	1.12	1.43	1.52	1.46	1.12
	Antimony (Sb) (ppm)	<0.05	<0.05	0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.6	0.6	1.1	1.4	1.1
	Barium (Ba) (ppm)	180	220	80	50	140
	Beryllium (Be) (ppm)	0.34	0.31	0.51	0.36	0.34
	Bismuth (Bi) (ppm)	0.03	0.17	0.03	2.85	0.02
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.04	0.10	0.02	0.59	0.03
	Calcium (Ca) (%)	1.22	1.16	1.68	0.98	1.11
	Cerium (Ce) (ppm)	20.6	19.85	18.45	10.30	13.00
	Cesium (Cs) (ppm)	0.26	0.31	0.12	0.08	0.15
	Chromium (Cr) (ppm)	5	5	5	4	4
	Cobalt (Co) (ppm)	6.3	6.3	6.2	5.3	5.1
	Copper (Cu) (ppm)	278	1150	68.8	>10000	44.5
	Gallium (Ga) (ppm)	5.35	7.27	7.51	8.93	5.59
	Germanium (Ge) (ppm)	0.07	0.07	0.06	0.09	0.06
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	0.3	<0.2
	Hafnium (Hf) (ppm)	0.09	0.05	0.07	0.05	0.07
	Indium (In) (ppm)	0.016	0.022	0.016	0.085	0.014
	Iron (Fe) (%)	2.16	2.56	2.13	3.36	1.89
	Lanthanum (La) (ppm)	11.4	10.2	9.5	4.8	6.4
	Lead (Pb) (ppm)	2.5	3.7	3.8	12.1	6.7
	Lithium (Li) (ppm)	4.7	7.2	6.7	7.7	5.3
	Magnesium (Mg) (%)	0.58	0.72	0.75	0.83	0.58
	Manganese (Mn) (ppm)	503	572	534	506	433

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1802714-11	L1802714-12			
	Description	Waste	Waste			
	Sampled Date	06-JUL-16	16-JUL-16			
	Sampled Time					
	Client ID	119346	119347			
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.8	8.7			
Organic / Inorganic Carbon	Carbon (C) (%)	0.27	0.28			
Acid Base Accounting	FIZZ RATING (Unity)	2	2			
	MPA (tCaCO3/1Kt)	<0.3	0.9			
	Neutralization Potential (NP) (tCaCO3/1Kt)	32	27			
	NNP (tCaCO3/1Kt)	32	26			
	Ratio (NP/MPA) (Unity)	204.80	28.80			
	Sulfate Sulfur (carbonate leach) (%)	0.01	<0.01			
	Sulfate Sulfur (HCl leach) (%)	0.02	0.04			
	Sulfide Sulfur (T minus carbonate leach) (%)	<0.01	0.03			
	Total Sulfur (combustion) (%)	<0.01	0.03			
Total Metals	Aluminum (Al) (%)	1.18	1.05			
	Antimony (Sb) (ppm)	<0.05	<0.05			
	Arsenic (As) (ppm)	2.7	0.8			
	Barium (Ba) (ppm)	220	170			
	Beryllium (Be) (ppm)	0.25	0.30			
	Bismuth (Bi) (ppm)	0.01	0.05			
	Boron (B) (ppm)	<10	<10			
	Cadmium (Cd) (ppm)	0.02	0.05			
	Calcium (Ca) (%)	1.46	1.20			
	Cerium (Ce) (ppm)	13.10	18.85			
	Cesium (Cs) (ppm)	0.24	0.20			
	Chromium (Cr) (ppm)	5	5			
	Cobalt (Co) (ppm)	5.8	5.0			
	Copper (Cu) (ppm)	8.6	587			
	Gallium (Ga) (ppm)	5.70	5.04			
	Germanium (Ge) (ppm)	0.07	0.06			
	Gold (Au) (ppm)	<0.2	<0.2			
	Hafnium (Hf) (ppm)	0.07	0.07			
	Indium (In) (ppm)	0.014	0.020			
	Iron (Fe) (%)	2.23	2.08			
	Lanthanum (La) (ppm)	7.3	10.0			
	Lead (Pb) (ppm)	1.4	1.7			
	Lithium (Li) (ppm)	6.1	4.6			
	Magnesium (Mg) (%)	0.64	0.53			
	Manganese (Mn) (ppm)	569	472			

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1802714-1	L1802714-2	L1802714-3	L1802714-4	L1802714-5
	Description	Composite	Waste	Sat	Waste	Waste
	Sampled Date	27-JUN-16	27-JUN-16	28-JUN-16	27-JUN-16	28-JUN-16
	Sampled Time					
	Client ID	119336	119337	119338	119340	119341
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	0.03	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.53	0.78	0.75	0.59	0.48
	Nickel (Ni) (ppm)	2.0	2.8	2.4	2.3	2.1
	Niobium (Nb) (ppm)	0.20	0.26	0.34	0.28	0.23
	Phosphorus (P) (ppm)	660	700	750	750	680
	Potassium (K) (%)	0.25	0.59	0.14	0.49	0.36
	Rhenium (Re) (ppm)	<0.001	<0.001	0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	11.6	28.5	7.9	21.8	15.1
	Scandium (Sc) (ppm)	3.8	4.2	3.3	4.4	3.7
	Selenium (Se) (ppm)	0.5	0.9	1.4	0.3	0.3
	Silver (Ag) (ppm)	0.15	0.27	0.35	0.03	0.03
	Sodium (Na) (%)	0.08	0.11	0.08	0.10	0.10
	Strontium (Sr) (ppm)	106.5	65.7	191.0	67.6	92.7
	Sulfur (S) (%)	0.03	0.05	0.07	0.01	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.03	0.06	0.17	0.01	0.01
	Thallium (Tl) (ppm)	0.06	0.14	0.03	0.10	0.07
	Thorium (Th) (ppm)	3.4	2.1	2.6	1.5	1.7
	Tin (Sn) (ppm)	0.4	0.5	0.5	0.5	0.4
	Titanium (Ti) (%)	0.073	0.125	0.159	0.130	0.100
	Tungsten (W) (ppm)	0.23	0.75	0.39	0.53	0.43
	Uranium (U) (ppm)	0.23	0.25	0.19	0.19	0.22
	Vanadium (V) (ppm)	41	55	54	54	47
	Yttrium (Y) (ppm)	6.63	7.13	3.99	6.97	6.67
	Zinc (Zn) (ppm)	58	69	78	59	52
	Zirconium (Zr) (ppm)	1.0	1.1	0.5	1.4	1.2
Permanent Gases	Carbon Dioxide (CO_2) (%)	0.7	0.5	0.5	0.5	0.6

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1802714-6	L1802714-7	L1802714-8	L1802714-9	L1802714-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	28-JUN-16	28-JUN-16	01-JUL-16	06-JUL-16	06-JUL-16
	Sampled Time					
	Client ID	119342	119343	119339	119345	119344
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	0.01	0.01	0.03	0.01
	Molybdenum (Mo) (ppm)	0.41	0.37	0.80	0.49	0.49
	Nickel (Ni) (ppm)	2.1	2.4	2.3	1.8	2.0
	Niobium (Nb) (ppm)	0.20	0.21	0.12	0.38	0.21
	Phosphorus (P) (ppm)	720	690	730	880	600
	Potassium (K) (%)	0.41	0.51	0.17	0.16	0.25
	Rhenium (Re) (ppm)	<0.001	<0.001	0.001	0.002	<0.001
	Rubidium (Rb) (ppm)	19.3	24.4	7.2	7.7	10.9
	Scandium (Sc) (ppm)	3.7	4.0	3.7	3.7	3.5
	Selenium (Se) (ppm)	0.3	0.9	0.4	10.9	0.4
	Silver (Ag) (ppm)	0.18	0.58	0.06	3.41	0.02
	Sodium (Na) (%)	0.08	0.09	0.06	0.04	0.09
	Strontium (Sr) (ppm)	109.0	112.0	155.5	91.8	162.0
	Sulfur (S) (%)	0.02	0.06	0.02	0.65	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.05	0.15	<0.01	0.86	<0.01
	Thallium (Tl) (ppm)	0.10	0.16	0.04	0.05	0.05
	Thorium (Th) (ppm)	3.0	3.0	1.7	3.2	1.0
	Tin (Sn) (ppm)	0.5	0.6	0.4	0.6	0.4
	Titanium (Ti) (%)	0.084	0.102	0.057	0.133	0.080
	Tungsten (W) (ppm)	0.31	0.23	0.08	0.42	0.24
	Uranium (U) (ppm)	0.35	0.22	0.28	0.24	0.22
	Vanadium (V) (ppm)	46	49	42	56	42
	Yttrium (Y) (ppm)	7.08	5.68	7.46	4.20	5.75
	Zinc (Zn) (ppm)	58	84	62	105	49
	Zirconium (Zr) (ppm)	1.3	0.8	1.1	1.0	1.1
Permanent Gases	Carbon Dioxide (CO2) (%)	0.9	0.9	0.8	0.3	0.7

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1802714-11	L1802714-12			
	Description	Waste	Waste			
	Sampled Date	06-JUL-16	16-JUL-16			
	Sampled Time					
	Client ID	119346	119347			
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	0.01			
	Molybdenum (Mo) (ppm)	0.50	0.27			
	Nickel (Ni) (ppm)	2.3	2.2			
	Niobium (Nb) (ppm)	0.19	0.16			
	Phosphorus (P) (ppm)	710	640			
	Potassium (K) (%)	0.48	0.35			
	Rhenium (Re) (ppm)	<0.001	<0.001			
	Rubidium (Rb) (ppm)	21.7	15.1			
	Scandium (Sc) (ppm)	3.7	3.7			
	Selenium (Se) (ppm)	0.3	0.7			
	Silver (Ag) (ppm)	0.02	0.27			
	Sodium (Na) (%)	0.08	0.07			
	Strontium (Sr) (ppm)	58.7	96.6			
	Sulfur (S) (%)	0.01	0.04			
	Tantalum (Ta) (ppm)	<0.01	<0.01			
	Tellurium (Te) (ppm)	<0.01	0.02			
	Thallium (Tl) (ppm)	0.10	0.08			
	Thorium (Th) (ppm)	1.1	2.0			
	Tin (Sn) (ppm)	0.4	0.5			
	Titanium (Ti) (%)	0.112	0.069			
	Tungsten (W) (ppm)	0.48	0.29			
	Uranium (U) (ppm)	0.17	0.22			
	Vanadium (V) (ppm)	51	41			
	Yttrium (Y) (ppm)	4.94	7.08			
	Zinc (Zn) (ppm)	58	58			
	Zirconium (Zr) (ppm)	1.0	1.1			
Permanent Gases	Carbon Dioxide (CO2) (%)	1.0	1.0			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ABA-OA-VOL08-AX	Soil	Acid Base Accounting	OA-VOL08
CARBON-C-GAS05-AX	Soil	Carbon, TOC and CO2	C-GAS05
ME-MS41-AX	Soil	Aqua Regia ICPMS	Aqua Regia ICPMS

A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-OA-ELE07-AX	Soil	pH	OA-ELE07
SULPHUR-S-CAL06-AX	Soil	Sulfide Sulfur Calc from Carbonate Leach	ALS Minerals S-CAL06

Sulfide Sulfur (as S) is calculated by subtracting the Carbonate Leachable Sulfate Sulfur (as S) from the Total Sulfur (as S) obtained from combustion.

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06-AX	Soil	Sulfate Sulfur in Soil (Carbonate Leach)	ALS Minerals S-GRA06

A prepared sample is boiled with a sodium carbonate solution for 30 minutes. Any insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06A-AX	Soil	Sulfate Sulfur in Soil (HCl Leach)	ALS Minerals S-GRA06A

A prepared sample is heated with dilute hydrochloric acid for 30 minutes. Silica and any acid-insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-IR08-AX	Soil	Total Sulfur in Soil by Combustion	ALS Minerals S-IR08

The sample is heated to approximately 1350 °C in an induction furnace while passing a stream of oxygen through the sample. Sulfur dioxide released from the sample is measured by an IR detection system and the Total Sulfur result is provided.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
AX	ALS MINERALS - VANCOUVER, B.C., CANADA

Chain of Custody Numbers:

15-007

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Canada Ltd.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

CERTIFICATE VA16120822

Project: L1802714

P.O. No.: ALSM-CW16-102-APN

This report is for 12 Other samples submitted to our lab in Vancouver, BC, Canada on 25-JUL-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	CAN DANG	SOFTWARE DEVELOPMENT GROUP

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
ME-OG46	Ore Grade Elements - AquaRegia	ICP-AES
Cu-OG46	Ore Grade Cu - Aqua Regia	VARIABLE
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: CAN DANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method Analyte Units LOR	WEI-21 Recvd Wt. kg 0.02	OA-VOL08m MPA tCaCO3/1Kt 0.3	OA-VOL08m FIZZ RAT Unity 1	OA-VOL08m NNP tCaCO3/1Kt 1	OA-VOL08m NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08m Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	S-CAL06 S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2	ME-MS41 Ag ppm 0.01	ME-MS41 Al % 0.01
L1802714-1 119336		1.08	0.9	2	23	24	8.6	25.60	0.03	0.02	0.02	0.01	0.19	0.7	0.15	1.16
L1802714-2 119337		1.70	1.6	2	18	20	8.8	12.80	0.05	0.02	<0.01	0.03	0.15	0.5	0.27	1.20
L1802714-3 119338		1.48	2.2	1	16	18	8.6	8.23	0.07	0.02	0.04	0.05	0.12	0.5	0.35	1.81
L1802714-4 119340		1.16	0.3	1	18	18	8.9	57.60	0.01	0.01	<0.01	<0.01	0.13	0.5	0.03	1.20
L1802714-5 119341		1.14	0.3	1	19	19	8.9	60.80	0.01	0.01	0.02	<0.01	0.16	0.6	0.03	1.17
L1802714-6 119342		1.10	0.6	2	26	27	8.6	43.20	0.02	<0.01	0.02	0.02	0.26	0.9	0.18	1.12
L1802714-7 119343		1.10	1.6	2	23	25	8.8	16.00	0.05	0.02	0.02	0.03	0.24	0.9	0.58	1.43
L1802714-8 119339		0.96	0.3	2	32	32	8.6	102.40	0.01	0.01	<0.01	<0.01	0.22	0.8	0.06	1.52
L1802714-9 119345		1.36	19.4	1	-3	16	8.5	0.83	0.62	0.02	0.01	0.60	0.09	0.3	3.41	1.46
L1802714-10 119344		1.04	<0.3	2	23	23	8.9	147.20	<0.01	<0.01	<0.01	<0.01	0.19	0.7	0.02	1.12
L1802714-11 119346		1.04	<0.3	2	32	32	8.8	204.80	<0.01	0.01	0.02	<0.01	0.27	1.0	0.02	1.18
L1802714-12 119347		1.10	0.9	2	26	27	8.7	28.80	0.03	<0.01	0.04	0.03	0.28	1.0	0.27	1.05

***** See Appendix Page for comments regarding this certificate *****

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ALS Minerals

To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	As	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga
	Units	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm
	LOR	0.1	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05
L1802714-1 119336		2.4	<0.2	<10	120	0.42	0.11	1.13	0.03	20.7	5.9	4	0.18	371	2.12	6.05
L1802714-2 119337		0.7	<0.2	<10	210	0.24	0.18	0.92	0.05	19.15	6.4	5	0.31	624	2.54	6.12
L1802714-3 119338		1.6	<0.2	<10	80	0.69	0.25	1.36	0.07	13.75	6.4	5	0.10	970	2.44	8.39
L1802714-4 119340		0.6	<0.2	<10	210	0.30	0.01	0.92	0.02	16.55	6.6	5	0.26	29.7	2.25	5.88
L1802714-5 119341		0.6	<0.2	<10	170	0.30	0.01	1.04	0.03	16.25	5.9	5	0.19	33.2	2.18	5.45
L1802714-6 119342		0.6	<0.2	<10	180	0.34	0.03	1.22	0.04	20.6	6.3	5	0.26	278	2.16	5.35
L1802714-7 119343		0.6	<0.2	<10	220	0.31	0.17	1.16	0.10	19.85	6.3	5	0.31	1150	2.56	7.27
L1802714-8 119339		1.1	<0.2	<10	80	0.51	0.03	1.68	0.02	18.45	6.2	5	0.12	68.8	2.13	7.51
L1802714-9 119345		1.4	0.3	<10	50	0.36	2.85	0.98	0.59	10.30	5.3	4	0.08	>10000	3.36	8.93
L1802714-10 119344		1.1	<0.2	<10	140	0.34	0.02	1.11	0.03	13.00	5.1	4	0.15	44.5	1.89	5.59
L1802714-11 119346		2.7	<0.2	<10	220	0.25	0.01	1.46	0.02	13.10	5.8	5	0.24	8.6	2.23	5.70
L1802714-12 119347		0.8	<0.2	<10	170	0.30	0.05	1.20	0.05	18.85	5.0	5	0.20	587	2.08	5.04

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2
L1802714-1 119336		0.07	0.06	<0.01	0.017	0.25	11.1	5.1	0.62	520	0.53	0.08	0.20	2.0	660	3.2
L1802714-2 119337		0.08	0.07	<0.01	0.025	0.59	10.0	5.3	0.66	539	0.78	0.11	0.26	2.8	700	1.9
L1802714-3 119338		0.07	0.02	0.03	0.016	0.14	6.7	8.9	0.93	530	0.75	0.08	0.34	2.4	750	6.5
L1802714-4 119340		0.08	0.09	<0.01	0.016	0.49	9.1	5.5	0.70	511	0.59	0.10	0.28	2.3	750	5.7
L1802714-5 119341		0.07	0.08	<0.01	0.015	0.36	8.7	4.8	0.63	477	0.48	0.10	0.23	2.1	680	2.1
L1802714-6 119342		0.07	0.09	<0.01	0.016	0.41	11.4	4.7	0.58	503	0.41	0.08	0.20	2.1	720	2.5
L1802714-7 119343		0.07	0.05	0.01	0.022	0.51	10.2	7.2	0.72	572	0.37	0.09	0.21	2.4	690	3.7
L1802714-8 119339		0.06	0.07	0.01	0.016	0.17	9.5	6.7	0.75	534	0.80	0.06	0.12	2.3	730	3.8
L1802714-9 119345		0.09	0.05	0.03	0.085	0.16	4.8	7.7	0.83	506	0.49	0.04	0.38	1.8	880	12.1
L1802714-10 119344		0.06	0.07	0.01	0.014	0.25	6.4	5.3	0.58	433	0.49	0.09	0.21	2.0	600	6.7
L1802714-11 119346		0.07	0.07	0.01	0.014	0.48	7.3	6.1	0.64	569	0.50	0.08	0.19	2.3	710	1.4
L1802714-12 119347		0.06	0.07	0.01	0.020	0.35	10.0	4.6	0.53	472	0.27	0.07	0.16	2.2	640	1.7

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V
	Units	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	LOR	0.1	0.001	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1
L1802714-1 119336		11.6	<0.001	0.03	<0.05	3.8	0.5	0.4	106.5	<0.01	0.03	3.4	0.073	0.06	0.23	41
L1802714-2 119337		28.5	<0.001	0.05	<0.05	4.2	0.9	0.5	65.7	<0.01	0.06	2.1	0.125	0.14	0.25	55
L1802714-3 119338		7.9	0.001	0.07	<0.05	3.3	1.4	0.5	191.0	<0.01	0.17	2.6	0.159	0.03	0.19	54
L1802714-4 119340		21.8	<0.001	0.01	<0.05	4.4	0.3	0.5	67.6	<0.01	0.01	1.5	0.130	0.10	0.19	54
L1802714-5 119341		15.1	<0.001	0.01	<0.05	3.7	0.3	0.4	92.7	<0.01	0.01	1.7	0.100	0.07	0.22	47
L1802714-6 119342		19.3	<0.001	0.02	<0.05	3.7	0.3	0.5	109.0	<0.01	0.05	3.0	0.084	0.10	0.35	46
L1802714-7 119343		24.4	<0.001	0.06	<0.05	4.0	0.9	0.6	112.0	<0.01	0.15	3.0	0.102	0.16	0.22	49
L1802714-8 119339		7.2	0.001	0.02	0.05	3.7	0.4	0.4	155.5	<0.01	<0.01	1.7	0.057	0.04	0.28	42
L1802714-9 119345		7.7	0.002	0.65	<0.05	3.7	10.9	0.6	91.8	<0.01	0.86	3.2	0.133	0.05	0.24	56
L1802714-10 119344		10.9	<0.001	0.01	<0.05	3.5	0.4	0.4	162.0	<0.01	<0.01	1.0	0.080	0.05	0.22	42
L1802714-11 119346		21.7	<0.001	0.01	<0.05	3.7	0.3	0.4	58.7	<0.01	<0.01	1.1	0.112	0.10	0.17	51
L1802714-12 119347		15.1	<0.001	0.04	<0.05	3.7	0.7	0.5	96.6	<0.01	0.02	2.0	0.069	0.08	0.22	41

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

CERTIFICATE OF ANALYSIS VA16120822

Sample Description / Method / Analyte / Units / LOR	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5	Cu-OG46 Cu % 0.001
L1802714-1 119336	0.23	6.63	58	1.0	
L1802714-2 119337	0.75	7.13	69	1.1	
L1802714-3 119338	0.39	3.99	78	0.5	
L1802714-4 119340	0.53	6.97	59	1.4	
L1802714-5 119341	0.43	6.67	52	1.2	
L1802714-6 119342	0.31	7.08	58	1.3	
L1802714-7 119343	0.23	5.68	84	0.8	
L1802714-8 119339	0.08	7.46	62	1.1	
L1802714-9 119345	0.42	4.20	105	1.0	1.195
L1802714-10 119344	0.24	5.75	49	1.1	
L1802714-11 119346	0.48	4.94	58	1.0	
L1802714-12 119347	0.29	7.08	58	1.1	

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

CERTIFICATE OF ANALYSIS VA16120822

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	Cu-OG46	LOG-22	ME-MS41
ME-OG46	OA-ELE07	OA-VOL08m	PUL-31
S-CAL06	S-GRA06	S-GRA06a	S-IR08
SPL-21	WEI-21		

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BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

QC CERTIFICATE VA16120822

Project: L1802714

P.O. No.: ALSM-CW16-102-APN

This report is for 12 Other samples submitted to our lab in Vancouver, BC, Canada on 25-JUL-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	CAN DANG	SOFTWARE DEVELOPMENT GROUP

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
ME-OG46	Ore Grade Elements - AquaRegia	ICP-AES
Cu-OG46	Ore Grade Cu - Aqua Regia	VARIABLE
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: CAN DANG
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
STANDARDS																
Buffer pH6						6.1										
Buffer pH6						6.1										
Target Range - Lower Bound						5.3										
Upper Bound						6.7										
CCU-1d																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY												0.51	1.9			
Target Range - Lower Bound												0.42	1.5			
Upper Bound												0.64	2.4			
DS-1								2.66								
Target Range - Lower Bound								2.51								
Upper Bound								2.71								
GBM903-13																
Target Range - Lower Bound																
Upper Bound																
GS310-10								0.28								
Target Range - Lower Bound								0.25								
Upper Bound								0.29								
KZK-1		25.0	2	32	57		2.28									
KZK-1		25.0	2	32	57		2.28									
Target Range - Lower Bound		22.9	<1	30	54		2.18									
Upper Bound		27.1	>4	38	64		2.53									
MA-2c												1.60	5.9			
Target Range - Lower Bound												1.50	5.5			
Upper Bound												1.84	6.8			
MA-3a												2.39	8.8			
MA-3a												2.43	8.9			
Target Range - Lower Bound												2.31	8.4			
Upper Bound												2.77	10.2			
NCSDC70006																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CCU-1d																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GBM903-13																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
NCSDC70006																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method Analyte Units LOR	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1
									STANDARDS							
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CCU-1d																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GBM903-13																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
NCSDC70006																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CCU-1d																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GBM903-13																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
NCSDC70006																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5	Cu-OG46 Cu % 0.001
STANDARDS					
Buffer pH6					
Buffer pH6					
Target Range - Lower Bound					
Upper Bound					
CCU-1d					23.6
Target Range - Lower Bound					23.1
Upper Bound					24.8
CO-ASSAY					
Target Range - Lower Bound					
Upper Bound					
DS-1					
Target Range - Lower Bound					
Upper Bound					
GBM903-13					2.89
Target Range - Lower Bound					2.79
Upper Bound					3.00
GS310-10					
Target Range - Lower Bound					
Upper Bound					
KZK-1					
KZK-1					
Target Range - Lower Bound					
Upper Bound					
MA-2c					
Target Range - Lower Bound					
Upper Bound					
MA-3a					
MA-3a					
Target Range - Lower Bound					
Upper Bound					
NCSDC70006					0.008
Target Range - Lower Bound					
Upper Bound					

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
STANDARDS															
OGGeo08													20.2	2.23	117.0
OGGeo08													20.6	2.19	120.0
Target Range - Lower Bound													18.15	2.05	107.0
Upper Bound													22.2	2.53	131.0
OREAS 604															
Target Range - Lower Bound															
Upper Bound															
OREAS 621															
Target Range - Lower Bound															
Upper Bound															
OREAS 920													0.10	2.36	5.2
OREAS 920													0.11	2.40	4.9
Target Range - Lower Bound													0.07	2.18	3.8
Upper Bound													0.12	2.68	4.9
SY-4											0.87	3.2			
SY-4											0.89	3.3			
Target Range - Lower Bound											0.84	3.0			
Upper Bound											1.08	4.0			
UTS-1								0.92							
Target Range - Lower Bound								0.83							
Upper Bound								0.93							
UTS-1									0.92						
UTS-1									0.84						
Target Range - Lower Bound									0.81						
Upper Bound									0.95						
UTS-4								1.73							
Target Range - Lower Bound								1.64							
Upper Bound								1.84							
UTS-4									1.79						
UTS-4									1.68						
Target Range - Lower Bound									1.61						
Upper Bound									1.87						

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge
Units	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
LOR	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05	0.05
STANDARDS															
OGGeo08	<0.2	<10	100	0.80	9.86	0.87	18.40	55.6	92.4	80	8.70	8550	5.22	8.55	0.17
OGGeo08	<0.2	<10	90	0.73	9.89	0.87	19.30	61.2	94.9	81	9.23	8670	5.18	8.58	0.16
Target Range - Lower Bound	<0.2	<10	60	0.61	9.44	0.82	16.75	56.7	87.2	75	8.68	7800	4.51	8.05	0.21
Upper Bound	0.4	30	110	0.89	11.55	1.02	20.5	69.3	107.0	93	10.70	8980	5.53	9.95	0.45
OREAS 604															
Target Range - Lower Bound															
Upper Bound															
OREAS 621															
Target Range - Lower Bound															
Upper Bound															
OREAS 920	<0.2	<10	80	0.75	0.66	0.32	0.06	74.8	15.2	41	2.20	109.5	3.61	7.16	0.10
OREAS 920	<0.2	<10	80	0.74	0.61	0.32	0.07	74.4	15.5	42	1.89	117.5	3.66	7.27	0.09
Target Range - Lower Bound	<0.2	<10	50	0.59	0.60	0.28	0.04	64.8	13.4	37	1.84	102.0	3.26	6.12	<0.05
Upper Bound	0.4	20	110	0.87	0.76	0.37	0.09	79.2	16.6	48	2.36	118.0	4.00	7.60	0.10
SY-4															
SY-4															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
UTS-4															
Target Range - Lower Bound															
Upper Bound															

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BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	Hf	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb
Units	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
LOR	0.02	0.01	0.005	0.01	0.2	0.1	0.01	5	0.05	0.01	0.05	0.2	10	0.2	0.1
STANDARDS															
OGGeo08	0.74	0.56	1.365	1.08	27.7	31.9	0.96	383	869	0.30	1.17	9100	820	7240	113.0
OGGeo08	0.78	0.52	1.415	1.07	29.5	31.5	0.95	385	881	0.29	1.15	8640	820	7230	120.0
Target Range - Lower Bound	0.72	0.41	1.335	0.94	27.7	29.8	0.84	350	811	0.26	0.97	7760	700	6520	109.5
Upper Bound	0.92	0.57	1.645	1.18	34.3	36.6	1.05	438	991	0.34	1.29	9480	880	7970	134.5
OREAS 604															
Target Range - Lower Bound															
Upper Bound															
OREAS 621															
Target Range - Lower Bound															
Upper Bound															
OREAS 920	0.63	<0.01	0.031	0.41	38.3	19.6	1.06	504	0.40	0.03	0.43	39.8	720	21.3	24.2
OREAS 920	0.53	0.01	0.029	0.42	36.9	21.3	1.08	511	0.39	0.02	0.36	39.5	720	20.7	24.0
Target Range - Lower Bound	0.53	<0.01	0.019	0.39	33.3	19.0	0.98	472	0.29	<0.01	0.31	34.4		19.2	22.2
Upper Bound	0.69	0.02	0.043	0.50	41.1	23.4	1.22	588	0.53	0.02	0.55	42.4		23.9	27.4
SY-4															
SY-4															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
UTS-4															
Target Range - Lower Bound															
Upper Bound															

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BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05
								STANDARDS								
OGGeo08		1.365	2.76	20.3	6.2	11.8	12.6	60.0	0.01	0.16	15.7	0.312	1.31	4.76	80	3.00
OGGeo08		1.380	2.79	21.6	6.1	11.4	14.0	62.0	<0.01	0.15	17.2	0.317	1.44	4.79	80	3.31
Target Range - Lower Bound		1.295	2.51	17.70	6.0	9.7	12.0	59.6	<0.01	0.14	15.6	0.279	1.14	4.45	70	2.58
Upper Bound		1.585	3.09	24.1	7.6	12.3	15.1	73.2	0.03	0.20	19.6	0.353	1.58	5.55	88	3.60
OREAS 604																
Target Range - Lower Bound																
Upper Bound																
OREAS 621																
Target Range - Lower Bound																
Upper Bound																
OREAS 920		<0.001	0.03	0.68	2.9	0.9	1.1	18.2	0.01	0.02	15.9	0.121	0.15	2.24	24	0.53
OREAS 920		0.001	0.03	0.61	2.9	0.9	1.1	17.3	0.01	0.02	16.1	0.129	0.16	2.08	25	0.48
Target Range - Lower Bound		<0.001	<0.01	0.45	2.5	0.4	0.7	15.0	<0.01	<0.01	13.6	0.106	0.07	1.89	23	<0.05
Upper Bound		0.002	0.05	0.77	3.3	1.3	1.7	18.8	0.02	0.02	17.0	0.140	0.18	2.42	30	0.10
SY-4																
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
UTS-4																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method Analyte Units LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5	Cu-OG46 Cu % 0.001
STANDARDS					
OGGeo08		15.75	7030	21.7	
OGGeo08		16.30	6980	24.0	
Target Range - Lower Bound		15.35	6500	19.5	
Upper Bound		18.85	7950	27.5	
OREAS 604					2.19
Target Range - Lower Bound					
Upper Bound					
OREAS 621					0.359
Target Range - Lower Bound					
Upper Bound					
OREAS 920		18.80	101	23.9	
OREAS 920		18.25	105	20.0	
Target Range - Lower Bound		16.85	93	17.6	
Upper Bound		20.7	119	25.0	
SY-4					
SY-4					
Target Range - Lower Bound					
Upper Bound					
UTS-1					
Target Range - Lower Bound					
Upper Bound					
UTS-1					
UTS-1					
Target Range - Lower Bound					
Upper Bound					
UTS-4					
Target Range - Lower Bound					
Upper Bound					
UTS-4					
UTS-4					
Target Range - Lower Bound					
Upper Bound					

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Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
BLANKS																
BLANK												<0.05	<0.2			
BLANK												<0.05	<0.2			
BLANK												<0.05	<0.2			
Target Range - Lower Bound												<0.05	<0.2			
Upper Bound												0.10	0.4			
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK														<0.01	<0.01	<0.1
BLANK														<0.01	<0.01	<0.1
Target Range - Lower Bound														<0.01	<0.01	<0.1
Upper Bound														0.02	0.02	0.2
BLANK						6.0										
Target Range - Lower Bound						5.5										
Upper Bound						6.9										
BLANK									<0.01							
Target Range - Lower Bound									<0.01							
Upper Bound									0.02							
BLANK										<0.01						
BLANK										<0.01						
Target Range - Lower Bound										<0.01						
Upper Bound										0.02						
BLANK								0.01								
Target Range - Lower Bound								<0.01								
Upper Bound								0.02								
DUPLICATES																
ORIGINAL														0.19	0.32	8.5
DUP														0.26	0.33	8.8
Target Range - Lower Bound														0.20	0.30	8.1
Upper Bound														0.25	0.35	9.2

***** See Appendix Page for comments regarding this certificate *****

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05
BLANKS																
BLANK																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.2	<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05
BLANK		<0.2	<10	<10	<0.05	0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05
Target Range - Lower Bound		<0.2	<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05
Upper Bound		0.4	20	20	0.10	0.02	0.02	0.02	0.04	0.2	2	0.10	0.4	0.02	0.10	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL		<0.2	<10	40	0.41	0.02	0.28	1.52	67.0	2.7	7	0.20	25.0	1.95	1.46	0.10
DUP		0.6	<10	40	0.38	0.03	0.28	1.52	70.2	2.6	5	0.21	24.2	2.02	1.46	0.09
Target Range - Lower Bound		<0.2	<10	30	0.33	<0.01	0.26	1.43	65.2	2.4	5	0.14	23.5	1.88	1.34	<0.05
Upper Bound		0.6	20	50	0.46	0.04	0.30	1.61	72.1	2.9	7	0.27	25.7	2.09	1.58	0.10

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BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description / Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	Hf	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb
Units	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
LOR	0.02	0.01	0.005	0.01	0.2	0.1	0.01	5	0.05	0.01	0.05	0.2	10	0.2	0.1
BLANKS															
BLANK															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK	<0.02	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
BLANK	<0.02	0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
Target Range - Lower Bound	<0.02	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
Upper Bound	0.04	0.02	0.010	0.02	0.4	0.2	0.02	10	0.10	0.02	0.10	0.4	20	0.4	0.2
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
DUPLICATES															
ORIGINAL	1.43	0.01	0.023	0.21	31.6	1.8	0.04	849	0.75	0.02	0.09	3.2	300	131.0	8.6
DUP	1.50	<0.01	0.023	0.21	33.2	1.8	0.04	863	0.69	0.02	0.09	3.1	310	136.0	8.8
Target Range - Lower Bound	1.37	<0.01	0.017	0.19	30.6	1.6	0.03	808	0.63	<0.01	<0.05	2.8	280	126.5	8.2
Upper Bound	1.56	0.02	0.029	0.23	34.2	2.0	0.05	904	0.81	0.03	0.10	3.5	330	140.5	9.2

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BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method Analyte Units LOR	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05
BLANKS																
BLANK																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
BLANK		<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
Target Range - Lower Bound		<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
Upper Bound		0.002	0.02	0.10	0.2	0.4	0.4	0.4	0.02	0.02	0.4	0.010	0.04	0.10	2	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL		<0.001	0.32	1.04	1.9	0.7	0.3	9.9	<0.01	0.02	10.9	<0.005	0.04	2.22	1	0.32
DUP		<0.001	0.33	1.05	1.8	0.5	0.3	10.3	<0.01	0.04	11.6	<0.005	0.05	2.42	1	0.32
Target Range - Lower Bound		<0.001	0.30	0.92	1.7	0.4	<0.2	9.4	<0.01	0.02	10.5	<0.005	<0.02	2.15	<1	0.25
Upper Bound		0.002	0.35	1.17	2.0	0.8	0.4	10.8	0.02	0.04	12.0	0.010	0.07	2.49	2	0.39

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BURNABY BC V5A 1W9

Finalized Date: 19-AUG-2016
Account: APN

Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5	Cu-OG46 Cu % 0.001
BLANKS					
BLANK					
BLANK					
BLANK					
Target Range - Lower Bound					
Upper Bound					
BLANK					<0.001
Target Range - Lower Bound					<0.001
Upper Bound					0.002
BLANK		<0.05	<2	<0.5	
BLANK		<0.05	<2	<0.5	
Target Range - Lower Bound		<0.05	<2	<0.5	
Upper Bound		0.10	4	1.0	
BLANK					
Target Range - Lower Bound					
Upper Bound					
BLANK					
Target Range - Lower Bound					
Upper Bound					
BLANK					
BLANK					
Target Range - Lower Bound					
Upper Bound					
BLANK					
Target Range - Lower Bound					
Upper Bound					
DUPLICATES					
ORIGINAL		9.50	141	50.9	
DUP		9.43	144	51.4	
Target Range - Lower Bound		8.94	133	46.8	
Upper Bound		9.99	152	55.5	

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
DUPLICATES																
ORIGINAL										<0.01						
DUP										<0.01						
Target Range - Lower Bound										<0.01						
Upper Bound										0.02						
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-7 119343												0.24	0.9			
DUP												0.24	0.9			
Target Range - Lower Bound												0.18	0.7			
Upper Bound												0.30	1.1			
L1802714-8 119339												0.22	0.8			
DUP												0.24	0.9			
Target Range - Lower Bound												0.17	0.6			
Upper Bound												0.29	1.1			
L1802714-10 119344		<0.3	2	23	23	8.9	147.20	<0.01	<0.01	<0.01	<0.01	0.19	0.7			
DUP		<0.3	2	23	23	9.1	147.20	<0.01	<0.01	0.05	<0.01	0.16	0.6			
Target Range - Lower Bound		<0.3	<1	21	21	8.5	139.83	<0.01	<0.01	0.02	<0.01	0.12	0.4			
Upper Bound		0.6	3	25	25	9.6	154.57	0.02	0.02	0.04	0.02	0.23	0.9			
ORIGINAL														1.19	0.05	17.7
DUP														1.39	0.05	19.3
Target Range - Lower Bound														1.22	0.04	17.5
Upper Bound														1.36	0.06	19.5

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Finalized Date: 19-AUG-2016
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Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-7 119343																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-8 119339																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-10 119344																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL		<0.2	<10	10	<0.05	3.93	0.44	0.53	2.00	2.8	12	0.08	49.3	0.92	0.37	<0.05
DUP		<0.2	<10	10	<0.05	4.10	0.47	0.50	2.18	3.0	15	0.08	52.1	0.99	0.39	<0.05
Target Range - Lower Bound		<0.2	<10	<10	<0.05	3.80	0.42	0.48	1.97	2.7	12	<0.05	48.7	0.90	0.31	<0.05
Upper Bound		0.4	20	20	0.10	4.23	0.49	0.55	2.21	3.1	15	0.10	52.7	1.01	0.45	0.10

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1
DUPLICATES																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-7 119343																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-8 119339																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-10 119344																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL		0.02	<0.01	0.022	0.02	1.0	0.4	0.08	332	1.55	0.01	0.08	9.6	130	128.0	1.2
DUP		0.02	<0.01	0.022	0.02	1.2	0.4	0.09	351	1.72	0.01	0.08	10.4	140	136.5	1.3
Target Range - Lower Bound		<0.02	<0.01	0.016	<0.01	0.8	0.3	0.07	319	1.50	<0.01	<0.05	9.3	120	125.5	1.1
Upper Bound		0.04	0.02	0.028	0.03	1.4	0.5	0.10	364	1.77	0.02	0.10	10.7	150	139.0	1.4

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QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05
		DUPLICATES														
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-7 119343																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-8 119339																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1802714-10 119344																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL		<0.001	0.02	0.27	0.2	0.5	<0.2	12.9	<0.01	0.09	0.2	<0.005	0.04	0.25	3	<0.05
DUP		<0.001	0.02	0.31	0.2	0.5	<0.2	13.9	<0.01	0.09	0.2	<0.005	0.04	0.27	4	<0.05
Target Range - Lower Bound		<0.001	<0.01	0.22	<0.1	0.3	<0.2	12.5	<0.01	0.08	<0.2	<0.005	<0.02	0.20	2	<0.05
Upper Bound		0.002	0.03	0.36	0.3	0.7	0.4	14.3	0.02	0.10	0.4	0.010	0.06	0.32	5	0.10

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Project: L1802714

QC CERTIFICATE OF ANALYSIS VA16120822

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5	Cu-OG46 Cu % 0.001
DUPLICATES					
ORIGINAL					
DUP					
Target Range - Lower Bound					
Upper Bound					
ORIGINAL					2.05
DUP					2.05
Target Range - Lower Bound					2.000
Upper Bound					2.10
L1802714-7 119343					
DUP					
Target Range - Lower Bound					
Upper Bound					
L1802714-8 119339					
DUP					
Target Range - Lower Bound					
Upper Bound					
L1802714-10 119344					
DUP					
Target Range - Lower Bound					
Upper Bound					
ORIGINAL		1.07	152	0.7	
DUP		1.16	150	0.7	
Target Range - Lower Bound		1.01	141	<0.5	
Upper Bound		1.22	161	1.0	

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Finalized Date: 19-AUG-2016
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QC CERTIFICATE OF ANALYSIS VA16120822

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	Cu-OG46	LOG-22	ME-MS41
ME-OG46	OA-ELE07	OA-VOL08m	PUL-31
S-CAL06	S-GRA06	S-GRA06a	S-IR08
SPL-21	WEI-21		

Chain of Custody (COC) / Analytical Request Form

ALS

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1802714-COFC

COC Number: 15 - 007

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4669
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact:

Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals- Aqua regia digestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	119336 ✓	27-06-16		Composite	R	R	R	R	R	R	
	119337 ✓	27-06-16		waste							
	119338 ✓	28-06-16		SAT							
	119340 ✓	27-06-16		waste							
	119341 ✓	28-06-16		waste							
	119342 ✓	28-06-16		waste							
	119343 ✓	28-06-16		waste							
	119[illegible] ✓	01-07-16		waste							
	119345 ✓	July 6/16		waste							
	119344 ✓	July 6/16		waste							
	119346 ✓	July 6/16		waste							
	119347 ✓	July 16/16		waste							

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

ALSM - CW16 - 102 - APN

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C	
14.0				

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Phyllistine Hager	Date: July 18, 2016	Time:	Received by: [signature]	Date: 21-Jul-16	Time: 3:15	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

Minto Explorations Ltd.
ATTN: Minto Environment
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 16-AUG-16
Report Date: 19-SEP-16 17:52 (MT)
Version: FINAL

Client Phone: 604-759-0860

Certificate of Analysis

Lab Work Order #: L1813909

Project P.O. #: 220826
Job Reference: COMPOSITE
C of C Numbers: 15-008, 15-009
Legal Site Desc:

Comments: Please note, the ALS Minerals version of the finalized report and QC can be found at the end of the attachment.

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813909-1	L1813909-2	L1813909-3	L1813909-4	L1813909-5
	Description					
	Sampled Date	13-JUN-16	20-JUL-16	20-JUL-16	20-JUL-16	24-JUL-16
	Sampled Time					
	Client ID	JUNE 2016	119348	119349	119350	127976
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.3	8.5	8.9	8.9	8.3
Organic / Inorganic Carbon	Carbon (C) (%)	0.24	0.27	0.17	0.09	0.26
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	1	1
	MPA (tCaCO3/1Kt)	1.6	0.3	0.3	0.3	1.9
	Neutralization Potential (NP) (tCaCO3/1Kt)	20	26	17	13	22
	NNP (tCaCO3/1Kt)	18	26	17	13	20
	Ratio (NP/MPA) (Unity)	12.80	83.20	54.40	41.60	11.73
	Sulfate Sulfur (carbonate leach) (%)	<0.01	<0.01	<0.01	<0.01	0.01
	Sulfate Sulfur (HCl leach) (%)	<0.01	0.01	<0.01	<0.01	0.02
	Sulfide Sulfur (T minus carbonate leach) (%)	0.05	0.01	0.01	0.01	0.05
	Total Sulfur (combustion) (%)	0.05	0.01	0.01	0.01	0.06
Total Metals	Aluminum (Al) (%)	1.48	1.35	1.18	1.31	1.28
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	0.07	<0.05
	Arsenic (As) (ppm)	2.1	1.4	0.6	1.2	0.7
	Barium (Ba) (ppm)	190	120	220	170	230
	Beryllium (Be) (ppm)	0.23	0.39	0.23	0.30	0.26
	Bismuth (Bi) (ppm)	0.19	0.02	0.01	0.05	0.22
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.26	0.03	0.02	0.04	0.06
	Calcium (Ca) (%)	0.88	1.44	0.92	1.02	1.24
	Cerium (Ce) (ppm)	17.65	15.50	15.05	18.05	19.70
	Cesium (Cs) (ppm)	0.70	0.14	0.26	0.19	0.41
	Chromium (Cr) (ppm)	7	6	6	6	7
	Cobalt (Co) (ppm)	7.3	6.2	6.1	6.2	6.6
	Copper (Cu) (ppm)	871	45.5	16.8	25.5	1070
	Gallium (Ga) (ppm)	9.09	6.04	5.14	5.91	6.49
	Germanium (Ge) (ppm)	0.08	0.06	0.07	0.09	0.09
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.05	0.09	0.07	0.08	0.08
	Indium (In) (ppm)	0.097	0.019	0.020	0.018	0.034
	Iron (Fe) (%)	4.27	2.26	2.26	2.28	2.79
	Lanthanum (La) (ppm)	8.6	7.3	7.4	9.8	10.6
	Lead (Pb) (ppm)	3.1	2.6	1.9	2.7	2.4
	Lithium (Li) (ppm)	6.8	7.1	6.1	5.6	5.6
	Magnesium (Mg) (%)	0.72	0.65	0.63	0.71	0.59
	Manganese (Mn) (ppm)	648	537	511	511	568

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813909-6	L1813909-7	L1813909-8	L1813909-9	L1813909-10
	Description					
	Sampled Date	24-JUL-16	30-JUL-16	30-JUL-16	30-JUL-16	30-JUL-16
	Sampled Time					
	Client ID	127977	127980	127978	127979	130441
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.6	8.9	8.8	8.9	8.4
Organic / Inorganic Carbon	Carbon (C) (%)	0.16	0.20	0.17	0.25	0.08
Acid Base Accounting	FIZZ RATING (Unity)	1	1	1	2	1
	MPA (tCaCO3/1Kt)	4.7	0.3	0.3	0.9	12.5
	Neutralization Potential (NP) (tCaCO3/1Kt)	15	18	17	22	12
	NNP (tCaCO3/1Kt)	10	18	17	21	-1
	Ratio (NP/MPA) (Unity)	3.20	57.60	54.40	23.47	0.96
	Sulfate Sulfur (carbonate leach) (%)	0.01	0.02	0.01	0.01	0.23
	Sulfate Sulfur (HCl leach) (%)	0.03	0.02	<0.01	0.01	0.29
	Sulfide Sulfur (T minus carbonate leach) (%)	0.14	<0.01	<0.01	0.02	0.17
	Total Sulfur (combustion) (%)	0.15	0.01	0.01	0.03	0.40
Total Metals	Aluminum (Al) (%)	1.30	1.14	1.26	1.55	1.47
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.3	0.3	0.6	1.1	0.1
	Barium (Ba) (ppm)	230	240	230	240	410
	Beryllium (Be) (ppm)	0.21	0.26	0.29	0.33	0.15
	Bismuth (Bi) (ppm)	0.85	0.02	0.01	0.05	0.07
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.13	0.03	0.02	0.06	0.09
	Calcium (Ca) (%)	0.79	0.99	1.06	1.23	0.92
	Cerium (Ce) (ppm)	13.85	14.60	17.30	13.00	25.0
	Cesium (Cs) (ppm)	0.29	0.27	0.27	0.21	0.62
	Chromium (Cr) (ppm)	6	5	6	6	10
	Cobalt (Co) (ppm)	6.3	5.8	6.3	7.3	6.4
	Copper (Cu) (ppm)	2920	55.7	9.0	301	1085
	Gallium (Ga) (ppm)	6.34	5.08	5.61	7.06	6.93
	Germanium (Ge) (ppm)	0.06	0.07	0.08	0.08	0.08
	Gold (Au) (ppm)	0.4	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.05	0.08	0.09	0.06	0.03
	Indium (In) (ppm)	0.032	0.018	0.015	0.018	0.027
	Iron (Fe) (%)	2.71	2.20	2.35	2.73	2.64
	Lanthanum (La) (ppm)	7.5	7.6	9.6	7.3	12.8
	Lead (Pb) (ppm)	2.9	1.7	1.3	2.8	1.9
	Lithium (Li) (ppm)	5.9	4.9	6.1	7.6	6.1
	Magnesium (Mg) (%)	0.68	0.60	0.65	0.87	0.76
	Manganese (Mn) (ppm)	527	500	525	619	465

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813909-11	L1813909-12	L1813909-13	L1813909-14	L1813909-15
	Description					
	Sampled Date	30-JUL-16	02-AUG-16	02-AUG-16	02-AUG-16	02-AUG-16
	Sampled Time					
	Client ID	130440	127787	127786	127785	127788
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.4	9.2	9.1	9.2	9.2
Organic / Inorganic Carbon	Carbon (C) (%)	0.10	0.08	0.08	0.08	0.08
Acid Base Accounting	FIZZ RATING (Unity)	1	1	1	1	1
	MPA (tCaCO3/1Kt)	17.5	0.3	1.3	0.3	<0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	12	11	12	11	12
	NNP (tCaCO3/1Kt)	-6	11	11	11	12
	Ratio (NP/MPA) (Unity)	0.69	35.20	9.60	35.20	76.80
	Sulfate Sulfur (carbonate leach) (%)	0.33	0.02	0.02	0.01	0.01
	Sulfate Sulfur (HCl leach) (%)	0.36	<0.01	0.03	0.02	<0.01
	Sulfide Sulfur (T minus carbonate leach) (%)	0.23	<0.01	0.02	<0.01	<0.01
	Total Sulfur (combustion) (%)	0.56	0.01	0.04	0.01	<0.01
Total Metals	Aluminum (Al) (%)	1.29	1.25	1.28	1.18	1.33
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.2	0.7	0.7	0.4	0.7
	Barium (Ba) (ppm)	330	220	200	200	230
	Beryllium (Be) (ppm)	0.12	0.27	0.26	0.27	0.33
	Bismuth (Bi) (ppm)	0.21	0.01	0.07	0.02	0.01
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.16	0.03	0.04	0.04	0.03
	Calcium (Ca) (%)	1.04	0.85	0.86	0.85	0.90
	Cerium (Ce) (ppm)	19.05	13.90	14.60	16.55	19.35
	Cesium (Cs) (ppm)	0.50	0.25	0.26	0.26	0.29
	Chromium (Cr) (ppm)	10	7	7	7	8
	Cobalt (Co) (ppm)	5.0	6.1	6.3	6.0	6.6
	Copper (Cu) (ppm)	1855	18.1	514	91.0	27.9
	Gallium (Ga) (ppm)	5.80	5.54	5.64	5.54	5.98
	Germanium (Ge) (ppm)	0.07	0.08	0.09	0.11	0.10
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.02	0.08	0.07	0.11	0.10
	Indium (In) (ppm)	0.030	0.014	0.021	0.019	0.020
	Iron (Fe) (%)	2.23	2.23	2.37	2.16	2.45
	Lanthanum (La) (ppm)	9.8	7.2	7.6	8.7	10.6
	Lead (Pb) (ppm)	2.1	1.5	2.0	1.4	1.6
	Lithium (Li) (ppm)	5.3	5.7	6.6	5.4	6.4
	Magnesium (Mg) (%)	0.68	0.68	0.74	0.66	0.73
	Manganese (Mn) (ppm)	384	485	516	488	526

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813909-16	L1813909-17	L1813909-18	L1813909-19	L1813909-20
	Description					
	Sampled Date	02-AUG-16	04-AUG-16	09-AUG-16	09-AUG-16	20-JUL-16
	Sampled Time		16:15	16:15	16:15	
	Client ID	127981	127982	127983	127984	TAILS
SOIL						
Physical Tests	pH (Unity)	8.7	9.2	9.1	8.9	8.5
Organic / Inorganic Carbon	Carbon (C) (%)	0.32	0.09	0.15	0.19	0.20
Acid Base Accounting	FIZZ RATING (Unity)	1	1	1	1	1
	MPA (tCaCO3/1Kt)	0.3	0.3	<0.3	<0.3	1.9
	Neutralization Potential (NP) (tCaCO3/1Kt)	25	14	16	19	12
	NNP (tCaCO3/1Kt)	25	14	16	19	10
	Ratio (NP/MPA) (Unity)	80.00	44.80	102.40	121.60	6.40
	Sulfate Sulfur (carbonate leach) (%)	0.01	<0.01	0.02	<0.01	0.02
	Sulfate Sulfur (HCl leach) (%)	0.02	0.02	0.02	0.01	<0.01
	Sulfide Sulfur (T minus carbonate leach) (%)	<0.01	0.01	<0.01	<0.01	0.04
	Total Sulfur (combustion) (%)	0.01	0.01	<0.01	<0.01	0.06
Total Metals	Aluminum (Al) (%)	1.28	1.32	1.25	1.29	1.16
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.7	0.4	0.6	0.6	0.7
	Barium (Ba) (ppm)	260	150	200	180	120
	Beryllium (Be) (ppm)	0.33	0.35	0.30	0.36	0.18
	Bismuth (Bi) (ppm)	0.01	0.01	0.01	0.02	0.30
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.03	0.02	0.02	0.03	0.28
	Calcium (Ca) (%)	1.30	1.08	1.02	1.13	0.59
	Cerium (Ce) (ppm)	19.50	14.35	15.15	16.90	8.68
	Cesium (Cs) (ppm)	0.28	0.14	0.22	0.21	0.31
	Chromium (Cr) (ppm)	5	6	6	6	8
	Cobalt (Co) (ppm)	6.5	5.9	6.2	5.8	7.9
	Copper (Cu) (ppm)	23.3	14.1	11.0	57.1	1280
	Gallium (Ga) (ppm)	5.83	5.93	5.83	5.94	10.65
	Germanium (Ge) (ppm)	0.07	0.08	0.08	0.08	0.06
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	0.2
	Hafnium (Hf) (ppm)	0.09	0.09	0.09	0.08	0.04
	Indium (In) (ppm)	0.019	0.015	0.015	0.014	0.083
	Iron (Fe) (%)	2.43	2.18	2.32	2.27	5.79
	Lanthanum (La) (ppm)	10.3	7.4	7.7	8.8	4.5
	Lead (Pb) (ppm)	2.5	2.2	1.7	3.2	3.4
	Lithium (Li) (ppm)	6.2	5.8	5.9	6.1	5.3
	Magnesium (Mg) (%)	0.63	0.70	0.69	0.65	0.58
	Manganese (Mn) (ppm)	557	504	520	520	650

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813909-21	L1813909-22	L1813909-23	L1813909-24	
	Description					
	Sampled Date	10-AUG-16				
	Sampled Time					
	Client ID	127985	127986	127987	127988	
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.9	8.6	8.5	8.9	
Organic / Inorganic Carbon	Carbon (C) (%)	0.20	0.30	0.41	0.20	
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	
	MPA (tCaCO3/1Kt)	0.3	0.3	1.6	0.3	
	Neutralization Potential (NP) (tCaCO3/1Kt)	22	30	38	21	
	NNP (tCaCO3/1Kt)	22	30	36	21	
	Ratio (NP/MPA) (Unity)	70.40	96.00	24.32	67.20	
	Sulfate Sulfur (carbonate leach) (%)	0.01	0.01	0.01	0.01	
	Sulfate Sulfur (HCl leach) (%)	0.01	0.03	0.06	<0.01	
	Sulfide Sulfur (T minus carbonate leach) (%)	<0.01	<0.01	0.04	<0.01	
	Total Sulfur (combustion) (%)	0.01	0.01	0.05	0.01	
Total Metals	Aluminum (Al) (%)	1.48	1.41	1.69	1.43	
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	
	Arsenic (As) (ppm)	0.9	1.2	1.1	0.8	
	Barium (Ba) (ppm)	100	80	60	190	
	Beryllium (Be) (ppm)	0.45	0.49	0.62	0.36	
	Bismuth (Bi) (ppm)	0.04	0.02	0.22	0.02	
	Boron (B) (ppm)	<10	<10	<10	<10	
	Cadmium (Cd) (ppm)	0.04	0.04	0.06	0.03	
	Calcium (Ca) (%)	1.48	1.66	2.13	1.31	
	Cerium (Ce) (ppm)	18.70	18.05	17.70	13.95	
	Cesium (Cs) (ppm)	0.12	0.14	0.15	0.18	
	Chromium (Cr) (ppm)	6	5	5	6	
	Cobalt (Co) (ppm)	6.1	5.7	6.1	6.4	
	Copper (Cu) (ppm)	195.0	97.8	861	79.0	
	Gallium (Ga) (ppm)	6.88	6.13	7.76	6.57	
	Germanium (Ge) (ppm)	0.09	0.07	0.07	0.08	
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	
	Hafnium (Hf) (ppm)	0.06	0.09	0.06	0.08	
	Indium (In) (ppm)	0.017	0.016	0.021	0.017	
	Iron (Fe) (%)	2.27	2.02	2.28	2.37	
	Lanthanum (La) (ppm)	9.6	9.7	9.0	7.3	
	Lead (Pb) (ppm)	5.2	4.1	7.7	2.7	
	Lithium (Li) (ppm)	6.7	6.1	6.9	6.3	
	Magnesium (Mg) (%)	0.72	0.60	0.69	0.75	
	Manganese (Mn) (ppm)	528	490	535	563	

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813909-1	L1813909-2	L1813909-3	L1813909-4	L1813909-5
	Sample ID	L1813909-1	L1813909-2	L1813909-3	L1813909-4	L1813909-5
	Description					
	Sampled Date	13-JUN-16	20-JUL-16	20-JUL-16	20-JUL-16	24-JUL-16
	Sampled Time					
	Client ID	JUNE 2016	119348	119349	119350	127976
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.78	0.68	0.63	0.34	0.81
	Nickel (Ni) (ppm)	2.8	2.6	2.3	2.3	3.5
	Niobium (Nb) (ppm)	0.24	0.20	0.19	0.25	0.36
	Phosphorus (P) (ppm)	870	700	720	760	800
	Potassium (K) (%)	0.82	0.24	0.53	0.35	0.64
	Rhenium (Re) (ppm)	0.001	<0.001	<0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	46.9	9.4	23.2	13.8	31.7
	Scandium (Sc) (ppm)	4.5	4.5	4.1	3.9	5.5
	Selenium (Se) (ppm)	0.9	0.4	0.2	0.3	1.1
	Silver (Ag) (ppm)	0.49	0.03	0.02	0.09	0.36
	Sodium (Na) (%)	0.07	0.10	0.13	0.13	0.09
	Strontium (Sr) (ppm)	73.3	113.5	64.7	113.5	62.1
	Sulfur (S) (%)	0.07	0.02	0.02	0.01	0.06
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.21	0.01	<0.01	0.02	0.08
	Thallium (Tl) (ppm)	0.34	0.06	0.11	0.06	0.19
	Thorium (Th) (ppm)	5.0	1.1	1.1	1.6	3.1
	Tin (Sn) (ppm)	1.1	0.5	0.4	0.4	0.8
	Titanium (Ti) (%)	0.135	0.090	0.116	0.136	0.139
	Tungsten (W) (ppm)	0.09	0.66	0.44	0.33	1.46
	Uranium (U) (ppm)	0.31	0.26	0.20	0.26	0.21
	Vanadium (V) (ppm)	75	47	51	52	58
	Yttrium (Y) (ppm)	5.76	7.11	5.73	6.77	8.21
	Zinc (Zn) (ppm)	130	56	55	55	74
	Zirconium (Zr) (ppm)	1.3	1.2	1.2	1.5	1.5
Permanent Gases	Carbon Dioxide (CO2) (%)	0.9	1.0	0.6	0.3	1.0

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813909-6	L1813909-7	L1813909-8	L1813909-9	L1813909-10
	Description					
	Sampled Date	24-JUL-16	30-JUL-16	30-JUL-16	30-JUL-16	30-JUL-16
	Sampled Time					
	Client ID	127977	127980	127978	127979	130441
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	<0.01	<0.01	0.01	<0.01
	Molybdenum (Mo) (ppm)	0.83	0.38	0.49	0.29	1.58
	Nickel (Ni) (ppm)	2.1	2.3	2.5	2.9	2.2
	Niobium (Nb) (ppm)	0.11	0.20	0.23	0.15	0.22
	Phosphorus (P) (ppm)	690	720	700	850	890
	Potassium (K) (%)	0.51	0.50	0.55	0.44	1.01
	Rhenium (Re) (ppm)	0.001	<0.001	0.001	<0.001	0.003
	Rubidium (Rb) (ppm)	23.8	20.3	23.1	18.4	48.5
	Scandium (Sc) (ppm)	2.5	4.3	4.4	4.3	3.3
	Selenium (Se) (ppm)	3.9	0.3	0.3	0.5	1.1
	Silver (Ag) (ppm)	1.21	0.03	0.02	0.22	0.31
	Sodium (Na) (%)	0.09	0.11	0.12	0.10	0.11
	Strontium (Sr) (ppm)	107.5	68.3	72.4	124.5	94.3
	Sulfur (S) (%)	0.17	0.01	0.01	0.03	0.40
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.26	<0.01	<0.01	0.03	0.07
	Thallium (Tl) (ppm)	0.12	0.11	0.12	0.09	0.30
	Thorium (Th) (ppm)	2.0	1.2	1.5	1.1	4.6
	Tin (Sn) (ppm)	0.4	0.4	0.5	0.4	0.7
	Titanium (Ti) (%)	0.095	0.112	0.133	0.133	0.188
	Tungsten (W) (ppm)	0.11	0.27	0.26	0.29	<0.05
	Uranium (U) (ppm)	0.23	0.21	0.21	0.16	0.34
	Vanadium (V) (ppm)	52	50	55	60	63
	Yttrium (Y) (ppm)	3.83	6.97	6.63	4.51	7.12
	Zinc (Zn) (ppm)	86	57	56	76	83
	Zirconium (Zr) (ppm)	0.9	1.3	1.4	1.0	0.6
Permanent Gases	Carbon Dioxide (CO2) (%)	0.6	0.8	0.6	0.9	0.3

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813909-11	L1813909-12	L1813909-13	L1813909-14	L1813909-15
	Description					
	Sampled Date	30-JUL-16	02-AUG-16	02-AUG-16	02-AUG-16	02-AUG-16
	Sampled Time					
	Client ID	130440	127787	127786	127785	127788
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	4.71	0.16	0.16	0.21	0.20
	Nickel (Ni) (ppm)	1.9	2.0	2.1	2.0	2.1
	Niobium (Nb) (ppm)	0.19	0.22	0.20	0.29	0.24
	Phosphorus (P) (ppm)	740	710	740	740	800
	Potassium (K) (%)	0.91	0.50	0.49	0.51	0.54
	Rhenium (Re) (ppm)	0.009	<0.001	<0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	41.5	21.7	22.0	22.2	25.8
	Scandium (Sc) (ppm)	3.1	3.9	4.1	4.3	4.6
	Selenium (Se) (ppm)	1.6	0.3	0.5	0.3	0.4
	Silver (Ag) (ppm)	0.73	0.02	0.15	0.05	0.03
	Sodium (Na) (%)	0.11	0.12	0.11	0.13	0.14
	Strontium (Sr) (ppm)	111.5	55.4	57.4	47.2	64.6
	Sulfur (S) (%)	0.57	0.01	0.05	0.01	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.13	<0.01	0.04	0.01	0.01
	Thallium (Tl) (ppm)	0.29	0.10	0.11	0.11	0.12
	Thorium (Th) (ppm)	3.7	1.2	1.7	2.0	2.3
	Tin (Sn) (ppm)	0.7	0.5	0.4	0.5	0.5
	Titanium (Ti) (%)	0.161	0.140	0.142	0.141	0.148
	Tungsten (W) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Uranium (U) (ppm)	0.21	0.22	0.27	0.34	0.40
	Vanadium (V) (ppm)	55	53	55	52	58
	Yttrium (Y) (ppm)	5.54	6.27	6.03	7.34	7.75
	Zinc (Zn) (ppm)	67	57	62	53	59
	Zirconium (Zr) (ppm)	0.6	1.3	1.2	1.8	1.6
Permanent Gases	Carbon Dioxide (CO2) (%)	0.4	0.3	0.3	0.3	0.3

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813909-16	L1813909-17	L1813909-18	L1813909-19	L1813909-20
	Description					
	Sampled Date	02-AUG-16	04-AUG-16	09-AUG-16	09-AUG-16	20-JUL-16
	Sampled Time		16:15	16:15	16:15	
	Client ID	127981	127982	127983	127984	TAILS
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	0.01	<0.01	0.01
	Molybdenum (Mo) (ppm)	0.37	0.30	0.32	0.40	0.58
	Nickel (Ni) (ppm)	2.5	2.2	2.3	2.2	3.2
	Niobium (Nb) (ppm)	0.16	0.24	0.21	0.19	0.15
	Phosphorus (P) (ppm)	710	690	690	640	460
	Potassium (K) (%)	0.46	0.29	0.43	0.37	0.48
	Rhenium (Re) (ppm)	<0.001	<0.001	<0.001	0.001	<0.001
	Rubidium (Rb) (ppm)	20.4	11.5	18.1	15.4	24.4
	Scandium (Sc) (ppm)	4.6	4.1	4.4	3.9	3.6
	Selenium (Se) (ppm)	0.3	0.3	0.2	0.4	1.0
	Silver (Ag) (ppm)	0.03	0.02	0.02	0.04	0.75
	Sodium (Na) (%)	0.09	0.12	0.13	0.11	0.06
	Strontium (Sr) (ppm)	95.8	192.0	80.8	118.5	54.1
	Sulfur (S) (%)	0.01	0.01	0.01	0.01	0.08
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	<0.01	<0.01	<0.01	0.01	0.17
	Thallium (Tl) (ppm)	0.10	0.05	0.08	0.08	0.18
	Thorium (Th) (ppm)	2.1	1.2	1.2	1.7	3.5
	Tin (Sn) (ppm)	0.5	0.5	0.5	0.4	0.9
	Titanium (Ti) (%)	0.107	0.133	0.124	0.105	0.089
	Tungsten (W) (ppm)	0.08	0.22	0.16	0.08	<0.05
	Uranium (U) (ppm)	0.32	0.19	0.24	0.24	0.23
	Vanadium (V) (ppm)	54	51	54	50	84
	Yttrium (Y) (ppm)	7.72	6.57	7.11	6.84	3.17
	Zinc (Zn) (ppm)	61	52	54	56	151
	Zirconium (Zr) (ppm)	1.4	1.5	1.5	1.4	1.0
Permanent Gases	Carbon Dioxide (CO2) (%)	1.2	0.3	0.5	0.7	0.7

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813909-21	L1813909-22	L1813909-23	L1813909-24	
	Description					
	Sampled Date	10-AUG-16				
	Sampled Time					
	Client ID	127985	127986	127987	127988	
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	
	Molybdenum (Mo) (ppm)	0.88	0.40	0.17	0.30	
	Nickel (Ni) (ppm)	2.1	2.0	2.0	2.3	
	Niobium (Nb) (ppm)	0.15	0.14	0.09	0.16	
	Phosphorus (P) (ppm)	750	670	680	750	
	Potassium (K) (%)	0.18	0.16	0.12	0.36	
	Rhenium (Re) (ppm)	<0.001	0.001	0.001	<0.001	
	Rubidium (Rb) (ppm)	7.1	7.0	6.1	14.8	
	Scandium (Sc) (ppm)	3.8	3.7	4.5	4.6	
	Selenium (Se) (ppm)	0.4	0.2	1.0	0.4	
	Silver (Ag) (ppm)	0.09	0.08	0.35	0.05	
	Sodium (Na) (%)	0.10	0.08	0.06	0.10	
	Strontium (Sr) (ppm)	138.0	142.5	161.0	151.5	
	Sulfur (S) (%)	0.02	0.02	0.06	0.01	
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	
	Tellurium (Te) (ppm)	0.01	0.01	0.07	0.02	
	Thallium (Tl) (ppm)	0.04	0.03	0.03	0.07	
	Thorium (Th) (ppm)	2.2	2.7	2.0	1.4	
	Tin (Sn) (ppm)	0.5	0.4	0.5	0.5	
	Titanium (Ti) (%)	0.102	0.060	0.057	0.117	
	Tungsten (W) (ppm)	0.08	<0.05	0.07	0.15	
	Uranium (U) (ppm)	0.24	0.49	0.20	0.25	
	Vanadium (V) (ppm)	48	43	46	53	
	Yttrium (Y) (ppm)	7.13	6.91	7.86	6.59	
	Zinc (Zn) (ppm)	64	59	62	69	
	Zirconium (Zr) (ppm)	1.1	1.3	0.9	1.6	
Permanent Gases	Carbon Dioxide (CO2) (%)	0.7	1.1	1.5	0.7	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ABA-OA-VOL08-AX	Soil	Acid Base Accounting	OA-VOL08
CARBON-C-GAS05-AX	Soil	Carbon, TOC and CO2	C-GAS05
ME-MS41-AX	Soil	Aqua Regia ICPMS	Aqua Regia ICPMS

A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-OA-ELE07-AX	Soil	pH	OA-ELE07
SULPHUR-S-CAL06-AX	Soil	Sulfide Sulfur Calc from Carbonate Leach	ALS Minerals S-CAL06

Sulfide Sulfur (as S) is calculated by subtracting the Carbonate Leachable Sulfate Sulfur (as S) from the Total Sulfur (as S) obtained from combustion.

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06-AX	Soil	Sulfate Sulfur in Soil (Carbonate Leach)	ALS Minerals S-GRA06

A prepared sample is boiled with a sodium carbonate solution for 30 minutes. Any insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06A-AX	Soil	Sulfate Sulfur in Soil (HCl Leach)	ALS Minerals S-GRA06A

A prepared sample is heated with dilute hydrochloric acid for 30 minutes. Silica and any acid-insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-IR08-AX	Soil	Total Sulfur in Soil by Combustion	ALS Minerals S-IR08

The sample is heated to approximately 1350 °C in an induction furnace while passing a stream of oxygen through the sample. Sulfur dioxide released from the sample is measured by an IR detection system and the Total Sulfur result is provided.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
AX	ALS MINERALS - VANCOUVER, B.C., CANADA

Chain of Custody Numbers:

15-008 15-009

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

CERTIFICATE VA16137517

Project: L1813909

P.O. No.: ALSM-CW16-102-APN

This report is for 24 Other samples submitted to our lab in Vancouver, BC, Canada on 18-AUG-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	ARIEL MCDONNELL	SOFTWARE DEVELOPMENT GROUP

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
PUL-QC	Pulverizing QC Test
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL MCDONNELL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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To: ALS ENVIRONMENTAL
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BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

CERTIFICATE OF ANALYSIS VA16137517

Sample Description	WEI-21	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41
Method / Analyte	Recvd Wt.	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al
Units	kg	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%
LOR	0.02	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01
L1813909-1 JUNE 2016	1.16	1.6	2	18	20	8.3	12.80	0.05	<0.01	<0.01	0.05	0.24	0.9	0.49	1.48
L1813909-2 119348	1.04	0.3	2	26	26	8.5	83.20	0.01	<0.01	0.01	0.01	0.27	1.0	0.03	1.35
L1813909-3 119349	1.10	0.3	2	17	17	8.9	54.40	0.01	<0.01	<0.01	0.01	0.17	0.6	0.02	1.18
L1813909-4 119350	1.14	0.3	1	13	13	8.9	41.60	0.01	<0.01	<0.01	0.01	0.09	0.3	0.09	1.31
L1813909-5 127976	0.98	1.9	1	20	22	8.3	11.73	0.06	0.01	0.02	0.05	0.26	1.0	0.36	1.28
L1813909-6 127977	1.02	4.7	1	10	15	8.6	3.20	0.15	0.01	0.03	0.14	0.16	0.6	1.21	1.30
L1813909-7 127980	0.96	0.3	1	18	18	8.9	57.60	0.01	0.02	0.02	<0.01	0.20	0.8	0.03	1.14
L1813909-8 127978	0.96	0.3	1	17	17	8.8	54.40	0.01	0.01	<0.01	<0.01	0.17	0.6	0.02	1.26
L1813909-9 127979	1.04	0.9	2	21	22	8.9	23.47	0.03	0.01	0.01	0.02	0.25	0.9	0.22	1.55
L1813909-10 130441	1.08	12.5	1	-1	12	8.4	0.96	0.40	0.23	0.29	0.17	0.08	0.3	0.31	1.47
L1813909-11 130440	1.64	17.5	1	-6	12	8.4	0.69	0.56	0.33	0.36	0.23	0.10	0.4	0.73	1.29
L1813909-12 127787	1.22	0.3	1	11	11	9.2	35.20	0.01	0.02	<0.01	<0.01	0.08	0.3	0.02	1.25
L1813909-13 127786	1.22	1.3	1	11	12	9.1	9.60	0.04	0.02	0.03	0.02	0.08	0.3	0.15	1.28
L1813909-14 127785	1.30	0.3	1	11	11	9.2	35.20	0.01	0.01	0.02	<0.01	0.08	0.3	0.05	1.18
L1813909-15 127788	1.26	<0.3	1	12	12	9.2	76.80	<0.01	0.01	<0.01	<0.01	0.08	0.3	0.03	1.33
L1813909-16 127981	0.86	0.3	1	25	25	8.7	80.00	0.01	0.01	0.02	<0.01	0.32	1.2	0.03	1.28
L1813909-17 127982	0.82	0.3	1	14	14	9.2	44.80	0.01	<0.01	0.02	0.01	0.09	0.3	0.02	1.32
L1813909-18 127983	0.84	<0.3	1	16	16	9.1	102.40	<0.01	0.02	0.02	<0.01	0.15	0.5	0.02	1.25
L1813909-19 127984	0.90	<0.3	1	19	19	8.9	121.60	<0.01	<0.01	0.01	<0.01	0.19	0.7	0.04	1.29
L1813909-20 TAILS	0.88	1.9	1	10	12	8.5	6.40	0.06	0.02	<0.01	0.04	0.20	0.7	0.75	1.16
L1813909-21 127985	1.48	0.3	2	22	22	8.9	70.40	0.01	0.01	0.01	<0.01	0.20	0.7	0.09	1.48
L1813909-22 127986	1.04	0.3	2	30	30	8.6	96.00	0.01	0.01	0.03	<0.01	0.30	1.1	0.08	1.41
L1813909-23 127987	1.04	1.6	2	36	38	8.5	24.32	0.05	0.01	0.06	0.04	0.41	1.5	0.35	1.69
L1813909-24 127988	1.08	0.3	2	21	21	8.9	67.20	0.01	0.01	<0.01	<0.01	0.20	0.7	0.05	1.43

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method Analyte Units LOR	ME-MS41 As ppm 0.1	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05
L1813909-1 JUNE 2016		2.1	<0.2	<10	190	0.23	0.19	0.88	0.26	17.65	7.3	7	0.70	871	4.27	9.09
L1813909-2 119348		1.4	<0.2	<10	120	0.39	0.02	1.44	0.03	15.50	6.2	6	0.14	45.5	2.26	6.04
L1813909-3 119349		0.6	<0.2	<10	220	0.23	0.01	0.92	0.02	15.05	6.1	6	0.26	16.8	2.26	5.14
L1813909-4 119350		1.2	<0.2	<10	170	0.30	0.05	1.02	0.04	18.05	6.2	6	0.19	25.5	2.28	5.91
L1813909-5 127976		0.7	<0.2	<10	230	0.26	0.22	1.24	0.06	19.70	6.6	7	0.41	1070	2.79	6.49
L1813909-6 127977		0.3	0.4	<10	230	0.21	0.85	0.79	0.13	13.85	6.3	6	0.29	2920	2.71	6.34
L1813909-7 127980		0.3	<0.2	<10	240	0.26	0.02	0.99	0.03	14.60	5.8	5	0.27	55.7	2.20	5.08
L1813909-8 127978		0.6	<0.2	<10	230	0.29	0.01	1.06	0.02	17.30	6.3	6	0.27	9.0	2.35	5.61
L1813909-9 127979		1.1	<0.2	<10	240	0.33	0.05	1.23	0.06	13.00	7.3	6	0.21	301	2.73	7.06
L1813909-10 130441		0.1	<0.2	<10	410	0.15	0.07	0.92	0.09	25.0	6.4	10	0.62	1085	2.64	6.93
L1813909-11 130440		0.2	<0.2	<10	330	0.12	0.21	1.04	0.16	19.05	5.0	10	0.50	1855	2.23	5.80
L1813909-12 127787		0.7	<0.2	<10	220	0.27	0.01	0.85	0.03	13.90	6.1	7	0.25	18.1	2.23	5.54
L1813909-13 127786		0.7	<0.2	<10	200	0.26	0.07	0.86	0.04	14.60	6.3	7	0.26	514	2.37	5.64
L1813909-14 127785		0.4	<0.2	<10	200	0.27	0.02	0.85	0.04	16.55	6.0	7	0.26	91.0	2.16	5.54
L1813909-15 127788		0.7	<0.2	<10	230	0.33	0.01	0.90	0.03	19.35	6.6	8	0.29	27.9	2.45	5.98
L1813909-16 127981		0.7	<0.2	<10	260	0.33	0.01	1.30	0.03	19.50	6.5	5	0.28	23.3	2.43	5.83
L1813909-17 127982		0.4	<0.2	<10	150	0.35	0.01	1.08	0.02	14.35	5.9	6	0.14	14.1	2.18	5.93
L1813909-18 127983		0.6	<0.2	<10	200	0.30	0.01	1.02	0.02	15.15	6.2	6	0.22	11.0	2.32	5.83
L1813909-19 127984		0.6	<0.2	<10	180	0.36	0.02	1.13	0.03	16.90	5.8	6	0.21	57.1	2.27	5.94
L1813909-20 TAILS		0.7	0.2	<10	120	0.18	0.30	0.59	0.28	8.68	7.9	8	0.31	1280	5.79	10.65
L1813909-21 127985		0.9	<0.2	<10	100	0.45	0.04	1.48	0.04	18.70	6.1	6	0.12	195.0	2.27	6.88
L1813909-22 127986		1.2	<0.2	<10	80	0.49	0.02	1.66	0.04	18.05	5.7	5	0.14	97.8	2.02	6.13
L1813909-23 127987		1.1	<0.2	<10	60	0.62	0.22	2.13	0.06	17.70	6.1	5	0.15	861	2.28	7.76
L1813909-24 127988		0.8	<0.2	<10	190	0.36	0.02	1.31	0.03	13.95	6.4	6	0.18	79.0	2.37	6.57

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

CERTIFICATE OF ANALYSIS VA16137517

Sample Description	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Method / Analyte	Ge	Hf	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb
Units	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm
LOR	0.05	0.02	0.01	0.005	0.01	0.2	0.1	0.01	5	0.05	0.01	0.05	0.2	10	0.2
L1813909-1 JUNE 2016	0.08	0.05	0.01	0.097	0.82	8.6	6.8	0.72	648	0.78	0.07	0.24	2.8	870	3.1
L1813909-2 119348	0.06	0.09	<0.01	0.019	0.24	7.3	7.1	0.65	537	0.68	0.10	0.20	2.6	700	2.6
L1813909-3 119349	0.07	0.07	<0.01	0.020	0.53	7.4	6.1	0.63	511	0.63	0.13	0.19	2.3	720	1.9
L1813909-4 119350	0.09	0.08	<0.01	0.018	0.35	9.8	5.6	0.71	511	0.34	0.13	0.25	2.3	760	2.7
L1813909-5 127976	0.09	0.08	<0.01	0.034	0.64	10.6	5.6	0.59	568	0.81	0.09	0.36	3.5	800	2.4
L1813909-6 127977	0.06	0.05	0.01	0.032	0.51	7.5	5.9	0.68	527	0.83	0.09	0.11	2.1	690	2.9
L1813909-7 127980	0.07	0.08	<0.01	0.018	0.50	7.6	4.9	0.60	500	0.38	0.11	0.20	2.3	720	1.7
L1813909-8 127978	0.08	0.09	<0.01	0.015	0.55	9.6	6.1	0.65	525	0.49	0.12	0.23	2.5	700	1.3
L1813909-9 127979	0.08	0.06	0.01	0.018	0.44	7.3	7.6	0.87	619	0.29	0.10	0.15	2.9	850	2.8
L1813909-10 130441	0.08	0.03	<0.01	0.027	1.01	12.8	6.1	0.76	465	1.58	0.11	0.22	2.2	890	1.9
L1813909-11 130440	0.07	0.02	0.01	0.030	0.91	9.8	5.3	0.68	384	4.71	0.11	0.19	1.9	740	2.1
L1813909-12 127787	0.08	0.08	<0.01	0.014	0.50	7.2	5.7	0.68	485	0.16	0.12	0.22	2.0	710	1.5
L1813909-13 127786	0.09	0.07	<0.01	0.021	0.49	7.6	6.6	0.74	516	0.16	0.11	0.20	2.1	740	2.0
L1813909-14 127785	0.11	0.11	<0.01	0.019	0.51	8.7	5.4	0.66	488	0.21	0.13	0.29	2.0	740	1.4
L1813909-15 127788	0.10	0.10	<0.01	0.020	0.54	10.6	6.4	0.73	526	0.20	0.14	0.24	2.1	800	1.6
L1813909-16 127981	0.07	0.09	<0.01	0.019	0.46	10.3	6.2	0.63	557	0.37	0.09	0.16	2.5	710	2.5
L1813909-17 127982	0.08	0.09	<0.01	0.015	0.29	7.4	5.8	0.70	504	0.30	0.12	0.24	2.2	690	2.2
L1813909-18 127983	0.08	0.09	0.01	0.015	0.43	7.7	5.9	0.69	520	0.32	0.13	0.21	2.3	690	1.7
L1813909-19 127984	0.08	0.08	<0.01	0.014	0.37	8.8	6.1	0.65	520	0.40	0.11	0.19	2.2	640	3.2
L1813909-20 TAILS	0.06	0.04	0.01	0.083	0.48	4.5	5.3	0.58	650	0.58	0.06	0.15	3.2	460	3.4
L1813909-21 127985	0.09	0.06	<0.01	0.017	0.18	9.6	6.7	0.72	528	0.88	0.10	0.15	2.1	750	5.2
L1813909-22 127986	0.07	0.09	<0.01	0.016	0.16	9.7	6.1	0.60	490	0.40	0.08	0.14	2.0	670	4.1
L1813909-23 127987	0.07	0.06	<0.01	0.021	0.12	9.0	6.9	0.69	535	0.17	0.06	0.09	2.0	680	7.7
L1813909-24 127988	0.08	0.08	<0.01	0.017	0.36	7.3	6.3	0.75	563	0.30	0.10	0.16	2.3	750	2.7

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method Analyte Units LOR	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1
L1813909-1 JUNE 2016		46.9	0.001	0.07	<0.05	4.5	0.9	1.1	73.3	<0.01	0.21	5.0	0.135	0.34	0.31	75
L1813909-2 119348		9.4	<0.001	0.02	<0.05	4.5	0.4	0.5	113.5	<0.01	0.01	1.1	0.090	0.06	0.26	47
L1813909-3 119349		23.2	<0.001	0.02	<0.05	4.1	0.2	0.4	64.7	<0.01	<0.01	1.1	0.116	0.11	0.20	51
L1813909-4 119350		13.8	<0.001	0.01	0.07	3.9	0.3	0.4	113.5	<0.01	0.02	1.6	0.136	0.06	0.26	52
L1813909-5 127976		31.7	<0.001	0.06	<0.05	5.5	1.1	0.8	62.1	<0.01	0.08	3.1	0.139	0.19	0.21	58
L1813909-6 127977		23.8	0.001	0.17	<0.05	2.5	3.9	0.4	107.5	<0.01	0.26	2.0	0.095	0.12	0.23	52
L1813909-7 127980		20.3	<0.001	0.01	<0.05	4.3	0.3	0.4	68.3	<0.01	<0.01	1.2	0.112	0.11	0.21	50
L1813909-8 127978		23.1	0.001	0.01	<0.05	4.4	0.3	0.5	72.4	<0.01	<0.01	1.5	0.133	0.12	0.21	55
L1813909-9 127979		18.4	<0.001	0.03	<0.05	4.3	0.5	0.4	124.5	<0.01	0.03	1.1	0.133	0.09	0.16	60
L1813909-10 130441		48.5	0.003	0.40	<0.05	3.3	1.1	0.7	94.3	<0.01	0.07	4.6	0.188	0.30	0.34	63
L1813909-11 130440		41.5	0.009	0.57	<0.05	3.1	1.6	0.7	111.5	<0.01	0.13	3.7	0.161	0.29	0.21	55
L1813909-12 127787		21.7	<0.001	0.01	<0.05	3.9	0.3	0.5	55.4	<0.01	<0.01	1.2	0.140	0.10	0.22	53
L1813909-13 127786		22.0	<0.001	0.05	<0.05	4.1	0.5	0.4	57.4	<0.01	0.04	1.7	0.142	0.11	0.27	55
L1813909-14 127785		22.2	<0.001	0.01	<0.05	4.3	0.3	0.5	47.2	<0.01	0.01	2.0	0.141	0.11	0.34	52
L1813909-15 127788		25.8	<0.001	0.01	<0.05	4.6	0.4	0.5	64.6	<0.01	0.01	2.3	0.148	0.12	0.40	58
L1813909-16 127981		20.4	<0.001	0.01	<0.05	4.6	0.3	0.5	95.8	<0.01	<0.01	2.1	0.107	0.10	0.32	54
L1813909-17 127982		11.5	<0.001	0.01	<0.05	4.1	0.3	0.5	192.0	<0.01	<0.01	1.2	0.133	0.05	0.19	51
L1813909-18 127983		18.1	<0.001	0.01	<0.05	4.4	0.2	0.5	80.8	<0.01	<0.01	1.2	0.124	0.08	0.24	54
L1813909-19 127984		15.4	0.001	0.01	<0.05	3.9	0.4	0.4	118.5	<0.01	0.01	1.7	0.105	0.08	0.24	50
L1813909-20 TAILS		24.4	<0.001	0.08	<0.05	3.6	1.0	0.9	54.1	<0.01	0.17	3.5	0.089	0.18	0.23	84
L1813909-21 127985		7.1	<0.001	0.02	<0.05	3.8	0.4	0.5	138.0	<0.01	0.01	2.2	0.102	0.04	0.24	48
L1813909-22 127986		7.0	0.001	0.02	<0.05	3.7	0.2	0.4	142.5	<0.01	0.01	2.7	0.060	0.03	0.49	43
L1813909-23 127987		6.1	0.001	0.06	<0.05	4.5	1.0	0.5	161.0	<0.01	0.07	2.0	0.057	0.03	0.20	46
L1813909-24 127988		14.8	<0.001	0.01	<0.05	4.6	0.4	0.5	151.5	<0.01	0.02	1.4	0.117	0.07	0.25	53

***** See Appendix Page for comments regarding this certificate *****

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	W	Y	Zn	Zr
	Units	ppm	ppm	ppm	ppm
	LOR	0.05	0.05	2	0.5
L1813909-1 JUNE 2016		0.09	5.76	130	1.3
L1813909-2 119348		0.66	7.11	56	1.2
L1813909-3 119349		0.44	5.73	55	1.2
L1813909-4 119350		0.33	6.77	55	1.5
L1813909-5 127976		1.46	8.21	74	1.5
L1813909-6 127977		0.11	3.83	86	0.9
L1813909-7 127980		0.27	6.97	57	1.3
L1813909-8 127978		0.26	6.63	56	1.4
L1813909-9 127979		0.29	4.51	76	1.0
L1813909-10 130441		<0.05	7.12	83	0.6
L1813909-11 130440		<0.05	5.54	67	0.6
L1813909-12 127787		<0.05	6.27	57	1.3
L1813909-13 127786		<0.05	6.03	62	1.2
L1813909-14 127785		<0.05	7.34	53	1.8
L1813909-15 127788		<0.05	7.75	59	1.6
L1813909-16 127981		0.08	7.72	61	1.4
L1813909-17 127982		0.22	6.57	52	1.5
L1813909-18 127983		0.16	7.11	54	1.5
L1813909-19 127984		0.08	6.84	56	1.4
L1813909-20 TAILS		<0.05	3.17	151	1.0
L1813909-21 127985		0.08	7.13	64	1.1
L1813909-22 127986		<0.05	6.91	59	1.3
L1813909-23 127987		0.07	7.86	62	0.9
L1813909-24 127988		0.15	6.59	69	1.6

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Project: L1813909

CERTIFICATE OF ANALYSIS VA16137517

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	PUL-QC	S-CAL06
S-GRA06	S-GRA06a	S-IR08	SPL-21
WEI-21			

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Finalized Date: 17-SEP-2016
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QC CERTIFICATE VA16137517

Project: L1813909

P.O. No.: ALSM-CW16-102-APN

This report is for 24 Other samples submitted to our lab in Vancouver, BC, Canada on 18-AUG-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	ARIEL MCDONNELL	SOFTWARE DEVELOPMENT GROUP

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
PUL-QC	Pulverizing QC Test
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ
S-CAL06	Sulfide Sulfur (calculated)	LECO

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL MCDONNELL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Minerals

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BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
Sample Description / LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
STANDARDS															
Buffer pH6					6.0										
Buffer pH6					6.1										
Target Range - Lower Bound					5.3										
Upper Bound					6.7										
CO-ASSAY										0.58	2.1				
Target Range - Lower Bound										0.42	1.5				
Upper Bound										0.64	2.4				
GS313-8							1.28								
Target Range - Lower Bound							1.19								
Upper Bound							1.29								
KZK-1	25.0	2	33	58		2.32									
KZK-1	25.0	2	32	57		2.28									
Target Range - Lower Bound	22.9	<1	30	54		2.18									
Upper Bound	27.1	>4	38	64		2.53									
MA-2c										1.74	6.4				
Target Range - Lower Bound										1.50	5.5				
Upper Bound										1.84	6.8				
MA-3a										2.54	9.3				
Target Range - Lower Bound										2.31	8.4				
Upper Bound										2.77	10.2				
MRGeo08												4.69	2.70	32.5	<0.2
Target Range - Lower Bound												4.00	2.44	29.6	<0.2
Upper Bound												4.92	3.00	36.4	0.4
OGGeo08												18.95	2.20	120.5	<0.2
Target Range - Lower Bound												18.15	2.05	107.0	<0.2
Upper Bound												22.2	2.53	131.0	0.4
OREAS 905												0.57	0.86	33.0	0.4
Target Range - Lower Bound												0.45	0.73	28.4	<0.2
Upper Bound												0.58	0.91	35.0	0.8
OREAS 920												0.12	2.33	4.7	<0.2
Target Range - Lower Bound												0.07	2.18	3.8	<0.2
Upper Bound												0.12	2.68	4.9	0.4

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals
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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		<10	450	0.93	0.71	1.12	2.36	76.3	20.5	90	11.20	644	3.64	10.20	0.16	0.74
Target Range - Lower Bound		<10	370	0.67	0.60	1.00	2.01	66.2	17.0	81	9.40	587	3.22	8.73	0.07	0.64
Upper Bound		20	530	0.95	0.76	1.24	2.47	81.0	21.0	102	11.60	675	3.96	10.80	0.29	0.83
OGGeo08		<10	90	0.72	9.82	0.86	19.70	62.3	99.1	78	9.57	8510	5.04	8.16	0.16	0.77
Target Range - Lower Bound		<10	60	0.61	9.44	0.82	16.75	56.7	87.2	75	8.68	7800	4.51	8.05	0.21	0.72
Upper Bound		30	110	0.89	11.55	1.02	20.5	69.3	107.0	93	10.70	8980	5.53	9.95	0.45	0.92
OREAS 905		<10	280	1.01	5.78	0.35	0.36	81.2	14.3	17	1.32	1585	3.50	6.47	0.10	1.12
Target Range - Lower Bound		<10	200	0.78	5.16	0.29	0.30	72.0	12.4	15	1.14	1450	3.14	5.74	<0.05	1.08
Upper Bound		20	300	1.08	6.32	0.38	0.38	88.0	15.4	20	1.50	1670	3.86	7.12	0.10	1.36
OREAS 920		<10	70	0.64	0.55	0.31	0.07	71.5	14.0	40	2.00	110.5	3.46	6.31	0.09	0.55
Target Range - Lower Bound		<10	50	0.59	0.60	0.28	0.04	64.8	13.4	37	1.84	102.0	3.26	6.12	<0.05	0.53
Upper Bound		20	110	0.87	0.76	0.37	0.09	79.2	16.6	48	2.36	118.0	4.00	7.60	0.10	0.69

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BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
GS313-8																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MA-3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.07	0.161	1.27	38.2	36.2	1.16	422	14.30	0.34	0.93	710	1010	1080	149.5	0.010
Target Range - Lower Bound		0.04	0.137	1.12	33.2	29.6	1.03	378	13.10	0.30	0.79	622	900	959	132.0	0.006
Upper Bound		0.10	0.179	1.40	41.0	36.4	1.29	473	16.10	0.39	1.09	760	1130	1175	162.0	0.010
OGGeo08		0.44	1.440	1.09	30.1	31.4	0.91	384	841	0.29	0.99	8800	800	7100	125.5	1.365
Target Range - Lower Bound		0.41	1.335	0.94	27.7	29.8	0.84	350	811	0.26	0.97	7760	700	6520	109.5	1.295
Upper Bound		0.57	1.645	1.18	34.3	36.6	1.05	438	991	0.34	1.29	9480	880	7970	134.5	1.585
OREAS 905		0.02	0.596	0.33	40.8	5.1	0.15	350	2.88	0.09	0.26	8.6	240	19.9	19.6	<0.001
Target Range - Lower Bound		<0.01	0.517	0.28	35.6	4.3	0.13	310	2.65	0.07	0.19	7.8		15.2	17.3	<0.001
Upper Bound		0.02	0.643	0.36	44.0	5.5	0.19	390	3.35	0.12	0.43	10.0		19.0	21.3	0.002
OREAS 920		0.01	0.032	0.41	36.3	20.8	1.01	500	0.33	0.02	0.32	35.8	700	21.9	23.7	<0.001
Target Range - Lower Bound		<0.01	0.019	0.39	33.3	19.0	0.98	472	0.29	<0.01	0.31	34.4		19.2	22.2	<0.001
Upper Bound		0.02	0.043	0.50	41.1	23.4	1.22	588	0.53	0.02	0.55	42.4		23.9	27.4	0.002

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BURNABY BC V5A 1W9

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Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y
Units	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
LOR	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1	0.05	0.05
STANDARDS															
Buffer pH6															
Buffer pH6															
Target Range - Lower Bound															
Upper Bound															
CO-ASSAY															
Target Range - Lower Bound															
Upper Bound															
GS313-8															
Target Range - Lower Bound															
Upper Bound															
KZK-1															
KZK-1															
Target Range - Lower Bound															
Upper Bound															
MA-2c															
Target Range - Lower Bound															
Upper Bound															
MA-3a															
Target Range - Lower Bound															
Upper Bound															
MRGeo08	0.31	2.94	8.0	1.5	3.6	82.8	0.01	0.02	22.5	0.391	0.82	5.87	100	2.57	20.7
Target Range - Lower Bound	0.27	2.80	6.7	0.9	2.8	72.1	<0.01	<0.01	19.1	0.338	0.64	4.93	90	2.44	17.50
Upper Bound	0.35	3.90	8.4	1.9	4.0	88.5	0.03	0.04	23.7	0.424	0.92	6.13	112	3.42	21.5
OGGeo08	2.68	18.50	6.3	10.9	12.8	60.7	0.01	0.15	17.0	0.305	1.49	4.75	77	3.07	16.50
Target Range - Lower Bound	2.51	17.70	6.0	9.7	12.0	59.6	<0.01	0.14	15.6	0.279	1.14	4.45	70	2.58	15.35
Upper Bound	3.09	24.1	7.6	12.3	15.1	73.2	0.03	0.20	19.6	0.353	1.58	5.55	88	3.60	18.85
OREAS 905	0.07	1.01	1.8	2.7	1.3	12.8	<0.01	0.06	9.0	0.022	0.11	2.37	6	0.48	7.49
Target Range - Lower Bound	0.04	0.90	1.6	1.8	0.8	10.9	<0.01	0.04	7.8	0.008	0.06	2.08	4	0.44	6.32
Upper Bound	0.09	1.34	2.2	2.8	1.7	13.7	0.02	0.09	10.0	0.030	0.16	2.66	8	0.76	7.84
OREAS 920	0.04	0.58	2.5	0.7	1.0	16.3	0.01	0.01	15.7	0.114	0.15	1.97	23	0.45	17.10
Target Range - Lower Bound	<0.01	0.45	2.5	0.4	0.7	15.0	<0.01	<0.01	13.6	0.106	0.07	1.89	23	<0.05	16.85
Upper Bound	0.05	0.77	3.3	1.3	1.7	18.8	0.02	0.02	17.0	0.140	0.18	2.42	30	0.10	20.7

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
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Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
STANDARDS			
Buffer pH6			
Buffer pH6			
Target Range - Lower Bound			
Upper Bound			
CO-ASSAY			
Target Range - Lower Bound			
Upper Bound			
GS313-8			
Target Range - Lower Bound			
Upper Bound			
KZK-1			
KZK-1			
Target Range - Lower Bound			
Upper Bound			
MA-2c			
Target Range - Lower Bound			
Upper Bound			
MA-3a			
Target Range - Lower Bound			
Upper Bound			
MRGeo08		792	23.3
Target Range - Lower Bound		708	18.1
Upper Bound		870	25.7
OGGeo08		6970	26.4
Target Range - Lower Bound		6500	19.5
Upper Bound		7950	27.5
OREAS 905		67	45.5
Target Range - Lower Bound		58	39.9
Upper Bound		76	55.1
OREAS 920		104	20.2
Target Range - Lower Bound		93	17.6
Upper Bound		119	25.0

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QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description / Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
STANDARDS															
SY-4										0.96	3.5				
Target Range - Lower Bound										0.84	3.0				
Upper Bound										1.08	4.0				
UTS-1								0.88							
UTS-1								0.90							
UTS-1								0.87							
Target Range - Lower Bound								0.83							
Upper Bound								0.93							
UTS-1									0.90						
UTS-1									0.91						
UTS-1									0.90						
Target Range - Lower Bound									0.81						
Upper Bound									0.95						
UTS-2							3.34								
Target Range - Lower Bound							3.11								
Upper Bound							3.35								
UTS-4								1.75							
Target Range - Lower Bound								1.64							
Upper Bound								1.84							
UTS-4									1.75						
Target Range - Lower Bound									1.61						
Upper Bound									1.87						
BLANKS															
BLANK										<0.05	<0.2				
BLANK										0.08	0.3				
Target Range - Lower Bound										<0.05	<0.2				
Upper Bound										0.10	0.4				
BLANK												<0.01	<0.01	0.2	<0.2
BLANK												<0.01	<0.01	<0.1	<0.2
Target Range - Lower Bound												<0.01	<0.01	<0.1	<0.2
Upper Bound												0.02	0.02	0.2	0.4
BLANK					6.5										
Target Range - Lower Bound					5.5										
Upper Bound					6.9										
BLANK								<0.01							
BLANK								<0.01							

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf
	Units	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	LOR	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05	0.05	0.02
STANDARDS																
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
UTS-1																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
UTS-1																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	0.2	<0.01	<0.05	<0.05	<0.02
BLANK		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
Target Range - Lower Bound		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
Upper Bound		20	20	0.10	0.02	0.02	0.02	0.04	0.2	2	0.10	0.4	0.02	0.10	0.10	0.04
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																

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Finalized Date: 17-SEP-2016
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Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description / Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
STANDARDS															
SY-4															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
UTS-1															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-1															
UTS-1															
UTS-1															
Target Range - Lower Bound															
Upper Bound															
UTS-2															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
BLANKS															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
BLANK	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Target Range - Lower Bound	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Upper Bound	0.02	0.010	0.02	0.4	0.2	0.02	10	0.10	0.02	0.10	0.4	20	0.4	0.2	0.002
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
BLANK															

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Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method / Analyte / Units / LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
STANDARDS																
SY-4																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
UTS-1																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
UTS-1																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
BLANK		<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Target Range - Lower Bound		<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Upper Bound		0.02	0.10	0.2	0.4	0.4	0.4	0.02	0.02	0.4	0.010	0.04	0.10	2	0.10	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals
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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
STANDARDS			
SY-4			
Target Range - Lower Bound			
Upper Bound			
UTS-1			
UTS-1			
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-1			
UTS-1			
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-2			
Target Range - Lower Bound			
Upper Bound			
UTS-4			
Target Range - Lower Bound			
Upper Bound			
UTS-4			
Target Range - Lower Bound			
Upper Bound			
BLANKS			
BLANK			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK		<2	<0.5
BLANK		<2	<0.5
Target Range - Lower Bound		<2	<0.5
Upper Bound		4	1.0
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
BLANK			

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QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description / Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
BLANKS															
Target Range - Lower Bound								<0.01							
Upper Bound								0.02							
BLANK									<0.01						
BLANK									<0.01						
Target Range - Lower Bound									<0.01						
Upper Bound									0.02						
BLANK							<0.01								
Target Range - Lower Bound							<0.01								
Upper Bound							0.02								
DUPLICATES															
ORIGINAL												0.58	0.98	47.9	<0.2
DUP												0.60	1.03	58.1	<0.2
Target Range - Lower Bound												0.55	0.94	50.3	<0.2
Upper Bound												0.63	1.07	55.8	0.4
L1813909-2 119348								<0.01							
DUP								<0.01							
Target Range - Lower Bound								<0.01							
Upper Bound								0.02							
L1813909-9 127979										0.25	0.9				
DUP										0.24	0.9				
Target Range - Lower Bound										0.18	0.7				
Upper Bound										0.31	1.1				
L1813909-10 130441	12.5	1	-1	12	8.4	0.96	0.40		0.29	0.08	0.3				
DUP	11.6	1		12	8.4	1.04	0.37		0.26	0.09	0.3				
Target Range - Lower Bound	11.1	<1		10	7.9	0.94	0.37		0.25	<0.05	<0.2				
Upper Bound	13.0	2		14	8.9	1.06	0.40		0.30	0.10	0.4				
L1813909-13 127786												0.15	1.28	0.7	<0.2
DUP												0.14	1.33	0.7	<0.2
Target Range - Lower Bound												0.13	1.23	0.6	<0.2
Upper Bound												0.16	1.38	0.8	0.4

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method Analyte Units LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
BLANKS																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL		<10	30	0.81	1.28	8.01	0.17	11.55	6.7	38	0.05	69.3	3.97	4.08	0.08	0.42
DUP		<10	30	0.84	1.15	8.38	0.20	12.45	7.6	39	0.06	73.4	4.20	4.41	0.08	0.47
Target Range - Lower Bound		<10	20	0.73	1.14	7.78	0.17	11.40	6.7	36	<0.05	68.7	3.87	3.98	<0.05	0.40
Upper Bound		20	40	0.92	1.29	8.61	0.20	12.60	7.6	41	0.10	74.0	4.30	4.51	0.10	0.49
L1813909-2 119348																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1813909-9 127979																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1813909-10 130441																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1813909-13 127786		<10	200	0.26	0.07	0.86	0.04	14.60	6.3	7	0.26	514	2.37	5.64	0.09	0.07
DUP		<10	210	0.32	0.08	0.88	0.04	16.70	6.5	6	0.28	538	2.45	5.90	0.08	0.08
Target Range - Lower Bound		<10	180	0.23	0.06	0.82	0.03	14.85	6.0	5	0.21	507	2.28	5.43	<0.05	0.05
Upper Bound		20	230	0.35	0.09	0.92	0.05	16.45	6.8	8	0.33	545	2.54	6.11	0.10	0.10

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method Analyte Units LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
BLANKS																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL		<0.01	0.050	0.01	4.8	5.9	3.53	730	31.7	0.21	<0.05	15.0	480	1.1	0.7	0.027
DUP		<0.01	0.052	0.02	5.3	6.6	3.66	750	34.6	0.23	<0.05	16.5	510	1.1	0.7	0.027
Target Range - Lower Bound		<0.01	0.043	<0.01	4.6	5.8	3.41	698	31.4	0.20	<0.05	14.8	460	0.8	0.6	0.025
Upper Bound		0.02	0.059	0.02	5.5	6.7	3.78	782	34.9	0.24	0.10	16.7	530	1.4	0.8	0.029
L1813909-2 119348																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1813909-9 127979																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1813909-10 130441																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1813909-13 127786		<0.01	0.021	0.49	7.6	6.6	0.74	516	0.16	0.11	0.20	2.1	740	2.0	22.0	<0.001
DUP		<0.01	0.025	0.53	8.5	7.4	0.76	538	0.21	0.12	0.21	2.0	760	2.6	22.9	<0.001
Target Range - Lower Bound		<0.01	0.017	0.47	7.4	6.6	0.70	496	0.13	0.10	0.14	1.7	700	2.0	21.2	<0.001
Upper Bound		0.02	0.029	0.55	8.7	7.5	0.80	558	0.24	0.13	0.27	2.4	800	2.6	23.7	0.002

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method / Analyte / Units / LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
BLANKS																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
DUPLICATES																
ORIGINAL		3.00	5.27	9.7	1.1	0.5	106.0	<0.01	0.69	0.7	0.120	0.29	0.26	84	0.35	6.63
DUP		3.16	5.66	10.7	1.5	0.5	113.0	<0.01	0.60	0.9	0.131	0.32	0.29	88	0.39	7.31
Target Range - Lower Bound		2.92	5.01	9.6	1.0	0.3	104.0	<0.01	0.60	0.6	0.114	0.26	0.21	81	0.29	6.57
Upper Bound		3.24	5.92	10.8	1.6	0.7	115.0	0.02	0.69	1.0	0.137	0.35	0.34	91	0.45	7.37
L1813909-2 119348																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1813909-9 127979																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1813909-10 130441																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1813909-13 127786		0.05	<0.05	4.1	0.5	0.4	57.4	<0.01	0.04	1.7	0.142	0.11	0.27	55	<0.05	6.03
DUP		0.05	<0.05	4.2	0.5	0.5	61.8	<0.01	0.04	2.0	0.148	0.11	0.29	56	<0.05	6.19
Target Range - Lower Bound		0.04	<0.05	3.8	0.3	<0.2	56.4	<0.01	0.03	1.6	0.133	0.08	0.22	52	<0.05	5.75
Upper Bound		0.06	0.10	4.5	0.7	0.7	62.8	0.02	0.05	2.1	0.157	0.14	0.34	59	0.10	6.47

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BURNABY BC V5A 1W9

Finalized Date: 17-SEP-2016
Account: APN

Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method Analyte Units LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
	BLANKS		
Target Range - Lower Bound			
Upper Bound			
BLANK			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
Target Range - Lower Bound			
Upper Bound			
	DUPLICATES		
ORIGINAL		23	8.1
DUP		21	8.8
Target Range - Lower Bound		19	7.3
Upper Bound		25	9.6
L1813909-2 119348			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1813909-9 127979			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1813909-10 130441			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1813909-13 127786		62	1.2
DUP		65	1.3
Target Range - Lower Bound		58	0.7
Upper Bound		69	1.8

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QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method / Analyte / Units / LOR	OA-VOL08m MPA tCaCO3/1Kt 0.3	OA-VOL08m FIZZ RAT Unity 1	OA-VOL08m NNP tCaCO3/1Kt 1	OA-VOL08m NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08m Ratio (N Unity 0.01	S-IR08 S % 0.01	S-GRA06 S % 0.01	S-GRA06a S % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2	ME-MS41 Ag ppm 0.01	ME-MS41 Al % 0.01	ME-MS41 As ppm 0.1	ME-MS41 Au ppm 0.2
DUPLICATES																
L1813909-19 127984									<0.01	0.01						
DUP									<0.01	0.02						
Target Range - Lower Bound									<0.01	<0.01						
Upper Bound									0.02	0.02						

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QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
								DUPLICATES								
L1813909-19 127984																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
								DUPLICATES								
L1813909-19 127984																
DUP																
Target Range - Lower Bound																
Upper Bound																

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Sample Description	Method / Analyte / Units / LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
DUPLICATES																
L1813909-19 127984																
DUP																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16137517

Sample Description	Method Analyte Units LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
	DUPLICATES		
L1813909-19 127984			
DUP			
Target Range - Lower Bound			
Upper Bound			

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Project: L1813909

QC CERTIFICATE OF ANALYSIS VA16137517

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	LOG-22	ME-MS41	OA-ELE07
OA-VOL08m	PUL-31	PUL-QC	S-CAL06
S-GRA06	S-GRA06a	S-IR08	SPL-21
WEI-21			

Chain of Custody (COC) / Analytical Request Form

ALS

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Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here (lab use only)

COC Number: 15 - 2008

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4559
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

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Email 1 or Fax ap@mintomine.com

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Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #

Job #:

PO / AFE: TBD

LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals- Aqua regia disgestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	June 2016	June 19, 16	TBD	Composite	R	R	R	R	R	R	
	~~July 20~~ 119348	July 20/16		waste							
	119349	July	20/16	waste							
	119350	July	20/16	waste							
	127976	July	24/16								
	127977	July	24/16								
	127980	July	30/16	waste							
	127978	July	30/16	waste							
	127979	July	30/16	waste							
	130441	July	30/16	UG							
	130440	July	30/16	UG							
	127787	~~July~~ Aug 2		UG							

L1813909-COFC

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C

FINAL COOLER TEMPERATURES °C: 15.3, 14.8

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date	Time:	Received by: Shayan	Date: Aug. 16	Time: 1005	Received by: JC (20,21°C)	Date: 17 Aug 16	Time: 12:40

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form.

ALS www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here (lab use only)

COC Number: 15 - CC9

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals- Aqua regia digestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	127786	9 Aug	2/16	~~Composite~~	R	R	R	R	R	R	
	127785	Aug	2/16	UG							
	127788	Aug	2/16	UG							
	127981	Aug	2/16	waste							
	127982	Aug 4	4:16	wst							
	127983	Aug 9	4:16	wst							
	127984	Aug 9	4:15	wst							
	TAILS	July 2016		TAILS							
	127985	Aug 10/16		waste							
	127986										
	127987										
	127988										

L1813909-COFC

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C

FINAL COOLER TEMPERATURES °C: 20 21

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by: JC	Date: AUG 17 2016	Time: 12:40

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

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1. If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

Minto Explorations Ltd.
ATTN: Minto Environment - Coordinator
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 06-SEP-16
Report Date: 14-OCT-16 17:58 (MT)
Version: FINAL

Client Phone: 604-759-4659

Certificate of Analysis

Lab Work Order #: L1825469

Project P.O. #: 220826

Job Reference:

C of C Numbers: 16-010, 16-011

Legal Site Desc:

Comments: Please note, the ALS Minerals version of the finalized report and QC can be found at the end of the attachment.

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825469-1	L1825469-2	L1825469-3	L1825469-4	L1825469-5
	Description	Composite	Waste	Waste	Waste	Waste
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	15-AUG-16	16-AUG-16
	Sampled Time					
	Client ID	127989	127990	127991	127992	127993
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.8	8.6	9.2	8.8	9.1
Organic / Inorganic Carbon	Carbon (C) (%)	0.18	0.39	0.10	0.27	0.14
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	1.9	0.3	<0.3	<0.3	0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	22	37	17	25	20
	NNP (tCaCO3/1Kt)	20	37	17	25	20
	Ratio (NP/MPA) (Unity)	11.73	118.40	108.80	160.00	64.00
	Sulfate Sulfur (carbonate leach) (%)	<0.01	<0.01	<0.01	<0.01	<0.01
	Sulfate Sulfur (HCl leach) (%)	0.02	0.01	0.01	<0.01	0.01
	Sulfide Sulfur (T minus carbonate leach) (%)	0.06	0.01	<0.01	<0.01	0.01
	Total Sulfur (combustion) (%)	0.06	0.01	<0.01	<0.01	0.01
Total Metals	Aluminum (Al) (%)	1.41	1.62	1.15	0.98	1.23
	Antimony (Sb) (ppm)	0.17	<0.05	0.05	<0.05	<0.05
	Arsenic (As) (ppm)	2.6	1.1	0.8	0.5	0.7
	Barium (Ba) (ppm)	80	60	160	180	210
	Beryllium (Be) (ppm)	0.48	0.65	0.31	0.28	0.28
	Bismuth (Bi) (ppm)	0.32	0.03	0.03	0.02	0.02
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.17	0.04	0.02	0.03	0.02
	Calcium (Ca) (%)	1.42	2.12	0.92	1.07	1.03
	Cerium (Ce) (ppm)	15.80	18.10	15.80	15.50	19.90
	Cesium (Cs) (ppm)	0.10	0.12	0.22	0.25	0.23
	Chromium (Cr) (ppm)	5	5	6	5	5
	Cobalt (Co) (ppm)	6.2	5.4	6.0	5.5	6.4
	Copper (Cu) (ppm)	1120	74.0	14.9	62.3	37.7
	Gallium (Ga) (ppm)	6.79	7.07	5.91	4.93	5.83
	Germanium (Ge) (ppm)	0.06	<0.05	0.07	0.05	0.08
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.08	0.06	0.09	0.07	0.07
	Indium (In) (ppm)	0.018	0.015	0.015	0.016	0.016
	Iron (Fe) (%)	2.14	1.87	2.22	2.04	2.31
	Lanthanum (La) (ppm)	8.4	9.9	8.7	8.3	11.3
	Lead (Pb) (ppm)	7.6	23.9	2.2	3.5	2.4
	Lithium (Li) (ppm)	6.6	5.9	6.0	5.3	6.2
	Magnesium (Mg) (%)	0.75	0.64	0.69	0.57	0.71
	Manganese (Mn) (ppm)	496	469	476	472	511

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825469-6	L1825469-7	L1825469-8	L1825469-9	L1825469-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	16-AUG-16	16-AUG-16	16-AUG-16	16-AUG-16	29-AUG-16
	Sampled Time					
	Client ID	127994	127995	127996	127997	127999
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.6	9.2	8.9	8.9	8.6
Organic / Inorganic Carbon	Carbon (C) (%)	0.42	0.08	0.18	0.16	0.39
Acid Base Accounting	FIZZ RATING (Unity)	2	1	2	2	2
	MPA (tCaCO3/1Kt)	0.6	0.9	1.6	5.9	0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	41	13	21	21	35
	NNP (tCaCO3/1Kt)	40	12	19	15	35
	Ratio (NP/MPA) (Unity)	65.60	13.87	13.44	3.54	112.00
	Sulfate Sulfur (carbonate leach) (%)	0.01	<0.01	<0.01	<0.01	<0.01
	Sulfate Sulfur (HCl leach) (%)	0.01	0.02	0.01	0.02	0.02
	Sulfide Sulfur (T minus carbonate leach) (%)	0.01	0.03	0.05	0.19	0.01
	Total Sulfur (combustion) (%)	0.02	0.03	0.05	0.19	0.01
Total Metals	Aluminum (Al) (%)	1.22	1.12	1.04	1.74	1.13
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	1.8	0.7	0.6	0.9	0.4
	Barium (Ba) (ppm)	80	220	140	440	180
	Beryllium (Be) (ppm)	0.47	0.24	0.32	0.26	0.32
	Bismuth (Bi) (ppm)	0.02	0.04	0.15	1.21	0.02
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.06	0.03	0.06	0.16	0.04
	Calcium (Ca) (%)	1.99	0.76	0.98	0.92	1.51
	Cerium (Ce) (ppm)	16.65	16.80	16.20	7.90	19.30
	Cesium (Cs) (ppm)	0.22	0.27	0.18	0.53	0.26
	Chromium (Cr) (ppm)	4	5	5	6	5
	Cobalt (Co) (ppm)	5.3	5.9	5.3	7.4	6.1
	Copper (Cu) (ppm)	148.5	239	990	4390	72.5
	Gallium (Ga) (ppm)	5.94	5.53	5.22	8.74	5.40
	Germanium (Ge) (ppm)	0.06	0.07	0.06	0.08	0.05
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	0.2	<0.2
	Hafnium (Hf) (ppm)	0.07	0.07	0.07	0.02	0.07
	Indium (In) (ppm)	0.017	0.019	0.015	0.027	0.015
	Iron (Fe) (%)	2.01	2.17	1.98	3.39	2.12
	Lanthanum (La) (ppm)	9.1	9.3	8.9	4.1	10.3
	Lead (Pb) (ppm)	4.9	1.9	3.7	3.4	4.7
	Lithium (Li) (ppm)	6.3	5.4	5.2	9.2	5.7
	Magnesium (Mg) (%)	0.55	0.65	0.59	0.94	0.60
	Manganese (Mn) (ppm)	508	463	447	630	545

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825469-11	L1825469-12	L1825469-13	L1825469-14	L1825469-15
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	29-AUG-16	29-AUG-16	29-AUG-16	29-AUG-16	29-AUG-16
	Sampled Time					
	Client ID	127953	127998	128000	127956	127954
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	9.1	8.7	8.9	8.7	8.9
Organic / Inorganic Carbon	Carbon (C) (%)	0.16	0.19	0.10	0.28	0.23
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	0.6	2.2	3.4	2.5	0.6
	Neutralization Potential (NP) (tCaCO3/1Kt)	19	24	16	25	25
	NNP (tCaCO3/1Kt)	18	22	13	23	24
	Ratio (NP/MPA) (Unity)	30.40	10.97	4.65	10.00	40.00
	Sulfate Sulfur (carbonate leach) (%)	<0.01	0.01	0.02	<0.01	0.02
	Sulfate Sulfur (HCl leach) (%)	0.04	0.02	0.05	0.05	0.03
	Sulfide Sulfur (T minus carbonate leach) (%)	0.02	0.06	0.09	0.08	<0.01
	Total Sulfur (combustion) (%)	0.02	0.07	0.11	0.08	0.02
Total Metals	Aluminum (Al) (%)	1.01	1.32	1.45	1.11	1.11
	Antimony (Sb) (ppm)	<0.05	<0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.5	1.2	0.9	0.5	0.9
	Barium (Ba) (ppm)	180	120	140	160	90
	Beryllium (Be) (ppm)	0.25	0.48	0.38	0.34	0.36
	Bismuth (Bi) (ppm)	0.01	0.16	0.62	0.29	0.02
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.02	0.09	0.13	0.07	0.02
	Calcium (Ca) (%)	0.85	1.32	1.03	1.13	1.24
	Cerium (Ce) (ppm)	14.35	19.20	26.3	18.60	15.35
	Cesium (Cs) (ppm)	0.25	0.20	0.21	0.30	0.18
	Chromium (Cr) (ppm)	4	4	5	5	4
	Cobalt (Co) (ppm)	5.4	6.1	6.8	6.2	5.3
	Copper (Cu) (ppm)	16.4	1300	2520	1400	81.2
	Gallium (Ga) (ppm)	4.98	6.62	7.38	5.86	5.84
	Germanium (Ge) (ppm)	0.07	0.07	0.08	0.06	0.05
	Gold (Au) (ppm)	<0.2	<0.2	0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.08	0.07	0.05	0.06	0.06
	Indium (In) (ppm)	0.013	0.025	0.029	0.026	0.013
	Iron (Fe) (%)	2.03	2.29	2.77	2.47	1.96
	Lanthanum (La) (ppm)	7.5	11.0	14.2	9.4	8.4
	Lead (Pb) (ppm)	1.4	2.9	4.6	3.4	2.5
	Lithium (Li) (ppm)	5.1	6.7	7.9	5.5	6.2
	Magnesium (Mg) (%)	0.59	0.70	0.87	0.63	0.61
	Manganese (Mn) (ppm)	448	471	538	534	451

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825469-16	L1825469-17	L1825469-18	L1825469-19
	Description	Waste	Waste	Waste	Waste
	Sampled Date	29-AUG-16	29-AUG-16	29-AUG-16	29-AUG-16
	Sampled Time				
	Client ID	127955	127957	127951	127952
Grouping	**Analyte**				
SOIL					
Physical Tests	pH (Unity)	8.7	8.9	8.7	8.8
Organic / Inorganic Carbon	Carbon (C) (%)	0.28	0.22	0.25	0.22
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2
	MPA (tCaCO3/1Kt)	0.9	0.9	0.9	0.9
	Neutralization Potential (NP) (tCaCO3/1Kt)	28	25	26	22
	NNP (tCaCO3/1Kt)	27	24	25	21
	Ratio (NP/MPA) (Unity)	29.87	26.67	27.73	23.47
	Sulfate Sulfur (carbonate leach) (%)	0.01	0.01	0.01	0.02
	Sulfate Sulfur (HCl leach) (%)	0.04	0.03	0.03	0.01
	Sulfide Sulfur (T minus carbonate leach) (%)	0.02	0.02	0.02	0.01
	Total Sulfur (combustion) (%)	0.03	0.03	0.03	0.03
Total Metals	Aluminum (Al) (%)	0.77	0.99	1.19	1.03
	Antimony (Sb) (ppm)	0.05	0.06	0.05	0.05
	Arsenic (As) (ppm)	1.0	0.6	0.8	1.0
	Barium (Ba) (ppm)	200	160	140	200
	Beryllium (Be) (ppm)	0.23	0.29	0.33	0.27
	Bismuth (Bi) (ppm)	0.03	0.06	0.02	0.01
	Boron (B) (ppm)	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.04	0.05	0.03	0.03
	Calcium (Ca) (%)	1.14	1.10	1.28	0.97
	Cerium (Ce) (ppm)	15.55	17.70	15.45	17.00
	Cesium (Cs) (ppm)	0.26	0.26	0.19	0.25
	Chromium (Cr) (ppm)	4	5	5	5
	Cobalt (Co) (ppm)	3.9	5.1	6.1	5.4
	Copper (Cu) (ppm)	203	276	162.0	297
	Gallium (Ga) (ppm)	3.73	5.02	5.82	4.96
	Germanium (Ge) (ppm)	0.05	0.07	0.07	0.07
	Gold (Au) (ppm)	<0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.04	0.06	0.05	0.06
	Indium (In) (ppm)	0.015	0.017	0.014	0.015
	Iron (Fe) (%)	1.51	1.97	2.25	2.02
	Lanthanum (La) (ppm)	8.6	9.5	8.6	9.3
	Lead (Pb) (ppm)	1.4	1.6	2.7	1.7
	Lithium (Li) (ppm)	3.1	4.9	5.4	5.0
	Magnesium (Mg) (%)	0.37	0.55	0.70	0.59
	Manganese (Mn) (ppm)	435	474	525	491

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825469-1	L1825469-2	L1825469-3	L1825469-4	L1825469-5
	Description	Composite	Waste	Waste	Waste	Waste
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	15-AUG-16	16-AUG-16
	Sampled Time					
	Client ID	127989	127990	127991	127992	127993
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.35	0.26	0.39	0.39	0.50
	Nickel (Ni) (ppm)	2.8	1.8	2.5	2.3	2.4
	Niobium (Nb) (ppm)	0.15	0.08	0.18	0.16	0.16
	Phosphorus (P) (ppm)	710	670	690	630	710
	Potassium (K) (%)	0.13	0.10	0.40	0.44	0.48
	Rhenium (Re) (ppm)	<0.001	<0.001	<0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	5.5	4.6	18.4	20.5	21.6
	Scandium (Sc) (ppm)	3.7	3.4	3.9	3.9	3.8
	Selenium (Se) (ppm)	1.2	0.3	0.2	0.3	<0.2
	Silver (Ag) (ppm)	0.89	0.07	0.02	0.04	0.03
	Sodium (Na) (%)	0.07	0.05	0.10	0.07	0.09
	Strontium (Sr) (ppm)	143.0	186.0	73.0	67.2	84.9
	Sulfur (S) (%)	0.04	<0.01	<0.01	<0.01	<0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.24	0.01	<0.01	<0.01	<0.01
	Thallium (Tl) (ppm)	0.03	0.02	0.09	0.10	0.10
	Thorium (Th) (ppm)	1.7	2.1	1.4	1.2	1.9
	Tin (Sn) (ppm)	0.4	0.4	0.4	0.4	0.4
	Titanium (Ti) (%)	0.087	0.034	0.116	0.090	0.119
	Tungsten (W) (ppm)	0.70	0.05	0.41	0.44	0.21
	Uranium (U) (ppm)	0.27	0.38	0.24	0.23	0.23
	Vanadium (V) (ppm)	45	38	52	45	51
	Yttrium (Y) (ppm)	6.42	7.01	6.05	6.06	5.37
	Zinc (Zn) (ppm)	55	54	51	48	61
	Zirconium (Zr) (ppm)	1.1	1.0	1.3	1.0	1.1
Permanent Gases	Carbon Dioxide (CO2) (%)	0.6	1.4	0.4	1.0	0.5

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825469-6	L1825469-7	L1825469-8	L1825469-9	L1825469-10
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	16-AUG-16	16-AUG-16	16-AUG-16	16-AUG-16	29-AUG-16
	Sampled Time					
	Client ID	127994	127995	127996	127997	127999
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.31	0.81	0.33	0.42	0.40
	Nickel (Ni) (ppm)	1.9	2.4	2.0	2.8	2.6
	Niobium (Nb) (ppm)	0.10	0.15	0.14	0.16	0.08
	Phosphorus (P) (ppm)	640	650	590	860	640
	Potassium (K) (%)	0.22	0.53	0.31	0.90	0.39
	Rhenium (Re) (ppm)	<0.001	<0.001	<0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	10.7	23.8	14.8	44.8	18.4
	Scandium (Sc) (ppm)	3.5	3.5	3.3	2.2	3.8
	Selenium (Se) (ppm)	0.3	0.3	0.8	9.5	0.3
	Silver (Ag) (ppm)	0.06	0.08	0.52	2.23	0.05
	Sodium (Na) (%)	0.05	0.09	0.07	0.07	0.06
	Strontium (Sr) (ppm)	85.5	53.0	77.8	59.2	119.5
	Sulfur (S) (%)	0.01	0.01	0.03	0.18	<0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.01	0.01	0.09	0.51	<0.01
	Thallium (Tl) (ppm)	0.05	0.12	0.09	0.26	0.09
	Thorium (Th) (ppm)	1.5	1.7	1.8	0.7	1.6
	Tin (Sn) (ppm)	0.4	0.4	0.4	0.6	0.4
	Titanium (Ti) (%)	0.058	0.130	0.083	0.190	0.068
	Tungsten (W) (ppm)	0.07	0.33	0.12	0.12	0.06
	Uranium (U) (ppm)	0.28	0.18	0.21	0.17	0.26
	Vanadium (V) (ppm)	41	50	42	72	43
	Yttrium (Y) (ppm)	6.12	4.88	5.45	2.92	7.73
	Zinc (Zn) (ppm)	54	59	54	120	57
	Zirconium (Zr) (ppm)	1.1	1.1	1.0	<0.5	0.9
Permanent Gases	Carbon Dioxide (CO2) (%)	1.5	0.3	0.7	0.6	1.4

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825469-11	L1825469-12	L1825469-13	L1825469-14	L1825469-15
	Description	Waste	Waste	Waste	Waste	Waste
	Sampled Date	29-AUG-16	29-AUG-16	29-AUG-16	29-AUG-16	29-AUG-16
	Sampled Time					
	Client ID	127953	127998	128000	127956	127954
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.33	0.49	0.37	0.43	0.36
	Nickel (Ni) (ppm)	2.2	2.1	2.6	2.3	2.0
	Niobium (Nb) (ppm)	0.15	0.11	0.22	0.14	0.09
	Phosphorus (P) (ppm)	620	740	850	700	600
	Potassium (K) (%)	0.43	0.29	0.40	0.39	0.20
	Rhenium (Re) (ppm)	<0.001	<0.001	<0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	19.7	14.5	19.8	19.0	10.2
	Scandium (Sc) (ppm)	3.5	3.2	5.1	4.0	3.1
	Selenium (Se) (ppm)	0.2	0.9	2.3	1.3	0.3
	Silver (Ag) (ppm)	0.02	0.52	0.99	0.58	0.05
	Sodium (Na) (%)	0.09	0.06	0.07	0.06	0.06
	Strontium (Sr) (ppm)	62.2	110.5	79.0	82.6	105.5
	Sulfur (S) (%)	<0.01	0.05	0.10	0.06	<0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	<0.01	0.10	0.16	0.09	0.01
	Thallium (Tl) (ppm)	0.09	0.06	0.11	0.11	0.04
	Thorium (Th) (ppm)	1.1	2.6	4.5	2.2	1.7
	Tin (Sn) (ppm)	0.4	0.4	0.5	0.4	0.3
	Titanium (Ti) (%)	0.101	0.085	0.142	0.083	0.055
	Tungsten (W) (ppm)	0.20	0.11	0.59	0.22	0.21
	Uranium (U) (ppm)	0.23	0.31	0.19	0.26	0.26
	Vanadium (V) (ppm)	45	50	57	48	40
	Yttrium (Y) (ppm)	6.01	4.76	5.42	7.69	4.81
	Zinc (Zn) (ppm)	48	59	84	65	54
	Zirconium (Zr) (ppm)	1.1	1.2	0.8	0.9	0.9
Permanent Gases	Carbon Dioxide (CO2) (%)	0.6	0.7	0.4	1.0	0.9

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1825469-16	L1825469-17	L1825469-18	L1825469-19	
	Description	Waste	Waste	Waste	Waste	
	Sampled Date	29-AUG-16	29-AUG-16	29-AUG-16	29-AUG-16	
	Sampled Time					
	Client ID	127955	127957	127951	127952	
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	<0.01	<0.01	<0.01	
	Molybdenum (Mo) (ppm)	0.32	0.45	0.41	0.35	
	Nickel (Ni) (ppm)	1.8	2.1	2.1	2.2	
	Niobium (Nb) (ppm)	0.11	0.18	0.15	0.16	
	Phosphorus (P) (ppm)	440	620	710	640	
	Potassium (K) (%)	0.40	0.41	0.33	0.49	
	Rhenium (Re) (ppm)	<0.001	<0.001	<0.001	<0.001	
	Rubidium (Rb) (ppm)	18.5	20.1	13.8	20.5	
	Scandium (Sc) (ppm)	2.5	3.0	3.3	3.4	
	Selenium (Se) (ppm)	0.4	0.5	0.3	0.4	
	Silver (Ag) (ppm)	0.10	0.10	0.07	0.17	
	Sodium (Na) (%)	0.05	0.06	0.06	0.06	
	Strontium (Sr) (ppm)	71.0	102.0	95.0	76.5	
	Sulfur (S) (%)	0.01	0.02	0.01	0.02	
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	
	Tellurium (Te) (ppm)	0.02	0.03	0.01	0.05	
	Thallium (Tl) (ppm)	0.09	0.10	0.07	0.10	
	Thorium (Th) (ppm)	1.4	2.1	1.3	1.7	
	Tin (Sn) (ppm)	0.3	0.4	0.4	0.4	
	Titanium (Ti) (%)	0.061	0.086	0.087	0.092	
	Tungsten (W) (ppm)	0.40	0.49	0.10	0.17	
	Uranium (U) (ppm)	0.14	0.34	0.22	0.25	
	Vanadium (V) (ppm)	31	44	48	44	
	Yttrium (Y) (ppm)	5.48	6.15	5.57	6.27	
	Zinc (Zn) (ppm)	45	59	61	62	
	Zirconium (Zr) (ppm)	0.6	0.9	0.9	0.9	
Permanent Gases	Carbon Dioxide (CO2) (%)	1.0	0.8	0.9	0.8	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ABA-OA-VOL08-AX	Soil	Acid Base Accounting	OA-VOL08
CARBON-C-GAS05-AX	Soil	Carbon, TOC and CO2	C-GAS05
ME-MS41-AX	Soil	Aqua Regia ICPMS	Aqua Regia ICPMS

A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-OA-ELE07-AX	Soil	pH	OA-ELE07
SULPHUR-S-CAL06-AX	Soil	Sulfide Sulfur Calc from Carbonate Leach	ALS Minerals S-CAL06

Sulfide Sulfur (as S) is calculated by subtracting the Carbonate Leachable Sulfate Sulfur (as S) from the Total Sulfur (as S) obtained from combustion.

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06-AX	Soil	Sulfate Sulfur in Soil (Carbonate Leach)	ALS Minerals S-GRA06

A prepared sample is boiled with a sodium carbonate solution for 30 minutes. Any insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06A-AX	Soil	Sulfate Sulfur in Soil (HCl Leach)	ALS Minerals S-GRA06A

A prepared sample is heated with dilute hydrochloric acid for 30 minutes. Silica and any acid-insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-IR08-AX	Soil	Total Sulfur in Soil by Combustion	ALS Minerals S-IR08

The sample is heated to approximately 1350 °C in an induction furnace while passing a stream of oxygen through the sample. Sulfur dioxide released from the sample is measured by an IR detection system and the Total Sulfur result is provided.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
AX	ALS MINERALS - VANCOUVER, B.C., CANADA

Chain of Custody Numbers:

16-010 16-011

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

CERTIFICATE VA16153016

Project: L1825469

P.O. No.: ALSM-CW16-102-APN

This report is for 19 Percussion samples submitted to our lab in Vancouver, BC, Canada on 9-SEP-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	ARIEL MCDONNELL	SOFTWARE DEVELOPMENT GROUP

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S-CAL06	Sulfide Sulfur (calculated)	LECO
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL MCDONNELL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Minerals

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method	WEI-21	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41
	Analyte	Recvd Wt.	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al
	Units	kg	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%
	LOR	0.02	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01
L1825469-1 127989		1.06	1.9	2	20	22	8.8	11.73	0.06	<0.01	0.02	0.06	0.18	0.6	0.89	1.41
L1825469-2 127990		1.08	0.3	2	37	37	8.6	118.40	0.01	<0.01	0.01	0.01	0.39	1.4	0.07	1.62
L1825469-3 127991		1.04	<0.3	2	17	17	9.2	108.80	<0.01	<0.01	0.01	<0.01	0.10	0.4	0.02	1.15
L1825469-4 127992		1.08	<0.3	2	25	25	8.8	160.00	<0.01	<0.01	<0.01	<0.01	0.27	1.0	0.04	0.98
L1825469-5 127993		1.04	0.3	2	20	20	9.1	64.00	0.01	<0.01	0.01	0.01	0.14	0.5	0.03	1.23
L1825469-6 127994		1.08	0.6	2	40	41	8.6	65.60	0.02	0.01	0.01	0.01	0.42	1.5	0.06	1.22
L1825469-7 127995		0.98	0.9	1	12	13	9.2	13.87	0.03	<0.01	0.02	0.03	0.08	0.3	0.08	1.12
L1825469-8 127996		1.06	1.6	2	19	21	8.9	13.44	0.05	<0.01	0.01	0.05	0.18	0.7	0.52	1.04
L1825469-9 127997		0.80	5.9	2	15	21	8.9	3.54	0.19	<0.01	0.02	0.19	0.16	0.6	2.23	1.74
L1825469-10 127999		1.02	0.3	2	35	35	8.6	112.00	0.01	<0.01	0.02	0.01	0.39	1.4	0.05	1.13
L1825469-11 127953		1.00	0.6	2	18	19	9.1	30.40	0.02	<0.01	0.04	0.02	0.16	0.6	0.02	1.01
L1825469-12 127998		1.02	2.2	2	22	24	8.7	10.97	0.07	0.01	0.02	0.06	0.19	0.7	0.52	1.32
L1825469-13 128000		0.98	3.4	2	13	16	8.9	4.65	0.11	0.02	0.05	0.09	0.10	0.4	0.99	1.45
L1825469-14 127956		1.00	2.5	2	23	25	8.7	10.00	0.08	<0.01	0.05	0.08	0.28	1.0	0.58	1.11
L1825469-15 127954		0.98	0.6	2	24	25	8.9	40.00	0.02	0.02	0.03	<0.01	0.23	0.9	0.05	1.11
L1825469-16 127955		1.02	0.9	2	27	28	8.7	29.87	0.03	0.01	0.04	0.02	0.28	1.0	0.10	0.77
L1825469-17 127957		1.00	0.9	2	24	25	8.9	26.67	0.03	0.01	0.03	0.02	0.22	0.8	0.10	0.99
L1825469-18 127951		0.98	0.9	2	25	26	8.7	27.73	0.03	0.01	0.03	0.02	0.25	0.9	0.07	1.19
L1825469-19 127952		1.00	0.9	2	21	22	8.8	23.47	0.03	0.02	0.01	0.01	0.22	0.8	0.17	1.03

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 As ppm 0.1	ME-MS41 Au ppm 0.2	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05
L1825469-1 127989		2.6	<0.2	<10	80	0.48	0.32	1.42	0.17	15.80	6.2	5	0.10	1120	2.14	6.79
L1825469-2 127990		1.1	<0.2	<10	60	0.65	0.03	2.12	0.04	18.10	5.4	5	0.12	74.0	1.87	7.07
L1825469-3 127991		0.8	<0.2	<10	160	0.31	0.03	0.92	0.02	15.80	6.0	6	0.22	14.9	2.22	5.91
L1825469-4 127992		0.5	<0.2	<10	180	0.28	0.02	1.07	0.03	15.50	5.5	5	0.25	62.3	2.04	4.93
L1825469-5 127993		0.7	<0.2	<10	210	0.28	0.02	1.03	0.02	19.90	6.4	5	0.23	37.7	2.31	5.83
L1825469-6 127994		1.8	<0.2	<10	80	0.47	0.02	1.99	0.06	16.65	5.3	4	0.22	148.5	2.01	5.94
L1825469-7 127995		0.7	<0.2	<10	220	0.24	0.04	0.76	0.03	16.80	5.9	5	0.27	239	2.17	5.53
L1825469-8 127996		0.6	<0.2	<10	140	0.32	0.15	0.98	0.06	16.20	5.3	5	0.18	990	1.98	5.22
L1825469-9 127997		0.9	0.2	<10	440	0.26	1.21	0.92	0.16	7.90	7.4	6	0.53	4390	3.39	8.74
L1825469-10 127999		0.4	<0.2	<10	180	0.32	0.02	1.51	0.04	19.30	6.1	5	0.26	72.5	2.12	5.40
L1825469-11 127953		0.5	<0.2	<10	180	0.25	0.01	0.85	0.02	14.35	5.4	4	0.25	16.4	2.03	4.98
L1825469-12 127998		1.2	<0.2	<10	120	0.48	0.16	1.32	0.09	19.20	6.1	4	0.20	1300	2.29	6.62
L1825469-13 128000		0.9	0.2	<10	140	0.38	0.62	1.03	0.13	26.3	6.8	5	0.21	2520	2.77	7.38
L1825469-14 127956		0.5	<0.2	<10	160	0.34	0.29	1.13	0.07	18.60	6.2	5	0.30	1400	2.47	5.86
L1825469-15 127954		0.9	<0.2	<10	90	0.36	0.02	1.24	0.02	15.35	5.3	4	0.18	81.2	1.96	5.84
L1825469-16 127955		1.0	<0.2	<10	200	0.23	0.03	1.14	0.04	15.55	3.9	4	0.26	203	1.51	3.73
L1825469-17 127957		0.6	<0.2	<10	160	0.29	0.06	1.10	0.05	17.70	5.1	5	0.26	276	1.97	5.02
L1825469-18 127951		0.8	<0.2	<10	140	0.33	0.02	1.28	0.03	15.45	6.1	5	0.19	162.0	2.25	5.82
L1825469-19 127952		1.0	<0.2	<10	200	0.27	0.01	0.97	0.03	17.00	5.4	5	0.25	297	2.02	4.96

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.

2103 Dollarton Hwy
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Phone: +1 (604) 984 0221 Fax: +1 (604) 984 0218
www.alsglobal.com

To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2
L1825469-1 127989		0.06	0.08	0.01	0.018	0.13	8.4	6.6	0.75	496	0.35	0.07	0.15	2.8	710	7.6
L1825469-2 127990		<0.05	0.06	<0.01	0.015	0.10	9.9	5.9	0.64	469	0.26	0.05	0.08	1.8	670	23.9
L1825469-3 127991		0.07	0.09	<0.01	0.015	0.40	8.7	6.0	0.69	476	0.39	0.10	0.18	2.5	690	2.2
L1825469-4 127992		0.05	0.07	<0.01	0.016	0.44	8.3	5.3	0.57	472	0.39	0.07	0.16	2.3	630	3.5
L1825469-5 127993		0.08	0.07	<0.01	0.016	0.48	11.3	6.2	0.71	511	0.50	0.09	0.16	2.4	710	2.4
L1825469-6 127994		0.06	0.07	<0.01	0.017	0.22	9.1	6.3	0.55	508	0.31	0.05	0.10	1.9	640	4.9
L1825469-7 127995		0.07	0.07	<0.01	0.019	0.53	9.3	5.4	0.65	463	0.81	0.09	0.15	2.4	650	1.9
L1825469-8 127996		0.06	0.07	<0.01	0.015	0.31	8.9	5.2	0.59	447	0.33	0.07	0.14	2.0	590	3.7
L1825469-9 127997		0.08	0.02	<0.01	0.027	0.90	4.1	9.2	0.94	630	0.42	0.07	0.16	2.8	860	3.4
L1825469-10 127999		0.05	0.07	<0.01	0.015	0.39	10.3	5.7	0.60	545	0.40	0.06	0.08	2.6	640	4.7
L1825469-11 127953		0.07	0.08	<0.01	0.013	0.43	7.5	5.1	0.59	448	0.33	0.09	0.15	2.2	620	1.4
L1825469-12 127998		0.07	0.07	<0.01	0.025	0.29	11.0	6.7	0.70	471	0.49	0.06	0.11	2.1	740	2.9
L1825469-13 128000		0.08	0.05	0.01	0.029	0.40	14.2	7.9	0.87	538	0.37	0.07	0.22	2.6	850	4.6
L1825469-14 127956		0.06	0.06	<0.01	0.026	0.39	9.4	5.5	0.63	534	0.43	0.06	0.14	2.3	700	3.4
L1825469-15 127954		0.05	0.06	<0.01	0.013	0.20	8.4	6.2	0.61	451	0.36	0.06	0.09	2.0	600	2.5
L1825469-16 127955		0.05	0.04	<0.01	0.015	0.40	8.6	3.1	0.37	435	0.32	0.05	0.11	1.8	440	1.4
L1825469-17 127957		0.07	0.06	<0.01	0.017	0.41	9.5	4.9	0.55	474	0.45	0.06	0.18	2.1	620	1.6
L1825469-18 127951		0.07	0.05	<0.01	0.014	0.33	8.6	5.4	0.70	525	0.41	0.06	0.15	2.1	710	2.7
L1825469-19 127952		0.07	0.06	<0.01	0.015	0.49	9.3	5.0	0.59	491	0.35	0.06	0.16	2.2	640	1.7

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method Analyte Units LOR	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1
L1825469-1 127989		5.5	<0.001	0.04	0.17	3.7	1.2	0.4	143.0	<0.01	0.24	1.7	0.087	0.03	0.27	45
L1825469-2 127990		4.6	<0.001	<0.01	<0.05	3.4	0.3	0.4	186.0	<0.01	0.01	2.1	0.034	0.02	0.38	38
L1825469-3 127991		18.4	<0.001	<0.01	0.05	3.9	0.2	0.4	73.0	<0.01	<0.01	1.4	0.116	0.09	0.24	52
L1825469-4 127992		20.5	<0.001	<0.01	<0.05	3.9	0.3	0.4	67.2	<0.01	<0.01	1.2	0.090	0.10	0.23	45
L1825469-5 127993		21.6	<0.001	<0.01	<0.05	3.8	<0.2	0.4	84.9	<0.01	<0.01	1.9	0.119	0.10	0.23	51
L1825469-6 127994		10.7	<0.001	0.01	<0.05	3.5	0.3	0.4	85.5	<0.01	0.01	1.5	0.058	0.05	0.28	41
L1825469-7 127995		23.8	<0.001	0.01	<0.05	3.5	0.3	0.4	53.0	<0.01	0.01	1.7	0.130	0.12	0.18	50
L1825469-8 127996		14.8	<0.001	0.03	<0.05	3.3	0.8	0.4	77.8	<0.01	0.09	1.8	0.083	0.09	0.21	42
L1825469-9 127997		44.8	<0.001	0.18	<0.05	2.2	9.5	0.6	59.2	<0.01	0.51	0.7	0.190	0.26	0.17	72
L1825469-10 127999		18.4	<0.001	<0.01	<0.05	3.8	0.3	0.4	119.5	<0.01	<0.01	1.6	0.068	0.09	0.26	43
L1825469-11 127953		19.7	<0.001	<0.01	<0.05	3.5	0.2	0.4	62.2	<0.01	<0.01	1.1	0.101	0.09	0.23	45
L1825469-12 127998		14.5	<0.001	0.05	<0.05	3.2	0.9	0.4	110.5	<0.01	0.10	2.6	0.085	0.06	0.31	50
L1825469-13 128000		19.8	<0.001	0.10	<0.05	5.1	2.3	0.5	79.0	<0.01	0.16	4.5	0.142	0.11	0.19	57
L1825469-14 127956		19.0	<0.001	0.06	<0.05	4.0	1.3	0.4	82.6	<0.01	0.09	2.2	0.083	0.11	0.26	48
L1825469-15 127954		10.2	<0.001	<0.01	<0.05	3.1	0.3	0.3	105.5	<0.01	0.01	1.7	0.055	0.04	0.26	40
L1825469-16 127955		18.5	<0.001	0.01	0.05	2.5	0.4	0.3	71.0	<0.01	0.02	1.4	0.061	0.09	0.14	31
L1825469-17 127957		20.1	<0.001	0.02	0.06	3.0	0.5	0.4	102.0	<0.01	0.03	2.1	0.086	0.10	0.34	44
L1825469-18 127951		13.8	<0.001	0.01	0.05	3.3	0.3	0.4	95.0	<0.01	0.01	1.3	0.087	0.07	0.22	48
L1825469-19 127952		20.5	<0.001	0.02	0.05	3.4	0.4	0.4	76.5	<0.01	0.05	1.7	0.092	0.10	0.25	44

***** See Appendix Page for comments regarding this certificate *****

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
L1825469-1 127989		0.70	6.42	55	1.1
L1825469-2 127990		0.05	7.01	54	1.0
L1825469-3 127991		0.41	6.05	51	1.3
L1825469-4 127992		0.44	6.06	48	1.0
L1825469-5 127993		0.21	5.37	61	1.1
L1825469-6 127994		0.07	6.12	54	1.1
L1825469-7 127995		0.33	4.88	59	1.1
L1825469-8 127996		0.12	5.45	54	1.0
L1825469-9 127997		0.12	2.92	120	<0.5
L1825469-10 127999		0.06	7.73	57	0.9
L1825469-11 127953		0.20	6.01	48	1.1
L1825469-12 127998		0.11	4.76	59	1.2
L1825469-13 128000		0.59	5.42	84	0.8
L1825469-14 127956		0.22	7.69	65	0.9
L1825469-15 127954		0.21	4.81	54	0.9
L1825469-16 127955		0.40	5.48	45	0.6
L1825469-17 127957		0.49	6.15	59	0.9
L1825469-18 127951		0.10	5.57	61	0.9
L1825469-19 127952		0.17	6.27	62	0.9

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BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

CERTIFICATE OF ANALYSIS VA16153016

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C-GAS05	CRU-31	LOG-22	ME-MS41
OA-ELE07	OA-VOL08m	PUL-31	S-CAL06
S-GRA06	S-GRA06a	S-IR08	SPL-21
WEI-21			

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To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

QC CERTIFICATE VA16153016

Project: L1825469

P.O. No.: ALSM-CW16-102-APN

This report is for 19 Percussion samples submitted to our lab in Vancouver, BC, Canada on 9-SEP-2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	ARIEL MCDONNELL	SOFTWARE DEVELOPMENT GROUP

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S-CAL06	Sulfide Sulfur (calculated)	LECO
C-GAS05	Inorganic Carbon (CO2)	
S-GRA06a	Sulfate Sulfur (HCl leachable)	WST-SEQ
ME-MS41	Ultra Trace Aqua Regia ICP-MS	
OA-VOL08m	Modified NP	
S-IR08	Total Sulphur (Leco)	LECO
OA-ELE07	Paste pH	
S-GRA06	Sulfate Sulfur-carbonate leach	WST-SEQ

To: **ALS ENVIRONMENTAL**
ATTN: ARIEL MCDONNELL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Canada Ltd.

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
	Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
	LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
STANDARDS																
Buffer pH6						6.0										
Buffer pH6						6.0										
Target Range - Lower Bound						5.3										
Upper Bound						6.7										
CO-ASSAY											0.49	1.8				
Target Range - Lower Bound											0.42	1.5				
Upper Bound											0.64	2.4				
DS-1								2.63								
Target Range - Lower Bound								2.51								
Upper Bound								2.71								
GS310-10								0.27								
GS310-10								0.26								
Target Range - Lower Bound								0.25								
Upper Bound								0.29								
KZK-1		25.0	2	33	58		2.32									
KZK-1		25.0	2	32	57		2.28									
Target Range - Lower Bound		22.9	<1	30	54		2.18									
Upper Bound		27.1	>4	38	64		2.53									
MA-2c											1.55	5.7				
Target Range - Lower Bound											1.50	5.5				
Upper Bound											1.84	6.8				
MRGeo08													4.27	2.50	32.7	<0.2
MRGeo08													4.27	2.60	34.0	<0.2
Target Range - Lower Bound													4.00	2.44	29.6	<0.2
Upper Bound													4.92	3.00	36.4	0.4
OREAS 905													0.49	0.78	31.6	0.3
OREAS 905													0.48	0.77	32.9	0.4
Target Range - Lower Bound													0.45	0.73	28.4	<0.2
Upper Bound													0.58	0.91	35.0	0.8
UTS-1									0.89							
Target Range - Lower Bound									0.83							
Upper Bound									0.93							
UTS-1										0.90						
Target Range - Lower Bound										0.81						
Upper Bound										0.95						
UTS-2								3.28								
Target Range - Lower Bound								3.11								
Upper Bound								3.35								
UTS-4									1.74							

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method Analyte Units LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
									STANDARDS							
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		<10	410	0.78	0.66	1.01	2.29	75.0	19.2	85	10.50	602	3.45	9.46	0.13	0.75
MRGeo08		<10	440	0.78	0.65	1.09	2.17	74.9	18.8	91	10.50	632	3.61	9.46	0.14	0.69
Target Range - Lower Bound		<10	370	0.67	0.60	1.00	2.01	66.2	17.0	81	9.40	587	3.22	8.73	0.07	0.64
Upper Bound		20	530	0.95	0.76	1.24	2.47	81.0	21.0	102	11.60	675	3.96	10.80	0.29	0.83
OREAS 905		<10	230	0.89	5.59	0.33	0.33	77.9	14.1	19	1.15	1530	3.39	5.95	0.09	1.12
OREAS 905		<10	240	0.90	5.76	0.35	0.34	80.1	13.6	16	1.17	1560	3.34	6.11	0.10	1.12
Target Range - Lower Bound		<10	200	0.78	5.16	0.29	0.30	72.0	12.4	15	1.14	1450	3.14	5.74	<0.05	1.08
Upper Bound		20	300	1.08	6.32	0.38	0.38	88.0	15.4	20	1.50	1670	3.86	7.12	0.10	1.36
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
DS-1																
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Upper Bound																
GS310-10																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.06	0.155	1.20	37.1	30.4	1.09	382	13.25	0.31	1.05	663	960	989	143.0	0.007
MRGeo08		0.05	0.155	1.31	37.3	31.0	1.17	419	14.00	0.32	1.14	700	1050	1080	142.0	0.007
Target Range - Lower Bound		0.04	0.137	1.12	33.2	29.6	1.03	378	13.10	0.30	0.79	622	900	959	132.0	0.006
Upper Bound		0.10	0.179	1.40	41.0	36.4	1.29	473	16.10	0.39	1.09	760	1130	1175	162.0	0.010
OREAS 905		0.02	0.580	0.30	38.8	4.5	0.15	327	2.80	0.09	0.22	9.8	230	16.3	17.8	<0.001
OREAS 905		0.01	0.585	0.32	40.1	4.4	0.15	342	2.91	0.08	0.26	8.4	250	16.5	18.0	<0.001
Target Range - Lower Bound		<0.01	0.517	0.28	35.6	4.3	0.13	310	2.65	0.07	0.19	7.8		15.2	17.3	<0.001
Upper Bound		0.02	0.643	0.36	44.0	5.5	0.19	390	3.35	0.12	0.43	10.0		19.0	21.3	0.002
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals

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2103 Dollarton Hwy
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www.alsglobal.com

To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y
	Units	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
	LOR	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1	0.05	0.05
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
CO-ASSAY																
Target Range - Lower Bound																
Upper Bound																
DS-1																
Target Range - Lower Bound																
Upper Bound																
GS310-10																
GS310-10																
Target Range - Lower Bound																
Upper Bound																
KZK-1																
KZK-1																
Target Range - Lower Bound																
Upper Bound																
MA-2c																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.27	3.05	7.2	1.2	3.1	75.9	0.01	0.02	21.5	0.359	0.81	5.55	94	2.68	19.55
MRGeo08		0.31	2.95	7.5	1.5	3.3	76.6	0.01	0.02	21.5	0.385	0.77	5.78	100	2.65	19.30
Target Range - Lower Bound		0.27	2.80	6.7	0.9	2.8	72.1	<0.01	<0.01	19.1	0.338	0.64	4.93	90	2.44	17.50
Upper Bound		0.35	3.90	8.4	1.9	4.0	88.5	0.03	0.04	23.7	0.424	0.92	6.13	112	3.42	21.5
OREAS 905		0.05	0.95	1.6	2.4	1.2	12.4	<0.01	0.05	8.9	0.019	0.11	2.30	5	0.49	7.08
OREAS 905		0.07	1.01	1.6	2.6	1.2	12.3	<0.01	0.06	8.7	0.020	0.11	2.21	5	0.52	7.05
Target Range - Lower Bound		0.04	0.90	1.6	1.8	0.8	10.9	<0.01	0.04	7.8	0.008	0.06	2.08	4	0.44	6.32
Upper Bound		0.09	1.34	2.2	2.8	1.7	13.7	0.02	0.09	10.0	0.030	0.16	2.66	8	0.76	7.84
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-1																
Target Range - Lower Bound																
Upper Bound																
UTS-2																
Target Range - Lower Bound																
Upper Bound																
UTS-4																

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BURNABY BC V5A 1W9

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Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
	STANDARDS		
Buffer pH6			
Buffer pH6			
Target Range - Lower Bound			
Upper Bound			
CO-ASSAY			
Target Range - Lower Bound			
Upper Bound			
DS-1			
Target Range - Lower Bound			
Upper Bound			
GS310-10			
GS310-10			
Target Range - Lower Bound			
Upper Bound			
KZK-1			
KZK-1			
Target Range - Lower Bound			
Upper Bound			
MA-2c			
Target Range - Lower Bound			
Upper Bound			
MRGeo08		723	25.2
MRGeo08		815	22.4
Target Range - Lower Bound		708	18.1
Upper Bound		870	25.7
OREAS 905		61	42.7
OREAS 905		66	46.3
Target Range - Lower Bound		58	39.9
Upper Bound		76	55.1
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-1			
Target Range - Lower Bound			
Upper Bound			
UTS-2			
Target Range - Lower Bound			
Upper Bound			
UTS-4			

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QC CERTIFICATE OF ANALYSIS VA16153016

Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
Sample Description / LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
STANDARDS															
Target Range - Lower Bound								1.64							
Upper Bound								1.84							
UTS-4									1.77						
Target Range - Lower Bound									1.61						
Upper Bound									1.87						
BLANKS															
BLANK										<0.05	<0.2				
Target Range - Lower Bound										<0.05	<0.2				
Upper Bound										0.10	0.4				
BLANK												<0.01	<0.01	<0.1	<0.2
BLANK												<0.01	<0.01	<0.1	<0.2
Target Range - Lower Bound												<0.01	<0.01	<0.1	<0.2
Upper Bound												0.02	0.02	0.2	0.4
BLANK					6.0										
Target Range - Lower Bound					5.5										
Upper Bound					6.9										
BLANK								<0.01							
Target Range - Lower Bound								<0.01							
Upper Bound								0.02							
BLANK									<0.01						
Target Range - Lower Bound									<0.01						
Upper Bound									0.02						
BLANK							0.01								
BLANK							<0.01								
Target Range - Lower Bound							<0.01								
Upper Bound							0.02								

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Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
STANDARDS																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
BLANK		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
Target Range - Lower Bound		<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05	<0.02
Upper Bound		20	20	0.10	0.02	0.02	0.02	0.04	0.2	2	0.10	0.4	0.02	0.10	0.10	0.04
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description / Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
STANDARDS															
Target Range - Lower Bound															
Upper Bound															
UTS-4															
Target Range - Lower Bound															
Upper Bound															
BLANKS															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK	<0.01	<0.005	<0.01	<0.2	0.2	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
BLANK	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Target Range - Lower Bound	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1	<0.001
Upper Bound	0.02	0.010	0.02	0.4	0.2	0.02	10	0.10	0.02	0.10	0.4	20	0.4	0.2	0.002
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
BLANK															
Target Range - Lower Bound															
Upper Bound															

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QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 S % 0.01	ME-MS41 Sb ppm 0.05	ME-MS41 Sc ppm 0.1	ME-MS41 Se ppm 0.2	ME-MS41 Sn ppm 0.2	ME-MS41 Sr ppm 0.2	ME-MS41 Ta ppm 0.01	ME-MS41 Te ppm 0.01	ME-MS41 Th ppm 0.2	ME-MS41 Ti % 0.005	ME-MS41 Tl ppm 0.02	ME-MS41 U ppm 0.05	ME-MS41 V ppm 1	ME-MS41 W ppm 0.05	ME-MS41 Y ppm 0.05
STANDARDS																
Target Range - Lower Bound																
Upper Bound																
UTS-4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
BLANK		<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Target Range - Lower Bound		<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05	<0.05
Upper Bound		0.02	0.10	0.2	0.4	0.4	0.4	0.02	0.02	0.4	0.010	0.04	0.10	2	0.10	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
BLANK																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
STANDARDS			
Target Range - Lower Bound			
Upper Bound			
UTS-4			
Target Range - Lower Bound			
Upper Bound			
BLANKS			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK		<2	<0.5
BLANK		<2	<0.5
Target Range - Lower Bound		<2	<0.5
Upper Bound		4	1.0
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
Target Range - Lower Bound			
Upper Bound			
BLANK			
BLANK			
Target Range - Lower Bound			
Upper Bound			

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Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description / Method	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	C	CO2	Ag	Al	As	Au
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	ppm	%	ppm	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1	0.2
DUPLICATES															
ORIGINAL												0.81	0.58	2990	<0.2
DUP												0.77	0.59	3000	<0.2
Target Range - Lower Bound												0.74	0.55	2850	<0.2
Upper Bound												0.84	0.62	3140	0.4
ORIGINAL					7.8										
DUP					7.8										
Target Range - Lower Bound					7.3										
Upper Bound					8.3										
L1825469-8 127996								<0.01							
DUP								<0.01							
Target Range - Lower Bound								<0.01							
Upper Bound								0.02							
L1825469-10 127999	0.3	2	35	35		112.00	0.01		0.02	0.39	1.4				
DUP	0.3	2	35	35		112.00	0.01		0.02	0.38	1.4				
Target Range - Lower Bound	<0.3	<1	32	32		106.39	<0.01		<0.01	0.32	1.1				
Upper Bound	0.6	3	38	38		117.61	0.02		0.03	0.45	1.7				
ORIGINAL							0.45								
DUP							0.46								
Target Range - Lower Bound							0.43								
Upper Bound							0.48								
ORIGINAL												0.03	1.63	34.6	<0.2
DUP												0.03	1.61	38.6	<0.2
Target Range - Lower Bound												0.02	1.53	34.7	<0.2
Upper Bound												0.04	1.71	38.5	0.4

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BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method Analyte Units LOR	ME-MS41 B ppm 10	ME-MS41 Ba ppm 10	ME-MS41 Be ppm 0.05	ME-MS41 Bi ppm 0.01	ME-MS41 Ca % 0.01	ME-MS41 Cd ppm 0.01	ME-MS41 Ce ppm 0.02	ME-MS41 Co ppm 0.1	ME-MS41 Cr ppm 1	ME-MS41 Cs ppm 0.05	ME-MS41 Cu ppm 0.2	ME-MS41 Fe % 0.01	ME-MS41 Ga ppm 0.05	ME-MS41 Ge ppm 0.05	ME-MS41 Hf ppm 0.02
								DUPLICATES								
ORIGINAL		10	40	0.89	0.09	12.55	1.15	23.7	4.5	41	2.34	74.9	2.02	1.68	0.08	0.07
DUP		10	40	0.91	0.09	12.50	1.16	25.0	4.5	41	2.48	74.6	2.00	1.78	0.09	0.09
Target Range - Lower Bound		<10	30	0.81	0.08	11.90	1.09	23.1	4.2	38	2.24	71.9	1.90	1.59	<0.05	0.06
Upper Bound		20	50	1.00	0.10	13.15	1.22	25.6	4.8	44	2.58	77.6	2.12	1.87	0.10	0.10
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1825469-8 127996																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1825469-10 127999																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL		<10	70	0.43	0.11	2.29	0.21	70.5	13.2	28	3.34	14.6	3.04	5.57	0.09	0.27
DUP		<10	70	0.42	0.12	2.19	0.21	75.3	14.0	28	3.52	16.3	3.03	5.73	0.08	0.27
Target Range - Lower Bound		<10	50	0.35	0.10	2.12	0.19	69.2	12.8	26	3.21	14.7	2.87	5.32	<0.05	0.24
Upper Bound		20	90	0.50	0.13	2.36	0.23	76.6	14.4	30	3.65	16.2	3.20	5.98	0.10	0.30

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BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Hg ppm 0.01	ME-MS41 In ppm 0.005	ME-MS41 K % 0.01	ME-MS41 La ppm 0.2	ME-MS41 Li ppm 0.1	ME-MS41 Mg % 0.01	ME-MS41 Mn ppm 5	ME-MS41 Mo ppm 0.05	ME-MS41 Na % 0.01	ME-MS41 Nb ppm 0.05	ME-MS41 Ni ppm 0.2	ME-MS41 P ppm 10	ME-MS41 Pb ppm 0.2	ME-MS41 Rb ppm 0.1	ME-MS41 Re ppm 0.001
								DUPLICATES								
ORIGINAL		2.18	0.037	0.24	17.7	5.7	3.48	392	6.43	<0.01	<0.05	93.2	7670	19.1	14.2	0.046
DUP		2.22	0.038	0.24	18.5	6.2	3.49	391	6.65	<0.01	0.06	94.2	7680	19.6	15.3	0.043
Target Range - Lower Bound		2.03	0.031	0.22	17.0	5.6	3.30	367	6.16	<0.01	<0.05	88.8	7280	18.2	13.9	0.041
Upper Bound		2.38	0.044	0.26	19.2	6.3	3.67	416	6.92	0.02	0.10	98.6	8070	20.5	15.6	0.048
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1825469-8 127996																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1825469-10 127999																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL		<0.01	0.014	0.66	34.7	18.9	1.10	826	0.90	0.03	0.26	29.9	870	6.5	51.3	0.001
DUP		<0.01	0.014	0.66	36.6	20.2	1.06	805	0.88	0.03	0.26	30.8	830	6.6	53.8	0.001
Target Range - Lower Bound		<0.01	0.008	0.62	33.7	18.5	1.02	770	0.80	0.02	0.20	28.6	800	6.0	49.8	<0.001
Upper Bound		0.02	0.020	0.70	37.6	20.6	1.14	861	0.98	0.04	0.32	32.1	900	7.1	55.3	0.002

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Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
	Analyte	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y
	Units	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
	LOR	0.01	0.05	0.1	0.2	0.2	0.2	0.01	0.01	0.2	0.005	0.02	0.05	1	0.05	0.05
DUPLICATES																
ORIGINAL		1.66	29.8	8.5	8.7	0.6	214	<0.01	0.05	2.9	<0.005	8.14	6.89	78	1.67	35.8
DUP		1.65	29.7	8.8	8.7	0.7	213	<0.01	0.06	3.0	<0.005	8.23	7.23	78	1.72	36.9
Target Range - Lower Bound		1.56	27.5	8.1	8.1	0.4	203	<0.01	0.04	2.6	<0.005	7.55	6.66	73	1.52	34.5
Upper Bound		1.75	32.0	9.2	9.3	0.9	224	0.02	0.07	3.3	0.010	8.82	7.46	83	1.87	38.2
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1825469-8 127996																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1825469-10 127999																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL																
DUP																
Target Range - Lower Bound																
Upper Bound																
ORIGINAL		0.03	0.20	2.6	0.4	0.5	98.2	<0.01	<0.01	5.4	0.103	0.47	0.93	30	0.81	7.10
DUP		0.03	0.19	2.7	0.3	0.6	100.5	<0.01	<0.01	5.6	0.102	0.50	0.97	29	0.82	7.47
Target Range - Lower Bound		0.02	0.13	2.4	<0.2	0.3	94.2	<0.01	<0.01	5.0	0.092	0.43	0.85	27	0.70	6.87
Upper Bound		0.04	0.26	2.9	0.4	0.8	104.5	0.02	0.02	6.0	0.113	0.54	1.05	32	0.93	7.70

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.

2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: +1 (604) 984 0221 Fax: +1 (604) 984 0218
www.alsglobal.com

To: **ALS ENVIRONMENTAL**
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

Sample Description	Method / Analyte / Units / LOR	ME-MS41 Zn ppm 2	ME-MS41 Zr ppm 0.5
	DUPLICATES		
ORIGINAL		368	6.6
DUP		366	6.7
Target Range - Lower Bound		347	5.7
Upper Bound		387	7.6
ORIGINAL			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1825469-8 127996			
DUP			
Target Range - Lower Bound			
Upper Bound			
L1825469-10 127999			
DUP			
Target Range - Lower Bound			
Upper Bound			
ORIGINAL			
DUP			
Target Range - Lower Bound			
Upper Bound			
ORIGINAL		69	8.3
DUP		67	8.7
Target Range - Lower Bound		63	7.4
Upper Bound		73	9.6

***** See Appendix Page for comments regarding this certificate *****

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BURNABY BC V5A 1W9

Finalized Date: 12-OCT-2016
Account: APN

Project: L1825469

QC CERTIFICATE OF ANALYSIS VA16153016

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).

Applies to Method: ME-MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:			
C-GAS05	CRU-31	LOG-22	ME-MS41
OA-ELE07	OA-VOL08m	PUL-31	S-CAL06
S-GRA06	S-GRA06a	S-IR08	SPL-21
WEI-21			

ALS

Chain of Custody (COC) / Analytical Request Form

L1825469-COFC

COC Number: 16-010

Canada Toll Free: 1 800 668 9878

Page of

www.alsglobal.com

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only) L1825469

ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals - Aqua regia disgestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	127989	Aug. 10/16		Composite	R	R	R	R	R	R	
	127990	Aug 10/16		waste							
	127991	Aug. 10/16		waste							
	127992	Aug 15/16		waste							
	127993	Aug 16/16		waste							
	127994	"		waste							
	127995	"		waste							
	127996	"		waste							
	127997	"		waste							
	127999	Aug 29/16		waste							
	127953	"		waste							
	127998	"		waste							

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☑

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 14.0

FINAL COOLER TEMPERATURES °C: 9

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: EHF	Date: 6 Sep 2016	Time: 10:26	Received by: JL	Date: SEP - 7 2016	Time: 9:25

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

ALS www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1825469-COFC

COC Number: 16- 11

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

ALS Lab Work Order # (lab use only) L1825469

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#

Major/Minor Code: | Routing Code:

Requisitioner:

Location:

ALS Contact: | Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals - Aqua regia digestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
					R	R	R	R	R	R	
	128000	Aug. 29/16		~~Composite~~							
	127956	Aug. 29/16		waste							
	127954	11		waste							
	1279 ~~5~~55	11		waste							
	127957	11		waste							
	127951	11		waste							
	127952	11		waste							

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☒

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 14.0

FINAL COOLER TEMPERATURES °C: 9

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: EHF	Date: 6 Sep 2016	Time: 10:26	Received by: JC	Date: SEP - 7 2016	Time: 9:25

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

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Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1 If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form

Minto Explorations Ltd.
ATTN: Minto Environment
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 08-NOV-16
Report Date: 09-DEC-16 17:52 (MT)
Version: FINAL

Client Phone: 604-759-0860

Certificate of Analysis

Lab Work Order #: L1855941
Project P.O. #: 220826
Job Reference:
C of C Numbers: 15-12
Legal Site Desc:

Comments: Please note, the results from ALS Minerals division can be found at the end of this attachment.

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1855941-1	L1855941-2	L1855941-3	L1855941-4	L1855941-5
	Description	THICKNER	WASTE	WASTE	WASTE	WASTE
	Sampled Date	05-OCT-16	06-SEP-16	06-SEP-16	06-SEP-16	06-SEP-16
	Sampled Time	16:00	14:15	14:15	14:15	14:15
	Client ID	THICKNER U/F SEPTEMBER 2016	852-15	858-12	858-13	858-14 127961
SOIL						
Physical Tests	pH (Unity)	8.4	8.2	8.8	8.7	8.7
Organic / Inorganic Carbon	Carbon (C) (%)	0.21	0.31	0.08	0.18	0.20
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	1.6	10.0	3.8	0.6	0.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	15	26	15	22	21
	NNP (tCaCO3/1Kt)	13	16	11	21	21
	Ratio (NP/MPA) (Unity)	9.60	2.60	4.00	35.20	67.20
	Sulfate Sulfur (carbonate leach) (%)	<0.01	0.01	0.01	0.01	<0.01
	Sulfate Sulfur (HCl leach) (%)	<0.01	0.01	0.01	0.01	0.02
	Sulfide Sulfur (T minus carbonate leach) (%)	0.05	0.31	0.11	0.01	0.01
	Total Sulfur (combustion) (%)	0.05	0.32	0.12	0.02	0.01
Total Metals	Aluminum (Al) (%)	0.92	1.27	1.31	1.16	0.98
	Antimony (Sb) (ppm)	<0.05	0.05	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.8	1.0	0.4	0.6	0.5
	Barium (Ba) (ppm)	120	220	150	170	180
	Beryllium (Be) (ppm)	0.17	0.24	0.32	0.26	0.22
	Bismuth (Bi) (ppm)	0.26	1.60	0.88	0.07	0.02
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.34	0.47	0.20	0.04	0.02
	Calcium (Ca) (%)	0.70	1.20	0.84	1.13	0.94
	Cerium (Ce) (ppm)	9.96	26.6	11.80	14.20	15.40
	Cesium (Cs) (ppm)	0.27	0.52	0.16	0.20	0.26
	Chromium (Cr) (ppm)	6	6	6	6	7
	Cobalt (Co) (ppm)	7.2	6.8	7.3	5.5	5.0
	Copper (Cu) (ppm)	927	6720	3100	330	110.0
	Gallium (Ga) (ppm)	8.53	7.55	7.80	5.04	4.49
	Germanium (Ge) (ppm)	0.05	0.08	0.07	0.10	0.10
	Gold (Au) (ppm)	0.4	0.3	0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.04	0.04	0.08	0.06	0.07
	Indium (In) (ppm)	0.080	0.096	0.017	0.018	0.021
	Iron (Fe) (%)	4.53	3.20	3.19	2.19	2.12
	Lanthanum (La) (ppm)	5.1	14.2	6.3	8.3	8.9
	Lead (Pb) (ppm)	3.4	5.3	4.7	2.0	1.3
	Lithium (Li) (ppm)	4.9	6.9	7.9	5.4	4.2
	Magnesium (Mg) (%)	0.52	0.68	0.82	0.69	0.55
	Manganese (Mn) (ppm)	578	606	617	521	476

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1855941-6	L1855941-7	L1855941-8	L1855941-9	L1855941-10
	Description	WASTE	WASTE	WASTE	WASTE	WASTE
	Sampled Date	06-SEP-16	06-SEP-16	06-SEP-16	04-OCT-16	04-OCT-16
	Sampled Time	14:15	14:15	14:15	07:50	08:10
	Client ID	858-14 127962	846-02 127963	846-02 127964	127969	127971
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.7	8.4	8.3	8.7	9.0
Organic / Inorganic Carbon	Carbon (C) (%)	0.20	0.21	0.30	0.15	0.08
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	<0.3	2.8	9.1	0.6	5.3
	Neutralization Potential (NP) (tCaCO3/1Kt)	22	18	26	18	13
	NNP (tCaCO3/1Kt)	22	15	17	17	8
	Ratio (NP/MPA) (Unity)	140.80	6.40	2.87	28.80	2.45
	Sulfate Sulfur (carbonate leach) (%)	<0.01	<0.01	<0.01	<0.01	<0.01
	Sulfate Sulfur (HCl leach) (%)	0.01	0.02	0.02	0.01	0.02
	Sulfide Sulfur (T minus carbonate leach) (%)	<0.01	0.09	0.29	0.02	0.17
	Total Sulfur (combustion) (%)	<0.01	0.09	0.29	0.02	0.17
Total Metals	Aluminum (Al) (%)	1.22	1.13	1.33	1.06	1.15
	Antimony (Sb) (ppm)	<0.05	0.05	0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.4	1.1	2.6	0.6	0.5
	Barium (Ba) (ppm)	180	270	330	160	260
	Beryllium (Be) (ppm)	0.27	0.23	0.22	0.25	0.17
	Bismuth (Bi) (ppm)	0.02	0.53	1.30	0.19	1.21
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.04	0.14	0.48	0.06	0.19
	Calcium (Ca) (%)	1.10	0.86	1.17	0.83	0.62
	Cerium (Ce) (ppm)	16.00	19.15	8.60	22.0	15.35
	Cesium (Cs) (ppm)	0.22	0.26	0.44	0.22	0.30
	Chromium (Cr) (ppm)	6	5	6	7	6
	Cobalt (Co) (ppm)	5.6	6.3	7.2	4.6	5.9
	Copper (Cu) (ppm)	48.3	2660	6130	913	5680
	Gallium (Ga) (ppm)	5.32	5.93	6.67	4.50	5.91
	Germanium (Ge) (ppm)	0.11	0.10	0.11	0.09	0.11
	Gold (Au) (ppm)	<0.2	0.2	0.2	0.2	0.2
	Hafnium (Hf) (ppm)	0.06	0.05	0.05	0.12	0.04
	Indium (In) (ppm)	0.022	0.042	0.049	0.022	0.037
	Iron (Fe) (%)	2.27	2.87	3.57	1.87	3.09
	Lanthanum (La) (ppm)	9.2	11.2	4.4	12.3	8.5
	Lead (Pb) (ppm)	2.2	2.1	3.3	2.1	2.6
	Lithium (Li) (ppm)	5.4	5.3	5.5	4.5	5.6
	Magnesium (Mg) (%)	0.70	0.57	0.71	0.53	0.66
	Manganese (Mn) (ppm)	535	484	664	482	541

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1855941-11	L1855941-12	L1855941-13	L1855941-14	L1855941-15
	Description	WASTE	TAILS			
	Sampled Date	04-OCT-16	05-OCT-16	11-SEP-16	13-SEP-16	13-SEP-16
	Sampled Time	08:13	16:00			
	Client ID	127970	TAILS U/F AUGUST 2016	852-16-120 127965	BLAST # 852-07 127966	BLAST # 846-03 127967
SOIL						
Physical Tests	pH (Unity)	8.6	8.5	8.7	8.8	8.6
Organic / Inorganic Carbon	Carbon (C) (%)	0.42	0.20	0.24	0.17	0.25
Acid Base Accounting	FIZZ RATING (Unity)	2	2	2	2	2
	MPA (tCaCO3/1Kt)	0.6	0.9	1.6	0.3	2.2
	Neutralization Potential (NP) (tCaCO3/1Kt)	42	17	22	19	28
	NNP (tCaCO3/1Kt)	41	16	20	19	26
	Ratio (NP/MPA) (Unity)	67.20	18.13	14.08	60.80	12.80
	Sulfate Sulfur (carbonate leach) (%)	0.01	<0.01	<0.01	<0.01	<0.01
	Sulfate Sulfur (HCl leach) (%)	0.01	0.04	0.03	<0.01	0.01
	Sulfide Sulfur (T minus carbonate leach) (%)	0.01	0.03	0.05	0.01	0.07
	Total Sulfur (combustion) (%)	0.02	0.03	0.05	0.01	0.07
Total Metals	Aluminum (Al) (%)	1.30	1.21	1.21	1.39	1.05
	Antimony (Sb) (ppm)	<0.05	0.06	<0.05	<0.05	<0.05
	Arsenic (As) (ppm)	0.8	0.9	0.4	0.5	0.5
	Barium (Ba) (ppm)	90	130	270	280	170
	Beryllium (Be) (ppm)	0.40	0.21	0.21	0.24	0.23
	Bismuth (Bi) (ppm)	0.14	0.28	0.26	0.02	0.47
	Boron (B) (ppm)	<10	<10	<10	<10	<10
	Cadmium (Cd) (ppm)	0.04	0.30	0.07	0.03	0.12
	Calcium (Ca) (%)	1.97	0.81	1.03	0.92	1.30
	Cerium (Ce) (ppm)	14.70	11.10	22.4	22.6	19.25
	Cesium (Cs) (ppm)	0.14	0.32	0.39	0.33	0.25
	Chromium (Cr) (ppm)	6	7	6	6	5
	Cobalt (Co) (ppm)	5.7	7.9	5.3	6.3	5.2
	Copper (Cu) (ppm)	635	986	1045	240	2240
	Gallium (Ga) (ppm)	6.11	10.10	5.21	5.99	5.20
	Germanium (Ge) (ppm)	0.09	0.11	0.10	0.11	0.10
	Gold (Au) (ppm)	<0.2	0.2	<0.2	<0.2	<0.2
	Hafnium (Hf) (ppm)	0.05	0.04	0.04	0.06	0.05
	Indium (In) (ppm)	0.023	0.094	0.032	0.019	0.037
	Iron (Fe) (%)	2.24	5.54	2.47	2.61	2.26
	Lanthanum (La) (ppm)	8.1	6.3	12.8	12.8	10.8
	Lead (Pb) (ppm)	4.3	4.0	1.8	1.8	2.1
	Lithium (Li) (ppm)	5.5	5.7	4.9	6.4	4.6
	Magnesium (Mg) (%)	0.72	0.64	0.61	0.76	0.51
	Manganese (Mn) (ppm)	647	667	522	589	488

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1855941-16				
	Description					
	Sampled Date	13-SEP-16				
	Sampled Time					
	Client ID	BLAST # 852-09 127968				
Grouping	**Analyte**					
SOIL						
Physical Tests	pH (Unity)	8.7				
Organic / Inorganic Carbon	Carbon (C) (%)	0.23				
Acid Base Accounting	FIZZ RATING (Unity)	2				
	MPA (tCaCO3/1Kt)	1.6				
	Neutralization Potential (NP) (tCaCO3/1Kt)	25				
	NNP (tCaCO3/1Kt)	23				
	Ratio (NP/MPA) (Unity)	16.00				
	Sulfate Sulfur (carbonate leach) (%)	<0.01				
	Sulfate Sulfur (HCl leach) (%)	<0.01				
	Sulfide Sulfur (T minus carbonate leach) (%)	0.05				
	Total Sulfur (combustion) (%)	0.05				
Total Metals	Aluminum (Al) (%)	1.30				
	Antimony (Sb) (ppm)	<0.05				
	Arsenic (As) (ppm)	0.6				
	Barium (Ba) (ppm)	180				
	Beryllium (Be) (ppm)	0.30				
	Bismuth (Bi) (ppm)	0.16				
	Boron (B) (ppm)	<10				
	Cadmium (Cd) (ppm)	0.04				
	Calcium (Ca) (%)	1.22				
	Cerium (Ce) (ppm)	18.20				
	Cesium (Cs) (ppm)	0.26				
	Chromium (Cr) (ppm)	5				
	Cobalt (Co) (ppm)	6.2				
	Copper (Cu) (ppm)	906				
	Gallium (Ga) (ppm)	5.89				
	Germanium (Ge) (ppm)	0.10				
	Gold (Au) (ppm)	<0.2				
	Hafnium (Hf) (ppm)	0.07				
	Indium (In) (ppm)	0.032				
	Iron (Fe) (%)	2.45				
	Lanthanum (La) (ppm)	10.1				
	Lead (Pb) (ppm)	3.2				
	Lithium (Li) (ppm)	6.1				
	Magnesium (Mg) (%)	0.74				
	Manganese (Mn) (ppm)	622				

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1855941-1	L1855941-2	L1855941-3	L1855941-4	L1855941-5
	Sample ID	L1855941-1	L1855941-2	L1855941-3	L1855941-4	L1855941-5
	Description	THICKNER	WASTE	WASTE	WASTE	WASTE
	Sampled Date	05-OCT-16	06-SEP-16	06-SEP-16	06-SEP-16	06-SEP-16
	Sampled Time	16:00	14:15	14:15	14:15	14:15
	Client ID	THICKNER U/F SEPTEMBER 2016	852-15	858-12	858-13	858-14 127961
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.01	0.01	0.01	<0.01	<0.01
	Molybdenum (Mo) (ppm)	0.59	0.64	0.42	0.55	2.29
	Nickel (Ni) (ppm)	3.0	2.4	2.6	2.8	2.0
	Niobium (Nb) (ppm)	0.20	0.23	0.21	0.20	0.21
	Phosphorus (P) (ppm)	490	760	660	720	680
	Potassium (K) (%)	0.37	0.71	0.26	0.37	0.45
	Rhenium (Re) (ppm)	0.001	0.001	0.001	<0.001	0.002
	Rubidium (Rb) (ppm)	19.1	39.5	12.6	15.3	19.9
	Scandium (Sc) (ppm)	2.5	3.2	2.3	3.3	3.4
	Selenium (Se) (ppm)	0.8	7.1	4.6	0.7	0.4
	Silver (Ag) (ppm)	0.81	2.53	1.70	0.16	0.06
	Sodium (Na) (%)	0.04	0.05	0.06	0.08	0.08
	Strontium (Sr) (ppm)	50.4	74.0	67.6	72.0	59.4
	Sulfur (S) (%)	0.05	0.39	0.16	0.02	0.01
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.24	0.61	0.50	0.03	0.02
	Thallium (Tl) (ppm)	0.13	0.22	0.06	0.08	0.10
	Thorium (Th) (ppm)	3.3	4.5	1.7	1.3	1.7
	Tin (Sn) (ppm)	0.6	0.5	0.4	0.4	0.4
	Titanium (Ti) (%)	0.079	0.130	0.138	0.102	0.091
	Tungsten (W) (ppm)	0.06	0.16	0.34	0.91	0.29
	Uranium (U) (ppm)	0.25	0.31	0.35	0.17	0.30
	Vanadium (V) (ppm)	72	59	63	49	47
	Yttrium (Y) (ppm)	2.91	5.57	3.15	5.33	5.96
	Zinc (Zn) (ppm)	119	100	99	58	53
	Zirconium (Zr) (ppm)	0.9	1.0	1.7	1.0	1.1
Permanent Gases	Carbon Dioxide (CO2) (%)	0.8	1.1	0.3	0.7	0.7

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1855941-6	L1855941-7	L1855941-8	L1855941-9	L1855941-10
	Description	WASTE	WASTE	WASTE	WASTE	WASTE
	Sampled Date	06-SEP-16	06-SEP-16	06-SEP-16	04-OCT-16	04-OCT-16
	Sampled Time	14:15	14:15	14:15	07:50	08:10
	Client ID	858-14 127962	846-02 127963	846-02 127964	127969	127971
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	<0.01	0.01	0.02	0.01	0.02
	Molybdenum (Mo) (ppm)	0.43	0.33	0.34	0.30	0.53
	Nickel (Ni) (ppm)	1.9	2.4	3.1	1.7	2.1
	Niobium (Nb) (ppm)	0.19	0.14	0.13	0.18	0.23
	Phosphorus (P) (ppm)	650	600	720	490	560
	Potassium (K) (%)	0.39	0.51	0.76	0.28	0.58
	Rhenium (Re) (ppm)	0.001	0.001	<0.001	<0.001	<0.001
	Rubidium (Rb) (ppm)	16.2	24.7	36.3	13.1	27.7
	Scandium (Sc) (ppm)	3.5	2.9	3.4	3.1	2.9
	Selenium (Se) (ppm)	0.3	2.7	6.8	1.2	5.9
	Silver (Ag) (ppm)	0.03	1.17	2.43	0.51	2.39
	Sodium (Na) (%)	0.09	0.06	0.08	0.07	0.09
	Strontium (Sr) (ppm)	98.5	89.7	76.2	101.5	58.3
	Sulfur (S) (%)	0.01	0.14	0.34	0.05	0.26
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.01	0.26	0.64	0.29	0.32
	Thallium (Tl) (ppm)	0.09	0.13	0.19	0.08	0.15
	Thorium (Th) (ppm)	1.6	3.5	0.9	4.2	2.0
	Tin (Sn) (ppm)	0.4	0.4	0.5	0.4	0.4
	Titanium (Ti) (%)	0.091	0.089	0.135	0.051	0.124
	Tungsten (W) (ppm)	0.19	0.40	0.54	0.11	0.30
	Uranium (U) (ppm)	0.29	0.26	0.17	0.42	0.31
	Vanadium (V) (ppm)	48	55	73	33	58
	Yttrium (Y) (ppm)	6.08	4.37	5.25	6.31	4.19
	Zinc (Zn) (ppm)	63	72	93	58	87
	Zirconium (Zr) (ppm)	0.9	1.0	0.8	2.4	0.8
Permanent Gases	Carbon Dioxide (CO2) (%)	0.7	0.8	1.1	0.6	0.3

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1855941-11	L1855941-12	L1855941-13	L1855941-14	L1855941-15
	Description	WASTE	TAILS			
	Sampled Date	04-OCT-16	05-OCT-16	11-SEP-16	13-SEP-16	13-SEP-16
	Sampled Time	08:13	16:00			
	Client ID	127970	TAILS U/F AUGUST 2016	852-16-120 127965	BLAST # 852-07 127966	BLAST # 846-03 127967
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.02	0.02	0.02	0.01	0.01
	Molybdenum (Mo) (ppm)	0.41	0.60	0.81	0.98	0.79
	Nickel (Ni) (ppm)	2.1	3.1	2.1	2.6	2.1
	Niobium (Nb) (ppm)	0.11	0.17	0.23	0.19	0.17
	Phosphorus (P) (ppm)	670	570	680	770	590
	Potassium (K) (%)	0.17	0.46	0.74	0.71	0.37
	Rhenium (Re) (ppm)	<0.001	0.001	<0.001	0.001	<0.001
	Rubidium (Rb) (ppm)	7.0	23.7	34.6	31.6	17.7
	Scandium (Sc) (ppm)	3.6	3.5	4.1	3.8	4.1
	Selenium (Se) (ppm)	0.7	1.0	1.3	0.4	2.5
	Silver (Ag) (ppm)	0.27	0.71	0.38	0.13	0.98
	Sodium (Na) (%)	0.07	0.06	0.09	0.09	0.08
	Strontium (Sr) (ppm)	104.0	69.4	80.2	70.2	74.7
	Sulfur (S) (%)	0.04	0.06	0.06	0.02	0.12
	Tantalum (Ta) (ppm)	<0.01	<0.01	<0.01	<0.01	<0.01
	Tellurium (Te) (ppm)	0.03	0.23	0.10	0.02	0.18
	Thallium (Tl) (ppm)	0.04	0.18	0.19	0.16	0.08
	Thorium (Th) (ppm)	1.5	3.9	3.5	3.4	2.3
	Tin (Sn) (ppm)	0.4	0.8	0.4	0.5	0.5
	Titanium (Ti) (%)	0.044	0.090	0.128	0.130	0.072
	Tungsten (W) (ppm)	0.13	0.05	0.37	0.38	0.36
	Uranium (U) (ppm)	0.17	0.28	0.39	0.20	0.27
	Vanadium (V) (ppm)	40	84	55	56	43
	Yttrium (Y) (ppm)	7.61	3.88	4.96	6.15	6.47
	Zinc (Zn) (ppm)	56	140	78	80	68
	Zirconium (Zr) (ppm)	0.8	1.1	0.6	0.8	0.7
Permanent Gases	Carbon Dioxide (CO_2) (%)	1.5	0.7	0.9	0.6	0.9

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1855941-16				
	Description					
	Sampled Date	13-SEP-16				
	Sampled Time					
	Client ID	BLAST # 852-09 127968				
Grouping	**Analyte**					
SOIL						
Total Metals	Mercury (Hg) (ppm)	0.02				
	Molybdenum (Mo) (ppm)	0.46				
	Nickel (Ni) (ppm)	2.3				
	Niobium (Nb) (ppm)	0.16				
	Phosphorus (P) (ppm)	740				
	Potassium (K) (%)	0.41				
	Rhenium (Re) (ppm)	<0.001				
	Rubidium (Rb) (ppm)	18.5				
	Scandium (Sc) (ppm)	4.3				
	Selenium (Se) (ppm)	1.1				
	Silver (Ag) (ppm)	0.32				
	Sodium (Na) (%)	0.08				
	Strontium (Sr) (ppm)	97.4				
	Sulfur (S) (%)	0.06				
	Tantalum (Ta) (ppm)	<0.01				
	Tellurium (Te) (ppm)	0.07				
	Thallium (Tl) (ppm)	0.10				
	Thorium (Th) (ppm)	2.0				
	Tin (Sn) (ppm)	0.5				
	Titanium (Ti) (%)	0.087				
	Tungsten (W) (ppm)	0.11				
	Uranium (U) (ppm)	0.34				
	Vanadium (V) (ppm)	50				
	Yttrium (Y) (ppm)	8.01				
	Zinc (Zn) (ppm)	72				
	Zirconium (Zr) (ppm)	1.1				
Permanent Gases	Carbon Dioxide (CO2) (%)	0.9				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ABA-OA-VOL08-AX	Soil	Acid Base Accounting	OA-VOL08
CARBON-C-GAS05-AX	Soil	Carbon, TOC and CO2	C-GAS05
ME-MS41-AX	Soil	Aqua Regia ICPMS	Aqua Regia ICPMS

A prepared sample (0.50 g) is digested with aqua regia in a graphite heating block. After cooling, the resulting solution is diluted to with deionized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry. Following this analysis, the results are reviewed for high concentrations of bismuth, mercury, molybdenum, silver and tungsten and diluted accordingly. Samples are then analysed by ICP-MS for the remaining suite of elements. The analytical results are corrected for inter-element spectral interferences.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-OA-ELE07-AX	Soil	pH	OA-ELE07
SULPHUR-S-CAL06-AX	Soil	Sulfide Sulfur Calc from Carbonate Leach	ALS Minerals S-CAL06

Sulfide Sulfur (as S) is calculated by subtracting the Carbonate Leachable Sulfate Sulfur (as S) from the Total Sulfur (as S) obtained from combustion.

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06-AX	Soil	Sulfate Sulfur in Soil (Carbonate Leach)	ALS Minerals S-GRA06

A prepared sample is boiled with a sodium carbonate solution for 30 minutes. Any insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-GRA06A-AX	Soil	Sulfate Sulfur in Soil (HCl Leach)	ALS Minerals S-GRA06A

A prepared sample is heated with dilute hydrochloric acid for 30 minutes. Silica and any acid-insoluble materials are removed by filtration and ferric iron is reduced to ferrous iron by the addition of hydroxylamine hydrochloride. The sulfate in the resulting filtrate is then precipitated with barium chloride in a dilute hydrochloric acid medium. The barium sulfate precipitate is filtered, ignited, weighed and the Sulfate Sulfur is calculated (as S).

ALS Test Code	Matrix	Test Description	Method Reference**
SULPHUR-S-IR08-AX	Soil	Total Sulfur in Soil by Combustion	ALS Minerals S-IR08

The sample is heated to approximately 1350 °C in an induction furnace while passing a stream of oxygen through the sample. Sulfur dioxide released from the sample is measured by an IR detection system and the Total Sulfur result is provided.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
AX	ALS MINERALS - VANCOUVER, B.C., CANADA

Chain of Custody Numbers:

15-12

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

CERTIFICATE VA16195955

Project: L1855941
P.O. No.: ALSM- CW16- 102- APN
This report is for 16 Percussion samples submitted to our lab in Vancouver, BC, Canada on 10- NOV- 2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	ARIEL MCDONNELL	SOFTWARE DEVELOPMENT GROUP

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LOG- 22	Sample login - Rcd w/o BarCode
CRU- QC	Crushing QC Test
PUL- QC	Pulverizing QC Test
CRU- 31	Fine crushing - 70% <2mm
SPL- 21	Split sample - riffle splitter
PUL- 31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S- CAL06	Sulfide Sulfur (calculated)	LECO
C- GAS05	Inorganic Carbon (CO2)	
S- GRA06a	Sulfate Sulfur (HCl leachable)	WST- SEQ
ME- MS41	Ultra Trace Aqua Regia ICP- MS	
OA- VOL08m	Modified NP	
S- IR08	Total Sulphur (Leco)	LECO
OA- ELE07	Paste pH	
S- GRA06	Sulfate Sulfur- carbonate leach	WST- SEQ

To: ALS ENVIRONMENTAL
ATTN: ARIEL MCDONNELL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

CERTIFICATE OF ANALYSIS VA16195955

Sample Description	WEI-21	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41
Method / Analyte / Units / LOR	Recvd Wt. kg 0.02	MPA tCaCO3/1Kt 0.3	FIZZ RAT Unity 1	NNP tCaCO3/1Kt 1	NP tCaCO3/1Kt 1	pH Unity 0.1	Ratio (N Unity 0.01	S % 0.01	S % 0.01	S % 0.01	S % 0.01	C % 0.05	CO2 % 0.2	Ag ppm 0.01	Al % 0.01
L1855941-1 THICKNER U/F SEPT 2016	0.86	1.6	2	13	15	8.4	9.60	0.05	<0.01	<0.01	0.05	0.21	0.8	0.81	0.92
L1855941-2 852-15	0.92	10.0	2	16	26	8.2	2.60	0.32	0.01	0.01	0.31	0.31	1.1	2.53	1.27
L1855941-3 858-12	1.00	3.8	2	11	15	8.8	4.00	0.12	0.01	0.01	0.11	0.08	0.3	1.70	1.31
L1855941-4 858-13	1.12	0.6	2	21	22	8.7	35.20	0.02	0.01	0.01	0.01	0.18	0.7	0.16	1.16
L1855941-5 858-14 127961	0.98	0.3	2	21	21	8.7	67.20	0.01	<0.01	0.02	0.01	0.20	0.7	0.06	0.98
L1855941-6 858-14 127962	0.98	<0.3	2	22	22	8.7	140.80	<0.01	<0.01	0.01	<0.01	0.20	0.7	0.03	1.22
L1855941-7 846-02 127963	0.84	2.8	2	15	18	8.4	6.40	0.09	<0.01	0.02	0.09	0.21	0.8	1.17	1.13
L1855941-8 846-02 127964	0.58	9.1	2	17	26	8.3	2.87	0.29	<0.01	0.02	0.29	0.30	1.1	2.43	1.33
L1855941-9 127969	0.90	0.6	2	17	18	8.7	28.80	0.02	<0.01	0.01	0.02	0.15	0.6	0.51	1.06
L1855941-10 127971	0.92	5.3	2	8	13	9.0	2.45	0.17	<0.01	0.02	0.17	0.08	0.3	2.39	1.15
L1855941-11 127970	1.00	0.6	2	41	42	8.6	67.20	0.02	0.01	0.01	0.01	0.42	1.5	0.27	1.30
L1855941-12 Tails U/F AUG 2016	0.94	0.9	2	16	17	8.5	18.13	0.03	<0.01	0.04	0.03	0.20	0.7	0.71	1.21
L1855941-13 852-16-120 127965	1.12	1.6	2	20	22	8.7	14.08	0.05	<0.01	0.03	0.05	0.24	0.9	0.38	1.21
L1855941-14 BLAST # 852-07 127966	1.06	0.3	2	19	19	8.8	60.80	0.01	<0.01	<0.01	0.01	0.17	0.6	0.13	1.39
L1855941-15 BLAST # 846-03 127967	1.06	2.2	2	26	28	8.6	12.80	0.07	<0.01	0.01	0.07	0.25	0.9	0.98	1.05
L1855941-16 BLAST # 852-09 127968	1.12	1.6	2	23	25	8.7	16.00	0.05	<0.01	<0.01	0.05	0.23	0.9	0.32	1.30

***** See Appendix Page for comments regarding this certificate *****

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To: ALS ENVIRONMENTAL
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Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

CERTIFICATE OF ANALYSIS VA16195955

Sample Description / Method / Analyte / Units / LOR	ME- MS41 As ppm 0.1	ME- MS41 Au ppm 0.2	ME- MS41 B ppm 10	ME- MS41 Ba ppm 10	ME- MS41 Be ppm 0.05	ME- MS41 Bi ppm 0.01	ME- MS41 Ca % 0.01	ME- MS41 Cd ppm 0.01	ME- MS41 Ce ppm 0.02	ME- MS41 Co ppm 0.1	ME- MS41 Cr ppm 1	ME- MS41 Cs ppm 0.05	ME- MS41 Cu ppm 0.2	ME- MS41 Fe % 0.01	ME- MS41 Ga ppm 0.05
L1855941- 1 THICKNER U/F SEPT 2016	0.8	0.4	<10	120	0.17	0.26	0.70	0.34	9.96	7.2	6	0.27	927	4.53	8.53
L1855941- 2 852- 15	1.0	0.3	<10	220	0.24	1.60	1.20	0.47	26.6	6.8	6	0.52	6720	3.20	7.55
L1855941- 3 858- 12	0.4	0.2	<10	150	0.32	0.88	0.84	0.20	11.80	7.3	6	0.16	3100	3.19	7.80
L1855941- 4 858- 13	0.6	<0.2	<10	170	0.26	0.07	1.13	0.04	14.20	5.5	6	0.20	330	2.19	5.04
L1855941- 5 858- 14 127961	0.5	<0.2	<10	180	0.22	0.02	0.94	0.02	15.40	5.0	7	0.26	110.0	2.12	4.49
L1855941- 6 858- 14 127962	0.4	<0.2	<10	180	0.27	0.02	1.10	0.04	16.00	5.6	6	0.22	48.3	2.27	5.32
L1855941- 7 846- 02 127963	1.1	0.2	<10	270	0.23	0.53	0.86	0.14	19.15	6.3	5	0.26	2660	2.87	5.93
L1855941- 8 846- 02 127964	2.6	0.2	<10	330	0.22	1.30	1.17	0.48	8.60	7.2	6	0.44	6130	3.57	6.67
L1855941- 9 127969	0.6	0.2	<10	160	0.25	0.19	0.83	0.06	22.0	4.6	7	0.22	913	1.87	4.50
L1855941- 10 127971	0.5	0.2	<10	260	0.17	1.21	0.62	0.19	15.35	5.9	6	0.30	5680	3.09	5.91
L1855941- 11 127970	0.8	<0.2	<10	90	0.40	0.14	1.97	0.04	14.70	5.7	6	0.14	635	2.24	6.11
L1855941- 12 Tails U/F AUG 2016	0.9	0.2	<10	130	0.21	0.28	0.81	0.30	11.10	7.9	7	0.32	986	5.54	10.10
L1855941- 13 852- 16- 120 127965	0.4	<0.2	<10	270	0.21	0.26	1.03	0.07	22.4	5.3	6	0.39	1045	2.47	5.21
L1855941- 14 BLAST # 852- 07 127966	0.5	<0.2	<10	280	0.24	0.02	0.92	0.03	22.6	6.3	6	0.33	240	2.61	5.99
L1855941- 15 BLAST # 846- 03 127967	0.5	<0.2	<10	170	0.23	0.47	1.30	0.12	19.25	5.2	5	0.25	2240	2.26	5.20
L1855941- 16 BLAST # 852- 09 127968	0.6	<0.2	<10	180	0.30	0.16	1.22	0.04	18.20	6.2	5	0.26	906	2.45	5.89

***** See Appendix Page for comments regarding this certificate *****

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

CERTIFICATE OF ANALYSIS VA16195955

Sample Description / Method / Analyte / Units / LOR	ME- MS41 Ge ppm 0.05	ME- MS41 Hf ppm 0.02	ME- MS41 Hg ppm 0.01	ME- MS41 In ppm 0.005	ME- MS41 K % 0.01	ME- MS41 La ppm 0.2	ME- MS41 Li ppm 0.1	ME- MS41 Mg % 0.01	ME- MS41 Mn ppm 5	ME- MS41 Mo ppm 0.05	ME- MS41 Na % 0.01	ME- MS41 Nb ppm 0.05	ME- MS41 Ni ppm 0.2	ME- MS41 P ppm 10	ME- MS41 Pb ppm 0.2
L1855941- 1 THICKNER U/F SEPT 2016	0.05	0.04	0.01	0.080	0.37	5.1	4.9	0.52	578	0.59	0.04	0.20	3.0	490	3.4
L1855941- 2 852- 15	0.08	0.04	0.01	0.096	0.71	14.2	6.9	0.68	606	0.64	0.05	0.23	2.4	760	5.3
L1855941- 3 858- 12	0.07	0.08	0.01	0.017	0.26	6.3	7.9	0.82	617	0.42	0.06	0.21	2.6	660	4.7
L1855941- 4 858- 13	0.10	0.06	<0.01	0.018	0.37	8.3	5.4	0.69	521	0.55	0.08	0.20	2.8	720	2.0
L1855941- 5 858- 14 127961	0.10	0.07	<0.01	0.021	0.45	8.9	4.2	0.55	476	2.29	0.08	0.21	2.0	680	1.3
L1855941- 6 858- 14 127962	0.11	0.06	<0.01	0.022	0.39	9.2	5.4	0.70	535	0.43	0.09	0.19	1.9	650	2.2
L1855941- 7 846- 02 127963	0.10	0.05	0.01	0.042	0.51	11.2	5.3	0.57	484	0.33	0.06	0.14	2.4	600	2.1
L1855941- 8 846- 02 127964	0.11	0.05	0.02	0.049	0.76	4.4	5.5	0.71	664	0.34	0.08	0.13	3.1	720	3.3
L1855941- 9 127969	0.09	0.12	0.01	0.022	0.28	12.3	4.5	0.53	482	0.30	0.07	0.18	1.7	490	2.1
L1855941- 10 127971	0.11	0.04	0.02	0.037	0.58	8.5	5.6	0.66	541	0.53	0.09	0.23	2.1	560	2.6
L1855941- 11 127970	0.09	0.05	0.02	0.023	0.17	8.1	5.5	0.72	647	0.41	0.07	0.11	2.1	670	4.3
L1855941- 12 Tails U/F AUG 2016	0.11	0.04	0.02	0.094	0.46	6.3	5.7	0.64	667	0.60	0.06	0.17	3.1	570	4.0
L1855941- 13 852- 16- 120 127965	0.10	0.04	0.02	0.032	0.74	12.8	4.9	0.61	522	0.81	0.09	0.23	2.1	680	1.8
L1855941- 14 BLAST # 852- 07 127966	0.11	0.06	0.01	0.019	0.71	12.8	6.4	0.76	589	0.98	0.09	0.19	2.6	770	1.8
L1855941- 15 BLAST # 846- 03 127967	0.10	0.05	0.01	0.037	0.37	10.8	4.6	0.51	488	0.79	0.08	0.17	2.1	590	2.1
L1855941- 16 BLAST # 852- 09 127968	0.10	0.07	0.02	0.032	0.41	10.1	6.1	0.74	622	0.46	0.08	0.16	2.3	740	3.2

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

CERTIFICATE OF ANALYSIS VA16195955

Sample Description / Method / Analyte / Units / LOR	ME- MS41 Rb ppm 0.1	ME- MS41 Re ppm 0.001	ME- MS41 S % 0.01	ME- MS41 Sb ppm 0.05	ME- MS41 Sc ppm 0.1	ME- MS41 Se ppm 0.2	ME- MS41 Sn ppm 0.2	ME- MS41 Sr ppm 0.2	ME- MS41 Ta ppm 0.01	ME- MS41 Te ppm 0.01	ME- MS41 Th ppm 0.2	ME- MS41 Ti % 0.005	ME- MS41 Tl ppm 0.02	ME- MS41 U ppm 0.05	ME- MS41 V ppm 1
L1855941- 1 THICKNER U/F SEPT 2016	19.1	0.001	0.05	<0.05	2.5	0.8	0.6	50.4	<0.01	0.24	3.3	0.079	0.13	0.25	72
L1855941- 2 852- 15	39.5	0.001	0.39	0.05	3.2	7.1	0.5	74.0	<0.01	0.61	4.5	0.130	0.22	0.31	59
L1855941- 3 858- 12	12.6	0.001	0.16	<0.05	2.3	4.6	0.4	67.6	<0.01	0.50	1.7	0.138	0.06	0.35	63
L1855941- 4 858- 13	15.3	<0.001	0.02	<0.05	3.3	0.7	0.4	72.0	<0.01	0.03	1.3	0.102	0.08	0.17	49
L1855941- 5 858- 14 127961	19.9	0.002	0.01	<0.05	3.4	0.4	0.4	59.4	<0.01	0.02	1.7	0.091	0.10	0.30	47
L1855941- 6 858- 14 127962	16.2	0.001	0.01	<0.05	3.5	0.3	0.4	98.5	<0.01	0.01	1.6	0.091	0.09	0.29	48
L1855941- 7 846- 02 127963	24.7	0.001	0.14	0.05	2.9	2.7	0.4	89.7	<0.01	0.26	3.5	0.089	0.13	0.26	55
L1855941- 8 846- 02 127964	36.3	<0.001	0.34	0.05	3.4	6.8	0.5	76.2	<0.01	0.64	0.9	0.135	0.19	0.17	73
L1855941- 9 127969	13.1	<0.001	0.05	<0.05	3.1	1.2	0.4	101.5	<0.01	0.29	4.2	0.051	0.08	0.42	33
L1855941- 10 127971	27.7	<0.001	0.26	<0.05	2.9	5.9	0.4	58.3	<0.01	0.32	2.0	0.124	0.15	0.31	58
L1855941- 11 127970	7.0	<0.001	0.04	<0.05	3.6	0.7	0.4	104.0	<0.01	0.03	1.5	0.044	0.04	0.17	40
L1855941- 12 Tails U/F AUG 2016	23.7	0.001	0.06	0.06	3.5	1.0	0.8	69.4	<0.01	0.23	3.9	0.090	0.18	0.28	84
L1855941- 13 852- 16- 120 127965	34.6	<0.001	0.06	<0.05	4.1	1.3	0.4	80.2	<0.01	0.10	3.5	0.128	0.19	0.39	55
L1855941- 14 BLAST # 852- 07 127966	31.6	0.001	0.02	<0.05	3.8	0.4	0.5	70.2	<0.01	0.02	3.4	0.130	0.16	0.20	56
L1855941- 15 BLAST # 846- 03 127967	17.7	<0.001	0.12	<0.05	4.1	2.5	0.5	74.7	<0.01	0.18	2.3	0.072	0.08	0.27	43
L1855941- 16 BLAST # 852- 09 127968	18.5	<0.001	0.06	<0.05	4.3	1.1	0.5	97.4	<0.01	0.07	2.0	0.087	0.10	0.34	50

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

CERTIFICATE OF ANALYSIS VA16195955

Sample Description / Method / Analyte / Units / LOR	ME- MS41 W ppm 0.05	ME- MS41 Y ppm 0.05	ME- MS41 Zn ppm 2	ME- MS41 Zr ppm 0.5
L1855941- 1 THICKNER U/F SEPT 2016	0.06	2.91	119	0.9
L1855941- 2 852- 15	0.16	5.57	100	1.0
L1855941- 3 858- 12	0.34	3.15	99	1.7
L1855941- 4 858- 13	0.91	5.33	58	1.0
L1855941- 5 858- 14 127961	0.29	5.96	53	1.1
L1855941- 6 858- 14 127962	0.19	6.08	63	0.9
L1855941- 7 846- 02 127963	0.40	4.37	72	1.0
L1855941- 8 846- 02 127964	0.54	5.25	93	0.8
L1855941- 9 127969	0.11	6.31	58	2.4
L1855941- 10 127971	0.30	4.19	87	0.8
L1855941- 11 127970	0.13	7.61	56	0.8
L1855941- 12 Tails U/F AUG 2016	0.05	3.88	140	1.1
L1855941- 13 852- 16- 120 127965	0.37	4.96	78	0.6
L1855941- 14 BLAST # 852- 07 127966	0.38	6.15	80	0.8
L1855941- 15 BLAST # 846- 03 127967	0.36	6.47	68	0.7
L1855941- 16 BLAST # 852- 09 127968	0.11	8.01	72	1.1

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CERTIFICATE OF ANALYSIS VA16195955

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi- quantitative due to the small sample weight used (0.5g).

Applies to Method: ME- MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C- GAS05	CRU- 31	CRU- QC	LOG- 22
ME- MS41	OA- ELE07	OA- VOL08m	PUL- 31
PUL- QC	S- CAL06	S- GRA06	S- GRA06a
S- IR08	SPL- 21	WEI- 21	

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Finalized Date: 8- DEC- 2016
Account: APN

QC CERTIFICATE VA16195955

Project: L1855941
P.O. No.: ALSM- CW16- 102- APN
This report is for 16 Percussion samples submitted to our lab in Vancouver, BC, Canada on 10- NOV- 2016.

The following have access to data associated with this certificate:

ALSE VANCOUVER WEBTRIEVE	ARIEL MCDONNELL	SOFTWARE DEVELOPMENT GROUP

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LOG- 22	Sample login - Rcd w/o BarCode
CRU- QC	Crushing QC Test
PUL- QC	Pulverizing QC Test
CRU- 31	Fine crushing - 70% <2mm
SPL- 21	Split sample - riffle splitter
PUL- 31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S- CAL06	Sulfide Sulfur (calculated)	LECO
C- GAS05	Inorganic Carbon (CO2)	
S- GRA06a	Sulfate Sulfur (HCl leachable)	WST- SEQ
ME- MS41	Ultra Trace Aqua Regia ICP- MS	
OA- VOL08m	Modified NP	
S- IR08	Total Sulphur (Leco)	LECO
OA- ELE07	Paste pH	
S- GRA06	Sulfate Sulfur- carbonate leach	WST- SEQ

To: ALS ENVIRONMENTAL
ATTN: ARIEL MCDONNELL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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Finalized Date: 8- DEC- 2016
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Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description / Method	OA- VOL08m	OA- VOL08m	OA- VOL08m	OA- VOL08m	OA- ELE07	OA- VOL08m	S- IR08	S- GRA06	S- GRA06a	S- CAL06	C- GAS05	C- GAS05	ME- MS41	ME- MS41	ME- MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
STANDARDS															
Buffer pH6					6.1										
Buffer pH6					6.1										
Target Range - Lower Bound					5.3										
Upper Bound					6.7										
DS- 1							2.70								
Target Range - Lower Bound							2.51								
Upper Bound							2.71								
GS310- 10							0.28								
Target Range - Lower Bound							0.25								
Upper Bound							0.29								
KZK- 1	25.0	2	30	55		2.20									
KZK- 1	25.0	2	30	55		2.20									
Target Range - Lower Bound	22.9	<1	30	54		2.18									
Upper Bound	27.1	>4	38	64		2.53									
MA- 3a											2.36	8.6			
Target Range - Lower Bound											2.31	8.4			
Upper Bound											2.77	10.2			
MRGeo08													4.53	2.54	33.3
Target Range - Lower Bound													4.00	2.44	29.6
Upper Bound													4.92	3.00	36.4
OGGeo08													20.5	2.30	120.5
Target Range - Lower Bound													18.15	2.05	107.0
Upper Bound													22.2	2.53	131.0
OREAS 905													0.50	0.74	31.8
Target Range - Lower Bound													0.45	0.73	28.4
Upper Bound													0.58	0.91	35.0
OREAS 920													0.10	2.51	5.1
Target Range - Lower Bound													0.07	2.18	3.8
Upper Bound													0.12	2.68	4.9
SY- 4											0.91	3.3			
Target Range - Lower Bound											0.84	3.0			
Upper Bound											1.08	4.0			
UTS- 1								0.89							
Target Range - Lower Bound								0.83							
Upper Bound								0.93							
UTS- 1									0.90						
Target Range - Lower Bound									0.81						
Upper Bound									0.95						
UTS- 4								1.74							

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BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description / Method	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41	ME- MS41
Analyte	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge
Units	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm
LOR	0.2	10	10	0.05	0.01	0.01	0.01	0.02	0.1	1	0.05	0.2	0.01	0.05	0.05
STANDARDS															
Buffer pH6															
Buffer pH6															
Target Range - Lower Bound															
Upper Bound															
DS- 1															
Target Range - Lower Bound															
Upper Bound															
GS310- 10															
Target Range - Lower Bound															
Upper Bound															
KZK- 1															
KZK- 1															
Target Range - Lower Bound															
Upper Bound															
MA- 3a															
Target Range - Lower Bound															
Upper Bound															
MRGeo08	<0.2	<10	430	0.87	0.68	1.09	2.36	74.9	19.0	90	10.75	616	3.52	9.94	0.14
Target Range - Lower Bound	<0.2	<10	370	0.67	0.60	1.00	2.01	66.2	17.0	81	9.40	587	3.22	8.73	0.07
Upper Bound	0.4	20	530	0.95	0.76	1.24	2.47	81.0	21.0	102	11.60	675	3.96	10.80	0.29
OGGeo08	<0.2	<10	100	0.62	10.90	0.94	19.15	59.4	97.0	85	9.52	8710	5.26	8.12	0.18
Target Range - Lower Bound	<0.2	<10	60	0.61	9.44	0.82	16.75	56.7	87.2	75	8.68	7800	4.51	8.05	0.21
Upper Bound	0.4	30	110	0.89	11.55	1.02	20.5	69.3	107.0	93	10.70	8980	5.53	9.95	0.45
OREAS 905	0.4	<10	230	0.86	5.69	0.33	0.35	78.0	13.3	17	1.18	1505	3.29	6.14	0.09
Target Range - Lower Bound	<0.2	<10	200	0.78	5.16	0.29	0.30	72.0	12.4	15	1.14	1450	3.14	5.74	<0.05
Upper Bound	0.8	20	300	1.08	6.32	0.38	0.38	88.0	15.4	20	1.50	1670	3.86	7.12	0.22
OREAS 920	<0.2	<10	80	0.68	0.63	0.35	0.07	75.8	15.2	46	2.20	115.5	3.77	6.72	0.13
Target Range - Lower Bound	<0.2	<10	50	0.59	0.60	0.28	0.04	64.8	13.4	37	1.84	102.0	3.26	6.12	<0.05
Upper Bound	0.4	20	110	0.87	0.76	0.37	0.09	79.2	16.6	48	2.36	118.0	4.00	7.60	0.22
SY- 4															
Target Range - Lower Bound															
Upper Bound															
UTS- 1															
Target Range - Lower Bound															
Upper Bound															
UTS- 1															
Target Range - Lower Bound															
Upper Bound															
UTS- 4															

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Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method / Analyte / Units / LOR	ME- MS41 Hf ppm 0.02	ME- MS41 Hg ppm 0.01	ME- MS41 In ppm 0.005	ME- MS41 K % 0.01	ME- MS41 La ppm 0.2	ME- MS41 Li ppm 0.1	ME- MS41 Mg % 0.01	ME- MS41 Mn ppm 5	ME- MS41 Mo ppm 0.05	ME- MS41 Na % 0.01	ME- MS41 Nb ppm 0.05	ME- MS41 Ni ppm 0.2	ME- MS41 P ppm 10	ME- MS41 Pb ppm 0.2	ME- MS41 Rb ppm 0.1
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
DS- 1																
Target Range - Lower Bound																
Upper Bound																
GS310- 10																
Target Range - Lower Bound																
Upper Bound																
KZK- 1																
KZK- 1																
Target Range - Lower Bound																
Upper Bound																
MA- 3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.70	0.06	0.161	1.23	38.0	34.8	1.15	411	14.55	0.32	0.78	697	1020	1070	143.0
Target Range - Lower Bound		0.64	0.04	0.137	1.12	33.2	29.6	1.03	378	13.10	0.30	0.79	622	900	959	132.0
Upper Bound		0.83	0.10	0.179	1.40	41.0	36.4	1.29	473	16.10	0.39	1.09	760	1130	1175	162.0
OGGeo08		0.76	0.46	1.510	1.12	30.7	29.2	0.99	409	906	0.31	1.03	9210	850	7500	123.5
Target Range - Lower Bound		0.72	0.41	1.335	0.94	27.7	28.4	0.84	350	811	0.26	0.97	7760	700	6520	109.5
Upper Bound		0.92	0.57	1.645	1.18	34.3	35.0	1.05	438	991	0.34	1.29	9480	880	7970	134.5
OREAS 905		1.21	0.02	0.566	0.29	39.4	4.4	0.14	334	2.99	0.08	0.30	8.4	240	15.9	17.5
Target Range - Lower Bound		1.08	<0.01	0.517	0.28	35.6	4.3	0.13	310	2.65	0.07	0.19	7.8		15.2	17.3
Upper Bound		1.36	0.04	0.643	0.36	44.0	5.5	0.19	390	3.35	0.12	0.43	10.0		19.0	21.3
OREAS 920		0.59	0.02	0.035	0.45	40.2	21.3	1.13	541	0.36	0.03	0.37	40.3	760	23.0	26.5
Target Range - Lower Bound		0.53	<0.01	0.019	0.39	33.3	19.0	0.98	472	0.29	<0.01	0.31	34.4		19.2	22.2
Upper Bound		0.69	0.02	0.043	0.50	41.1	23.4	1.22	588	0.53	0.02	0.55	42.4		23.9	27.4
SY- 4																
Target Range - Lower Bound																
Upper Bound																
UTS- 1																
Target Range - Lower Bound																
Upper Bound																
UTS- 1																
Target Range - Lower Bound																
Upper Bound																
UTS- 4																

***** See Appendix Page for comments regarding this certificate *****

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method / Analyte / Units / LOR	ME- MS41 Re ppm 0.001	ME- MS41 S % 0.01	ME- MS41 Sb ppm 0.05	ME- MS41 Sc ppm 0.1	ME- MS41 Se ppm 0.2	ME- MS41 Sn ppm 0.2	ME- MS41 Sr ppm 0.2	ME- MS41 Ta ppm 0.01	ME- MS41 Te ppm 0.01	ME- MS41 Th ppm 0.2	ME- MS41 Ti % 0.005	ME- MS41 Tl ppm 0.02	ME- MS41 U ppm 0.05	ME- MS41 V ppm 1	ME- MS41 W ppm 0.05
STANDARDS																
Buffer pH6																
Buffer pH6																
Target Range - Lower Bound																
Upper Bound																
DS- 1																
Target Range - Lower Bound																
Upper Bound																
GS310- 10																
Target Range - Lower Bound																
Upper Bound																
KZK- 1																
KZK- 1																
Target Range - Lower Bound																
Upper Bound																
MA- 3a																
Target Range - Lower Bound																
Upper Bound																
MRGeo08		0.008	0.30	3.23	7.3	1.7	3.6	78.3	0.01	0.02	22.2	0.370	0.80	5.60	98	2.85
Target Range - Lower Bound		0.006	0.27	2.80	6.7	0.9	2.8	72.1	<0.01	<0.01	19.1	0.338	0.64	4.93	90	2.44
Upper Bound		0.010	0.35	3.90	8.4	1.9	4.0	88.5	0.03	0.04	23.7	0.424	0.92	6.13	112	3.42
OGGeo08		1.400	2.86	20.1	6.2	11.6	12.9	65.9	0.01	0.13	17.2	0.314	1.36	4.90	83	3.13
Target Range - Lower Bound		1.295	2.51	17.70	6.0	9.7	12.0	59.6	<0.01	0.14	15.6	0.279	1.14	4.45	70	2.58
Upper Bound		1.585	3.09	24.1	7.6	12.3	15.1	73.2	0.03	0.20	19.6	0.353	1.58	5.55	88	3.60
OREAS 905		<0.001	0.07	1.04	1.6	2.4	1.3	12.2	<0.01	0.06	8.5	0.019	0.10	2.19	5	0.67
Target Range - Lower Bound		<0.001	0.04	0.90	1.6	1.8	0.8	10.9	<0.01	0.04	7.8	0.008	0.06	2.08	4	0.44
Upper Bound		0.002	0.09	1.34	2.2	2.8	1.7	13.7	0.02	0.09	10.0	0.030	0.16	2.66	8	0.76
OREAS 920		<0.001	0.04	0.69	2.9	1.2	1.1	18.0	0.01	0.02	16.9	0.135	0.17	2.26	26	0.51
Target Range - Lower Bound		<0.001	<0.01	0.45	2.5	0.4	0.7	15.0	<0.01	<0.01	13.6	0.106	0.07	1.89	23	0.31
Upper Bound		0.002	0.05	0.77	3.3	1.3	1.7	18.8	0.02	0.04	17.0	0.140	0.18	2.42	30	0.61
SY- 4																
Target Range - Lower Bound																
Upper Bound																
UTS- 1																
Target Range - Lower Bound																
Upper Bound																
UTS- 1																
Target Range - Lower Bound																
Upper Bound																
UTS- 4																

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method / Analyte / Units / LOR	ME- MS41 Y ppm 0.05	ME- MS41 Zn ppm 2	ME- MS41 Zr ppm 0.5
STANDARDS				
Buffer pH6				
Buffer pH6				
Target Range - Lower Bound				
Upper Bound				
DS- 1				
Target Range - Lower Bound				
Upper Bound				
GS310- 10				
Target Range - Lower Bound				
Upper Bound				
KZK- 1				
KZK- 1				
Target Range - Lower Bound				
Upper Bound				
MA- 3a				
Target Range - Lower Bound				
Upper Bound				
MRGeo08		19.40	775	21.7
Target Range - Lower Bound		17.50	708	18.1
Upper Bound		21.5	870	25.7
OGGeo08		16.95	7300	22.7
Target Range - Lower Bound		15.35	6500	19.5
Upper Bound		18.85	7950	27.5
OREAS 905		6.54	62	45.2
Target Range - Lower Bound		6.32	58	39.9
Upper Bound		7.84	76	55.1
OREAS 920		19.35	112	23.2
Target Range - Lower Bound		16.85	93	17.6
Upper Bound		20.7	119	25.0
SY- 4				
Target Range - Lower Bound				
Upper Bound				
UTS- 1				
Target Range - Lower Bound				
Upper Bound				
UTS- 1				
Target Range - Lower Bound				
Upper Bound				
UTS- 4				

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QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method / Analyte / Units / LOR	OA- VOL08m MPA tCaCO3/1Kt 0.3	OA- VOL08m FIZZ RAT Unity 1	OA- VOL08m NNP tCaCO3/1Kt 1	OA- VOL08m NP tCaCO3/1Kt 1	OA- ELE07 pH Unity 0.1	OA- VOL08m Ratio (N Unity 0.01	S- IR08 S % 0.01	S- GRA06 S % 0.01	S- GRA06a S % 0.01	S- CAL06 S % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	ME- MS41 Ag ppm 0.01	ME- MS41 Al % 0.01	ME- MS41 As ppm 0.1
STANDARDS																
Target Range - Lower Bound									1.64							
Upper Bound									1.84							
UTS- 4										1.78						
Target Range - Lower Bound										1.61						
Upper Bound										1.87						
BLANKS																
BLANK												<0.05	<0.2			
Target Range - Lower Bound												<0.05	<0.2			
Upper Bound												0.10	0.4			
BLANK														<0.01	<0.01	<0.1
BLANK														<0.01	<0.01	<0.1
Target Range - Lower Bound														<0.01	<0.01	<0.1
Upper Bound														0.02	0.02	0.2
BLANK						6.0										
Target Range - Lower Bound						5.5										
Upper Bound						6.9										
BLANK									<0.01							
Target Range - Lower Bound									<0.01							
Upper Bound									0.02							
BLANK										<0.01						
Target Range - Lower Bound										<0.01						
Upper Bound										0.02						
BLANK								<0.01								
Target Range - Lower Bound								<0.01								
Upper Bound								0.02								

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QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method Analyte Units LOR	ME- MS41 Au ppm 0.2	ME- MS41 B ppm 10	ME- MS41 Ba ppm 10	ME- MS41 Be ppm 0.05	ME- MS41 Bi ppm 0.01	ME- MS41 Ca % 0.01	ME- MS41 Cd ppm 0.01	ME- MS41 Ce ppm 0.02	ME- MS41 Co ppm 0.1	ME- MS41 Cr ppm 1	ME- MS41 Cs ppm 0.05	ME- MS41 Cu ppm 0.2	ME- MS41 Fe % 0.01	ME- MS41 Ga ppm 0.05	ME- MS41 Ge ppm 0.05
STANDARDS																
Target Range - Lower Bound																
Upper Bound																
UTS- 4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.2	<10	<10	<0.05	0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05
BLANK		<0.2	<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	0.05
Target Range - Lower Bound		<0.2	<10	<10	<0.05	<0.01	<0.01	<0.01	<0.02	<0.1	<1	<0.05	<0.2	<0.01	<0.05	<0.05
Upper Bound		0.4	20	20	0.10	0.02	0.02	0.02	0.04	0.2	2	0.10	0.4	0.02	0.10	0.10
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																

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QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method / Analyte / Units / LOR	ME- MS41 Hf ppm 0.02	ME- MS41 Hg ppm 0.01	ME- MS41 In ppm 0.005	ME- MS41 K % 0.01	ME- MS41 La ppm 0.2	ME- MS41 Li ppm 0.1	ME- MS41 Mg % 0.01	ME- MS41 Mn ppm 5	ME- MS41 Mo ppm 0.05	ME- MS41 Na % 0.01	ME- MS41 Nb ppm 0.05	ME- MS41 Ni ppm 0.2	ME- MS41 P ppm 10	ME- MS41 Pb ppm 0.2	ME- MS41 Rb ppm 0.1
STANDARDS																
Target Range - Lower Bound																
Upper Bound																
UTS- 4																
Target Range - Lower Bound																
Upper Bound																
BLANKS																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK		<0.02	0.01	<0.005	<0.01	<0.2	0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
BLANK		<0.02	<0.01	0.006	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
Target Range - Lower Bound		<0.02	<0.01	<0.005	<0.01	<0.2	<0.1	<0.01	<5	<0.05	<0.01	<0.05	<0.2	<10	<0.2	<0.1
Upper Bound		0.04	0.02	0.010	0.02	0.4	0.2	0.02	10	0.10	0.02	0.10	0.4	20	0.4	0.2
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																
BLANK																
Target Range - Lower Bound																
Upper Bound																

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Finalized Date: 8- DEC- 2016
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Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description / Method / Analyte / Units / LOR	ME- MS41 Re ppm 0.001	ME- MS41 S % 0.01	ME- MS41 Sb ppm 0.05	ME- MS41 Sc ppm 0.1	ME- MS41 Se ppm 0.2	ME- MS41 Sn ppm 0.2	ME- MS41 Sr ppm 0.2	ME- MS41 Ta ppm 0.01	ME- MS41 Te ppm 0.01	ME- MS41 Th ppm 0.2	ME- MS41 Ti % 0.005	ME- MS41 Tl ppm 0.02	ME- MS41 U ppm 0.05	ME- MS41 V ppm 1	ME- MS41 W ppm 0.05
STANDARDS															
Target Range - Lower Bound															
Upper Bound															
UTS- 4															
Target Range - Lower Bound															
Upper Bound															
BLANKS															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK	<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
BLANK	<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
Target Range - Lower Bound	<0.001	<0.01	<0.05	<0.1	<0.2	<0.2	<0.2	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	<0.05
Upper Bound	0.002	0.02	0.10	0.2	0.4	0.4	0.4	0.02	0.02	0.4	0.010	0.04	0.10	2	0.10
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															
BLANK															
Target Range - Lower Bound															
Upper Bound															

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100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method / Analyte / Units / LOR	ME- MS41 Y ppm 0.05	ME- MS41 Zn ppm 2	ME- MS41 Zr ppm 0.5
STANDARDS				
Target Range - Lower Bound				
Upper Bound				
UTS- 4				
Target Range - Lower Bound				
Upper Bound				
BLANKS				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK		<0.05	<2	<0.5
BLANK		<0.05	<2	<0.5
Target Range - Lower Bound		<0.05	<2	<0.5
Upper Bound		0.10	4	1.0
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
Target Range - Lower Bound				
Upper Bound				
BLANK				
Target Range - Lower Bound				
Upper Bound				

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BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-VOL08m	OA-ELE07	OA-VOL08m	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05	C-GAS05	ME-MS41	ME-MS41	ME-MS41
Analyte	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C	CO2	Ag	Al	As
Units	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%	%	ppm	%	ppm
LOR	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05	0.2	0.01	0.01	0.1
DUPLICATES															
ORIGINAL													0.01	0.02	1.3
DUP													0.01	0.02	1.4
Target Range - Lower Bound													<0.01	<0.01	1.2
Upper Bound													0.02	0.03	1.5
L1855941-10 127971	5.3	2	8	13	9.0	2.45	0.17	<0.01	0.02	0.17	0.08	0.3			
DUP	5.0	2	9	14	9.0	2.80	0.16	<0.01	0.02	0.16	0.08	0.3			
Target Range - Lower Bound	4.6	<1	7	12	8.5	2.48	0.15	<0.01	<0.01	0.15	<0.05	<0.2			
Upper Bound	5.7	3	10	15	9.6	2.77	0.18	0.02	0.03	0.18	0.10	0.4			
L1855941-12 Tails U/F AUG 2016													0.71	1.21	0.9
DUP													0.68	1.19	0.8
Target Range - Lower Bound													0.65	1.13	0.7
Upper Bound													0.74	1.27	1.0

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BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method Analyte Units LOR	ME- MS41 Au ppm 0.2	ME- MS41 B ppm 10	ME- MS41 Ba ppm 10	ME- MS41 Be ppm 0.05	ME- MS41 Bi ppm 0.01	ME- MS41 Ca % 0.01	ME- MS41 Cd ppm 0.01	ME- MS41 Ce ppm 0.02	ME- MS41 Co ppm 0.1	ME- MS41 Cr ppm 1	ME- MS41 Cs ppm 0.05	ME- MS41 Cu ppm 0.2	ME- MS41 Fe % 0.01	ME- MS41 Ga ppm 0.05	ME- MS41 Ge ppm 0.05
DUPLICATES																
ORIGINAL		<0.2	<10	10	<0.05	0.03	21.5	0.03	1.46	0.4	<1	0.05	2.1	0.11	0.15	0.09
DUP		<0.2	<10	10	<0.05	0.03	21.7	0.03	1.48	0.3	<1	0.05	2.7	0.11	0.13	<0.05
Target Range - Lower Bound		<0.2	<10	<10	<0.05	0.02	20.5	0.02	1.38	0.2	<1	<0.05	2.1	0.09	0.08	<0.05
Upper Bound		0.4	20	20	0.10	0.04	22.7	0.04	1.56	0.5	2	0.10	2.7	0.13	0.20	0.10
L1855941- 10 127971																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1855941- 12 Tails U/F AUG 2016		0.2	<10	130	0.21	0.28	0.81	0.30	11.10	7.9	7	0.32	986	5.54	10.10	0.11
DUP		0.2	<10	130	0.21	0.26	0.79	0.32	10.60	7.6	7	0.31	967	5.48	9.77	0.10
Target Range - Lower Bound		<0.2	<10	110	0.15	0.25	0.75	0.28	10.30	7.3	6	0.25	942	5.22	9.39	<0.05
Upper Bound		0.4	20	150	0.27	0.29	0.85	0.34	11.40	8.2	8	0.38	1010	5.80	10.50	0.16

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method / Analyte / Units / LOR	ME- MS41 Hf ppm 0.02	ME- MS41 Hg ppm 0.01	ME- MS41 In ppm 0.005	ME- MS41 K % 0.01	ME- MS41 La ppm 0.2	ME- MS41 Li ppm 0.1	ME- MS41 Mg % 0.01	ME- MS41 Mn ppm 5	ME- MS41 Mo ppm 0.05	ME- MS41 Na % 0.01	ME- MS41 Nb ppm 0.05	ME- MS41 Ni ppm 0.2	ME- MS41 P ppm 10	ME- MS41 Pb ppm 0.2	ME- MS41 Rb ppm 0.1
DUPLICATES																
ORIGINAL		<0.02	0.09	0.005	<0.01	2.6	0.6	11.95	214	0.05	<0.01	<0.05	0.5	100	0.7	0.4
DUP		<0.02	0.03	0.006	<0.01	2.7	0.6	12.15	217	0.05	<0.01	<0.05	0.3	100	0.7	0.3
Target Range - Lower Bound		<0.02	0.05	<0.005	<0.01	2.3	0.5	11.45	200	<0.05	<0.01	<0.05	<0.2	90	0.5	0.2
Upper Bound		0.04	0.07	0.010	0.02	3.0	0.7	12.65	231	0.10	0.02	0.10	0.6	120	0.9	0.5
L1855941- 10 127971																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1855941- 12 Tails U/F AUG 2016		0.04	0.02	0.094	0.46	6.3	5.7	0.64	667	0.60	0.06	0.17	3.1	570	4.0	23.7
DUP		0.04	0.01	0.089	0.45	6.0	5.6	0.63	663	0.60	0.06	0.18	3.0	560	3.5	22.9
Target Range - Lower Bound		<0.02	<0.01	0.082	0.42	5.6	5.3	0.59	627	0.52	0.05	0.12	2.7	530	3.4	22.0
Upper Bound		0.06	0.02	0.101	0.49	6.7	6.0	0.68	703	0.68	0.07	0.23	3.4	600	4.1	24.6

***** See Appendix Page for comments regarding this certificate *****

ALS Minerals

ALS Canada Ltd.

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To: ALS ENVIRONMENTAL
100 - 8081 LOUGHEED HWY.
BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method / Analyte / Units / LOR	ME- MS41 Re ppm 0.001	ME- MS41 S % 0.01	ME- MS41 Sb ppm 0.05	ME- MS41 Sc ppm 0.1	ME- MS41 Se ppm 0.2	ME- MS41 Sn ppm 0.2	ME- MS41 Sr ppm 0.2	ME- MS41 Ta ppm 0.01	ME- MS41 Te ppm 0.01	ME- MS41 Th ppm 0.2	ME- MS41 Ti % 0.005	ME- MS41 Tl ppm 0.02	ME- MS41 U ppm 0.05	ME- MS41 V ppm 1	ME- MS41 W ppm 0.05
DUPLICATES																
ORIGINAL		<0.001	<0.01	0.21	0.1	0.5	<0.2	54.2	<0.01	<0.01	<0.2	<0.005	<0.02	0.10	2	0.37
DUP		<0.001	<0.01	0.19	0.1	0.5	<0.2	53.6	<0.01	<0.01	<0.2	<0.005	<0.02	0.11	2	0.38
Target Range - Lower Bound		<0.001	<0.01	0.14	<0.1	0.3	<0.2	51.0	<0.01	<0.01	<0.2	<0.005	<0.02	<0.05	<1	0.30
Upper Bound		0.002	0.02	0.27	0.2	0.7	0.4	56.8	0.02	0.02	0.4	0.010	0.04	0.16	3	0.45
L1855941- 10 127971																
DUP																
Target Range - Lower Bound																
Upper Bound																
L1855941- 12 Tails U/F AUG 2016		0.001	0.06	0.06	3.5	1.0	0.8	69.4	<0.01	0.23	3.9	0.090	0.18	0.28	84	0.05
DUP		<0.001	0.06	<0.05	3.3	1.1	0.8	66.9	<0.01	0.20	3.7	0.090	0.16	0.26	83	0.05
Target Range - Lower Bound		<0.001	0.05	<0.05	3.1	0.8	0.6	64.5	<0.01	0.19	3.4	0.081	0.14	0.21	78	<0.05
Upper Bound		0.002	0.07	0.10	3.7	1.3	1.0	71.8	0.02	0.24	4.2	0.100	0.20	0.33	89	0.10

***** See Appendix Page for comments regarding this certificate *****

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BURNABY BC V5A 1W9

Finalized Date: 8- DEC- 2016
Account: APN

Project: L1855941

QC CERTIFICATE OF ANALYSIS VA16195955

Sample Description	Method / Analyte / Units / LOR	ME- MS41 Y ppm 0.05	ME- MS41 Zn ppm 2	ME- MS41 Zr ppm 0.5
		DUPLICATES		
ORIGINAL		1.25	5	<0.5
DUP		1.23	5	<0.5
Target Range - Lower Bound		1.13	3	<0.5
Upper Bound		1.35	7	1.0
L1855941- 10 127971				
DUP				
Target Range - Lower Bound				
Upper Bound				
L1855941- 12 Tails U/F AUG 2016		3.88	140	1.1
DUP		3.68	139	1.1
Target Range - Lower Bound		3.54	131	<0.5
Upper Bound		4.02	148	1.7

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QC CERTIFICATE OF ANALYSIS VA16195955

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi- quantitative due to the small sample weight used (0.5g).

Applies to Method: ME- MS41

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C- GAS05	CRU- 31	CRU- QC	LOG- 22
ME- MS41	OA- ELE07	OA- VOL08m	PUL- 31
PUL- QC	S- CAL06	S- GRA06	S- GRA06a
S- IR08	SPL- 21	WEI- 21	

Whitehorse Receive

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

L1855941-COFC

COC Number: 15 - 12

Page of

Report To	Contact and company name below will appear on the final report
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Phone:	1-604-759-4659
	Company address below will appear on the final report
Street:	2100-510 West Georgia St.
City/Province:	Vancouver, British Columbia
Postal Code:	V6B 0M3
Invoice To	Same as Report To ☐ YES ☑ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Minto Explorations Ltd.
Contact:	Ruth Cayetano

Report Format / Distribution

Select Report Format: ☑ PDF ☐ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax minto_environment@mintomine.com

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax ap@mintomine.com

Email 2

Select Service Level Below - Please confirm all E&P TATs with your AM - surcharges will apply

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4] ☐ 3 day [P3] ☐ 2 day [P2] ☐

EMERGENCY: 1 Business day [E1] ☐ Same Day, Weekend or Statutory holiday [E0] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:

Job #:

PO / AFE: TBD

LSD:

ALS Lab Work Order # (lab use only)

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Contact: Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Metals- Aqua regia disgestion (ICP)	Paste pH	% Inorganic Carbonate	Total Carbon/Sulphur (Leco)	AP - determination by % sulphide sulphur	Modified NP - (MEND 1991)	Number of Containers
	Thickner U/F September 2016	oct 5th	4:00pm	~~thickner~~ ~~Composite~~	R	R	R	R	R	R	
	852-15	Sep 8/16	2:15	waste							
	858-12	"	"	waste							
	858-13	"	"	waste							
	858-14	"	"	"							
	858-14	"	"	"							
	846-02	"	"	"							
	846-02	"	"	"							
	127969	Oct 4/16	7:50am	waste							
	127971	"	8:10am	waste							
	127970	"	8:13am	waste							
	Tails U/F ~~September 2016~~ August 2016	oct 5th	4:00pm	tails							

Drinking Water (DW) Samples [1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human drinking water use? ☐ YES ☑ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C

FINAL COOLER TEMPERATURES °C: 4 7

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: JOFFROY MADRIGAL	Date: NOV. 3/16	Time:	Received by:	Date:	Time:	Received by: RT	Date: 11/08	Time: 12:25

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System please submit using an Authorized DW COC form.

Appendix D: 2016 Modified NP Method (MEND 1991) ABA Results for Tailings

Appendix D. 2016 Summary Tailings Analysis Results from SGS and ALS Minerals										
Monthly Tails Sample ID	Paste pH	TIC %	CaCO3 NP	S(T) %	S(SO4) %	S(S-2) %	AP	NP Modified	Net NP	NP:AP Ratio (NP/AP)
January Tailings	8.70	0.22	18.3	0.052	0.01	0.05	1.6	20.1	18.5	12.4
February Tailings	8.5	0.24	20.0	0.05	0.01	0.04	1.25	25	23	20.0
March Tailings	8.6	0.28	23.3	0.05	0.01	0.04	1.25	26	24	20.8
April Tailings	8.8	0.24	20.0	0.04	0.02	0.02	0.63	22	21	35.2
May Tailings	8.8	0.27	22.5	0.04	0.02	0.02	0.63	22	21	35.2
June Tailings	8.3	0.24	20.0	0.05	0.01	0.05	1.56	20	18	12.8
July Tailings	8.5	0.2	16.7	0.06	0.01	0.06	1.88	12	10	6.4
August Tailings	8.5	0.2	16.7	0.03	0.04	0.01	0.31	17	16	54.4
September Tailings	8.4	0.21	17.5	0.05	0.01	0.05	1.56	15	13	9.6

Appendix R – Wildlife Tracking Report

Date	Time	Type of Animal	Number of Animals	Location	Description: Size/Color/Markings and Additional Notes
1-Jan-16	16:00	Fox	2	Road to MCDS	Two healthy looking red fox
12-Jan-16	13:00	Wolf tracks	4+	LTF	tracks throughout site
12-Jan-16	late night	Wolves	pack, maybe 8	Landfill	Looking around for moose or rabbits
19-Jan-16	11:30	Wolf tracks	unkown	MN repeater shack	tracks throughout site
21-Jan-16	11:15	Wolf	1	Big creek bridge	Black
17-Feb-16	11:30	Squirrel	1	Camp	Good condition-nice coat. Adult.
9-Mar-16	19:00	Fox	1	Behind Selkirk Towers	Looked healthy, dark coat. Adult.
21-Mar-16	9:00	Dunlin	40	Portal	Flock of sandpiper/dunlin
21-Mar-16	14:00	Mule Deer	3	km 24	Doe. Good Shape.
25-Mar-16	11:30	Squirrel	1	ERT Building	Ran past building
18-Apr-16	17:50	Bear	1	km 3	Nice and healthy black bear
18-Apr-16	11:00	Bear	1	New LTF	Big brown bear (black bear)
18-Apr-16	19:00	Bear	1	km 6.5 Access Rd	Black Bear
18-Apr-16	19:00	bear	1	6.5km	black
22-Apr-16	17:00	Bear	1	km 25	Black Bear. Fat. Ran across road.
22-Apr-16	22:00	Bear	1	Pelly Laydown/ MWD	black bear (cinnamon)
23-Apr-16	11:00	Bear	1	Dumas/ Airport corner	black bear (cinnamon)
23-Apr-16	13:00	Grouse	1	dyno access road	ruffed grouse hen
24-Apr-16	16:00	Bear	1	Dumas/ Airport corner	black bear (cinnamon)
25-Apr-16	7:30	Moose	2	km 10.5	Scruffy. Thin.
25-Apr-16	20:00	Bear	1	WSP	Black bear. Seen from a distance.
26-Apr-16	14:00	Geese	7	Yukon River	Heading up river
27-Apr-16	8:45	Black Bear	1	Dumas	Side of Dumas shop
27-Apr-16	8:45	Grizzly Bear	1	Km 23.5	Blonde feeding on hillside
29-Apr-16	11:30	Black Bear	1	Dumas/ Airport corner	black bear (cinnamon)
29-Apr-16	14:30	Bear	1	magazine access	brown
2-May-16	10:00	Bear	1	Pelly Laydown/ MWD	black bear (cinnamon)
5-May-16	0:30	Bear	1	Dumas/Airport Corner	Big brown bear (black bear)
5-May-16	9:25	Bear	1	Dumas/Airport Corner	Big brown bear (black bear)
6-May-16	18:00	Bear	1	around km1	black bear
7-May-16	11:00	Bear	1	lagoon area north of SWD	silver-brown black bear (colouration looks like grizzly, no notable grizzly morphology though)
9-May-16	11:00	Black Bear	1	Southwest dump near Pelly Laydown	
11-May-16	18:00	Black Bear	1	Road to airstrip near Dumas shop	medium black bear with lighter fur right around the nose
12-May-16	18:00	Rabbits	3	road down from radio repeater	All looked healhty and plump.
12-May-16	18:00	Squirrel	2	road down from radio repeater	All looked healhty and plump.
12-May-16	11:30	Bear	3	Airstip	Sow and 2 cubs
14-May-16	6:30	Bear	1	dyno access road	Brown
17-May-16	20:00	Dall Sheep	26	Yukon River	Healthy looking heard. 3 new lambs.
20-May-16	6:40	Moose	1	km 20	Skinny. 2" spike antler - bull
20-May-16	19:30	Rabbit	1	Km 3.5	Appeared healthy.
21-May-16	20:00	Rabbit	2	Trail	Healthy
26-May-16	12:45	Bear	2	Dyno road	2 young bears
26-May-16	13:30	Bear	2	Dyno gate	One brown , One black

27-May-16	9:00	Fox	1	KM 1	
28-May-16	17:30	Bear	1	dyno road	Brown
29-May-16	10:00	Fox	1	Minto North haul road	
31-May-16	13:00	Bear	1	dyno road	Black
2-Jun-16	14:38	Moose	3	km 9.5	Cow and two calves
5-Jun-16	19:30	Bear	1	Km 12	Young adult black bear. In ditch.
5-Jun-16	20:00	Deer	1	Km 16	Female - adult
6-Jun-16	18:30	Wolf	1	Near Minto North	Adult at the Yield sign at top of Minto north haul road
11-Jun-16	6:30	Deer	2	Confluence	
14-Jun-16	6:30	Deer	2	MWDE	
20-Jun-16	12:30	Bear	1	km 8	Brown
20-Jun-16	6:15	Deer	1	UG ore stockpile	
21-Jun-16	8:45	Bear	1	near portal	Small/ med. Black (brown) bear
24-Jun-16	10:30	Fox	1	KM 5	
27-Jun-16	11:45	Deer	1	above electrical dept. on cliff	
30-Jun-16	10:15	Black Bear	1	km 6.5 Access Rd	
30-Jun-16	10:18	Rabbit	1	km 5	
1-Jul-16	10:00	Deer	1	warehouse laydown	Medium sized doe
2-Jul-16	9:00	Mouse	1	office	
4-Jul-16	6:00	Deer	2	mine tech building	Small
7-Jul-16	19:45	Moose	2	By pelly office	
8-Jul-16	12:40	Moose	2	960 bench headed toward pit	
9-Jul-16	10:00	Black Bear	1	Barge landing	
10-Jul-16	20:00	Deer	3	Beside sewage treatment plant	A doe and 2 fawns
13-Jul-16	10:30	Deer	1	Between capstone and ERT	Brown and white
15-Jul-16	7:00	Grizzly Bear	2	Vent raise (portal area)	Sow and 1 cub
16-Jul-16	8:20	Deer	1	warehouse laydown	Female - adult
16-Jul-16	10:00	Black Bear	1	Landfill	small/med. (2-3 yr) black bear (golden on top).
16-Jul-16	13:30	Black Bear	1	Exploration laydown	small/med. (2-3 yr) black bear (golden on top).
16-Jul-16	2:30	Rabbit	1	821 bench	
17-Jul-16	15:30	Bear	1	Dyno AN storage	
19-Jul-16	22:50	Deer	1	948 bench, went off on ATV trail	
19-Jul-16	23:55	Bear	1	948	Brown
19-Jul-16	13:00	Bear	1	Portal ore pad	
29-Jul-16	12:51	Wolf	1	behind DSTF on TDD	large, grey,
7-Aug-16	19:00	Fox	1	Ramp to nuway stockpiles	sooty black coat
11-Aug-16	10:00	Chipmunk	1	rec room	
22-Aug-16	9:45	Black Bear	1	6.75km	
30-Aug-16	19:00	Wolverine	1	between W3-W7	Tracks along the road
20-Sep-16	10:00	Bear	1	WSP	
17-Oct-16	20:30	Fox	1	Kitchen smoke shack	
20-Oct-16	15:00	Fox	1	capstone bunk	Young, healthy
20-Oct-16	17:00	Fox	1	capstone bunk	Healthy
24-Oct-16	14:00	Fox	1	SWD	Healthy, good size
31-Oct-16	15:00	Fox	1	Km 15 on access rd	Young, healthy
31-Oct-16	16:30	Fox	1	ERT Building	
2-Nov-16	10:00	Fox	1	S. Selkirk tower	Small, red, good condition
7-Nov-16	13:00	Fox	1	KM 4 on access road	Found dead (ran over)
7-Nov-16	13:00	Fox	1	Dumas	reddy brown and white
7-Nov-16	14:30	Grizzly Bear	1	KM 12.5 on access rd	Large
18-Nov-16	17:00	Fox	1	Camp	red medium sized. Darker(brown) patch on top of lower back.

22-Nov-16	14:30	Fox	1	Kitchen smoke shack	
28-Nov-16	17:00	Fox	1	Mine road by Dumas	Red Medium. Darker spot on lower back.
5-Dec-16	14:00	Lynx	1	Fresh air / vent raise	Large, healthy looking, grey
10-Dec-16	10:30	Wolf	2	DYNO	one mostly grey and medium/large. One larger and grey with brown fur
13-Dec-16	12:00	Fox	1	Underground fuel tank pad	
13-Dec-16	14:30	Ptarmigan	1	Met station	White
17-Dec-16	11:15	Lynx	1	KM 16	Large, Grey, healthy
17-Dec-16	13:40	Lynx	5	W3	Small, grey
23-Dec-16	14:00	Fox	1	Behind Portal Road, around area 2	Healthy, good size
31-Dec-16	15:00	Caribou	unk	km21	Tracks from small herd

Appendix S – Vegetation Metal Uptake Report

VEGETATION METAL UPTAKE MONITORING PROGRAM

FOR MINTO MINE

February 2017

Prepared for:

MINTO EXPLORATIONS LTD.

ALEXCO ENVIRONMENTAL GROUP SIGNATURES

Report prepared by: ______________________ Febraury 28th, 2017

Mitchell Heynen, B.Sc., A.Ag. — Date
Environmental Scientist / GIS Technician

Report prepared by: ______________________ Febraury 28th, 2017

Jenifer Hill, B.Sc., M.Sc., R.P.Bio, — Date
Principal, JLH Environmental

Report reviewed by: ______________________ Febraury 28th, 2017

Kai Woloshyn — Date
Senior Environmental Manager

EXECUTIVE SUMMARY

Minto mine is a high-grade copper mine located approximately 240 km northwest of Whitehorse, Yukon Territory. The project is located within Selkirk First Nation (SFN) Category A Settlement Land Parcel R6A. The Minto Mine commenced commercial operation in October 2007. Minto initiated a vegetation metal uptake (VMU) monitoring program to meet requirements for Minto mine's permit compliance and the conditions specified in the Yukon Government's December 18, 2014 "Minto Mine Project QML-0001 Plan Requirements" letter. The objective of the program is to establish a network of monitoring sites around the mine site to quantify the effects of airborne transport and metal uptake in vegetation on the mine site and surrounding areas.

The VMU program was initiated in 2016 where activities included establishing sample sites, collection and analysis of soil from key soil horizons, and collection and analysis of vegetation samples for key plant species that could be vectors to humans or wildlife. Vegetation laboratory analyses were carried out on rinsed and unrinsed plants to determine if metal concentrations detected during the analyses were the result of particulates on the plant or the plant tissue itself.

Sixteen exposure and five control sites were established in 2016. Vegetation samples were collected from blueberry, horsetail, Labrador tea, lichen, and willow at each of these sites for all species that were present at the site. Constituents of Potential Concern (COPC) that were examined include: Aluminum (Al), Antimony (Sb), Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Molybdenum (Mo), Nickle (Ni), Selenium (Se), and Zinc (Zn). These COPCs were analyzed and then compared between control and exposure sites and between unrinsed and rinsed samples to try and quantify the effects of mine related activity on vegetation metal concentrations.

Paired sample Wilcoxon's statistical tests were conducted between unrinsed and rinsed samples for each species. It was found that lichen and willow species presented the greatest difference between the two when evaluated in respect to a significance value (p) of 0.05 (This means there is a 95% probability that there is a statistically significant difference between unrinsed and rinsed samples for lichen and willow). Two sample Wilcoxon's statistical tests were conducted between species collected at exposure and control sites to determine if there were any statistically significant differences. Lichen was found to have statistically higher ($p<0.05$) arsenic (As), cadmium (Cd), iron (Fe), and lead (Pb) at the exposure sites; willow had higher As, Fe, and Pb; Labrador tea and horsetail had higher copper (Cu) and Fe.

Soil samples were compared by horizon between exposure and control sites for the 2016 sampling event. Generally, exposure sites had higher concentrations of metals when compared to control sites. The most notable differences in concentrations were increased copper (Cu), molybdenum (Mo), selenium (Se), and zinc (Zn). Out of a total of 21 sites (40 samples), two sites, S02 and S19 (one sample per site), exceeded CCME industrial guidelines for arsenic and five sites, S16, S17, S07, S06, and S05 (total of ten samples) exceeded guidelines for copper. Soil pH didn't show much deviation between control and exposure sites; however, it was noted that surface topsoil horizons on average were more acidic than the lower horizons, which is consistent with typical soil profiles in this area. Soil texture at control sites ranged from clay loam to sand while exposure sites ranged from silt loam to loamy sand.

Overall, results indicate an increase in metal concentrations in vegetation located at exposure sites. For metals of potential wildlife and human health concern, arsenic and lead are higher at exposure than control sites for lichen and willow. Copper is higher at exposure than control sites for horsetail and Labrador tea. Blueberry showed no response. While this increase could potentially be the result of airborne particulates from the Minto mine, the results are inconclusive due to the high variability associated with the data and minimal pre-mine data. As this first program provides the basis for initial comparison, subsequent studies will help establish a trend and provide ongoing evaluation of the extent and degree that metals from mining activity may be affecting vegetation in the proximity of the project site.

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1 INTRODUCTION

Heavy metal contamination on mine sites is a common issue due to both the extraction of highly mineralized rock, which is transported, milled and stored in these areas, and the exposure of mined materials to environmental influences. Metals can leach from mining waste into the immediate aquatic environment via direct surface water runoff or infiltration of precipitation (aqueous transport). In terrestrial systems, in-situ soils may already have heightened concentrations of metals due to local mineralization of the surficial parent material. Dust from blasting, ore crushing and waste dumping, can be transported by wind (aeolian) to surrounding terrestrial areas, settling on the ground and the surface of plant leaves, stems and fruits. These receiving environments can, over time, accumulate contaminants to the point that biological functioning can be affected in aquatic and terrestrial ecosystems.

The potential for these effects, and the degree to which they occur, are a function of a number of variables, and the accumulation processes can be highly complex. Generally speaking, plants can become intermediaries or vectors in transferring heavy metals to higher trophic levels when consumed by herbivores, which in turn become prey for carnivorous species. Harvesting and consumption of country foods by humans can also present an exposure pathway.

Monitoring of metal uptake in plants in mining areas has been used to assess potential and ongoing risks to these receptors. Understanding this potential can be useful in guiding mine operations.

Alexco Environmental Group Inc. (AEG) was retained by Minto Explorations Ltd. (Minto) to develop a Vegetation Metals Uptake (VMU) Monitoring Plan (the Plan) to meet requirements for Minto mine's permit compliance. The long term goal of the VMU monitoring is to determine if, and to what extent, metals from the mine are transferred to the surrounding environment, which could pose a risk to wildlife or humans. Overall, this first monitoring program included establishing VMU sample sites, collection and analysis of soil from key soil horizons, and the collection and analysis of vegetation samples for key plant species that could be vectors to humans or wildlife. Vegetation laboratory analyses were carried out on rinsed and unrinsed plants to determine if metal concentrations determined by the plant analyses were from particulates on the plant or the plant itself. The following sections provide the details of the first monitoring program.

1.1 REGIONAL SETTING

The Minto mine lies within the Boreal Cordillera Ecozone and Yukon Plateau Ecoregion (Smith et al., 2004). The Minto Mine is situated in the far western part of the Yukon Plateau Ecoregion near the Dawson Range and adjacent to the Klondike Plateau Ecoregion in the west. This area was part of the eastern extent of Beringia, which remained ice free approximately twenty to fifteen thousand years ago (Smith et al., 2004).

Forest fires are frequent in this part of the Yukon Territory as it lies in the rain shadow of the St. Elias-Coast Mountains and receives less than 300 mm of precipitation per year (Smith et al., 2004). As a result, the study area around Minto Mine has experienced numerous fires over the last forty years rendering it a complex mosaic of plant communities at varying stages of succession. Young mixed lodgepole pine and trembling aspen forests are the most common forest type, and willow species are ubiquitous in the understory as well as in the main canopy in shrub dominated areas. Black and white spruce with shrub and feathermoss understories can be found on northerly aspects and in moist drainages. The study area is in the eastern part of the Dawson Range foothills with elevation range of 700 metres above sea level (masl) to 950 masl. The landscape has rounded mountains intersected by broad valleys and drainages that are part of the Yukon River watershed. The project is in the sporadic discontinuous permafrost zone where permafrost is encountered on northern slopes and in low lying areas where solar radiation is reduced (Smith, 2004).

1.2 SITE DESCRIPTION

Minto Explorations Ltd., a wholly owned subsidiary of Capstone Mining Corp. (Capstone), owns and operates the Minto Mine, a high-grade copper mine, located approximately 240 km northwest of Whitehorse, Yukon Territory (Figure 1-1). The project is located within Selkirk First Nation (SFN) Category A Settlement Land Parcel R6A, and is centered at approximately 62°37'N latitude and 137°15'W longitude (Figure 1-2). The Minto Mine commenced commercial operation in October 2007 and is permitted to conduct mining and milling operations at a rate of 4,200 tonnes of ore per day (tpd). Mining activities at the Minto mine consist of multiple open pits and an underground mine. In addition to the mining areas, the Minto mine site includes a number of other facilities and infrastructure, including waste rock storage areas, ore stockpiles, a crusher, a mill for processing the ore, and a dry stack tailings storage facility (Figure 1-3).

1.3 REGULATORY REQUIREMENTS

The VMU Monitoring Plan is required by the Government of Yukon, Department of Energy, Mines and Resources (EMR), to form part of the revised Minto Phase V/VI Environmental, Monitoring, Surveillance and Reporting Plan (EMSRP). Specifically, the VMU Monitoring Plan meets requirement (d) of EMR's Plan Requirement Letter (December, 2014) and to satisfy conditions (c, d, e, f) of the Environmental Monitoring, Surveillance and Reporting section of EMR's Approval of Operational and Environmental Plans – QML-0001 Letter (March, 2016), which specifies that the following be submitted:

EMR Plan Requirement Letter:

> *(d) a program for monitoring and measuring metal uptake in vegetation on the mine site, and in areas surrounding the mine site.*

Approval of Operational and Environmental Plans – QML-0001:

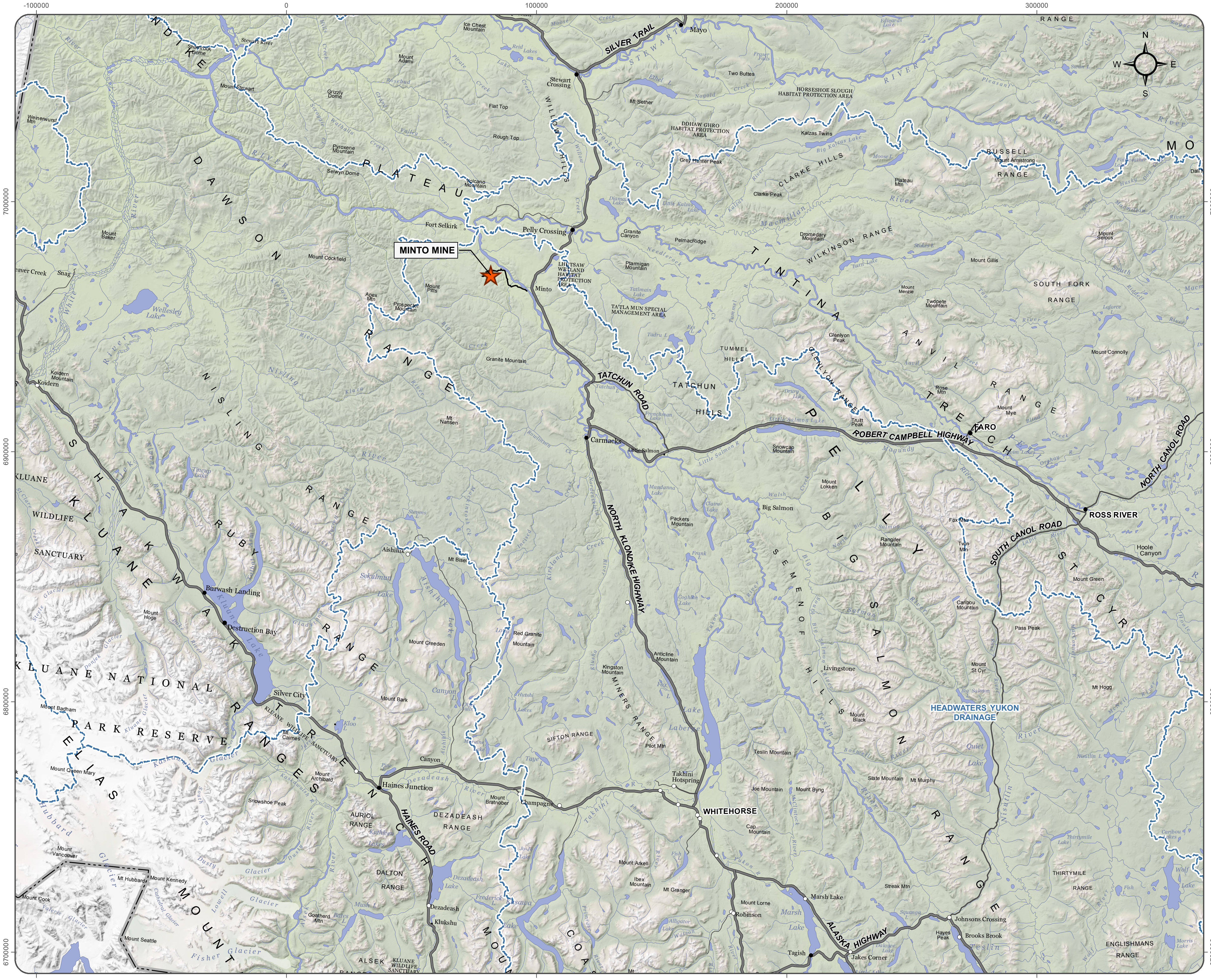
> *(c) the selection of vegetation control plots for the monitoring program must take into consideration the proximity of all active mining areas, and those areas located within migration paths of prevailing wind directions (after considering year-round prevailing wind directions);*
>
> *(d) the selection of vegetation species for the monitoring program must consider species that represent good indicators for evaluating airborne transport and metal uptake;*
>
> *(e) opportunities must be made available for Selkirk First Nation participation in the vegetation monitoring program, including the identification of key vegetation species for consideration prior to finalizing the selection of plants; and*

(f) a comprehensive soil sampling program must include sampling at various soil horizons to provide a more comprehensive soil profile.

1.4 PROGRAM OBJECTIVES

The main objective of the VMU Monitoring Program is to develop and execute a plan that monitors and measures the effects of airborne transport and metal uptake in vegetation on the mine site and surrounding areas that:

- Utilizes previously established or documented conditions, monitoring results or predictive efforts, where appropriate and possible;
- Establishes a network of plots for monitoring both soil and vegetation metal concentrations; and
- Allows for an ongoing evaluation of the extent and degree that metals from mining activity is affecting vegetation in proximity to the project site.



capstone

MINTO MINE

VEGETATION METAL UPTAKE MONITORING PROGRAM

FIGURE 1 -1
PROJECT LOCATION

FEBRUARY 2017

★ MINTO MINE

ALEXCO ENVIRONMENTAL GROUP

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Drainage areas obtained from National Hydrology Network 2011

Datum: NAD 83; Projection UTM Zone 8N

1:1,500,000 when printed on 11 x 17 inch paper

0 20 40 60 80

Kilometres

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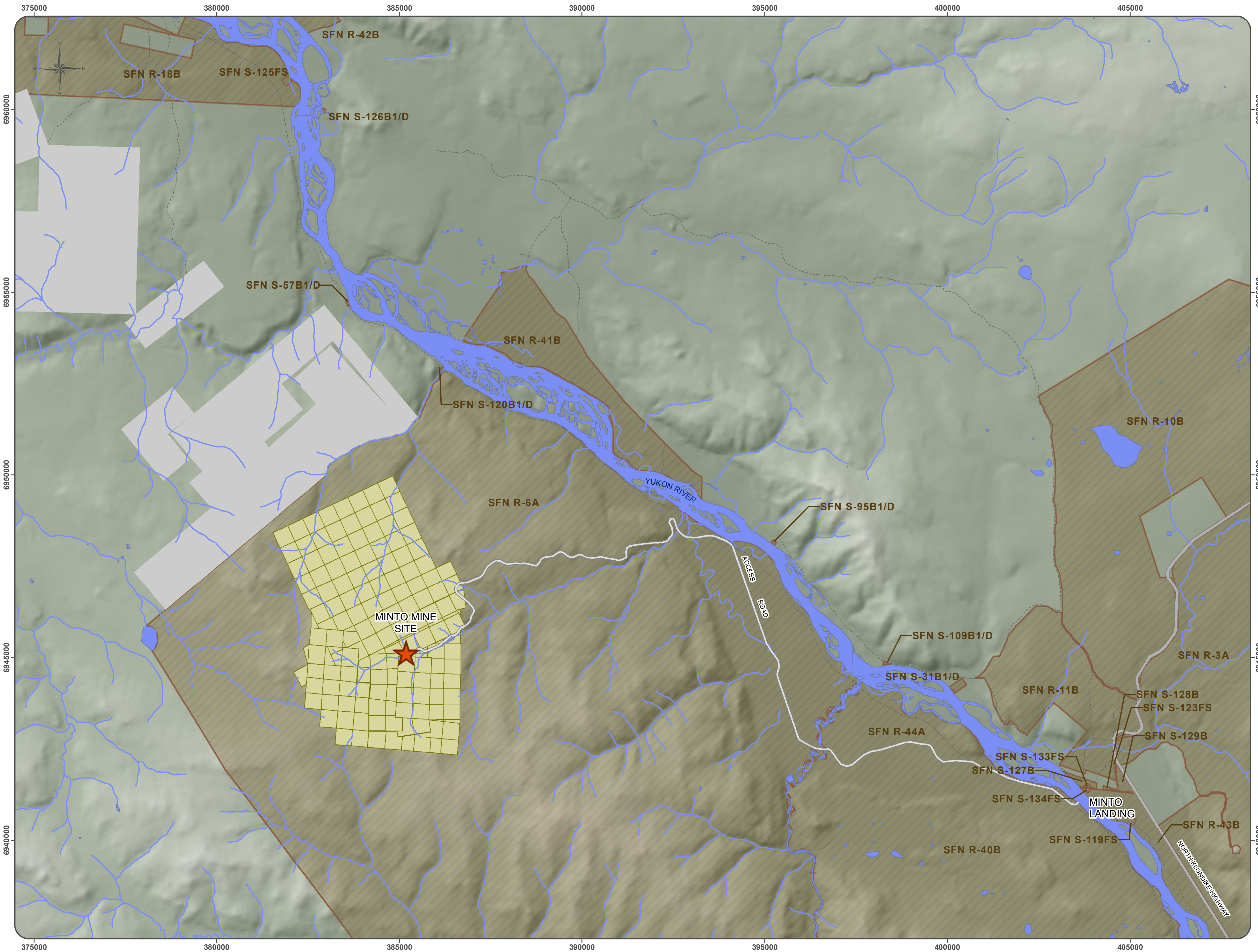
MINTO MINE

VEGETATION METAL UPTAKE MONITORING PROGRAM

FIGURE 1 -2

MINTO MINE SITE PROPERTY OVERVIEW

DECEMBER 2016



Minto Mine Site

Mine Access Road

Road

Trail

Selkirk First Nation Settlement Lands

Minto Explorations Ltd Quartz Claims

Quartz Claims Owned by Others

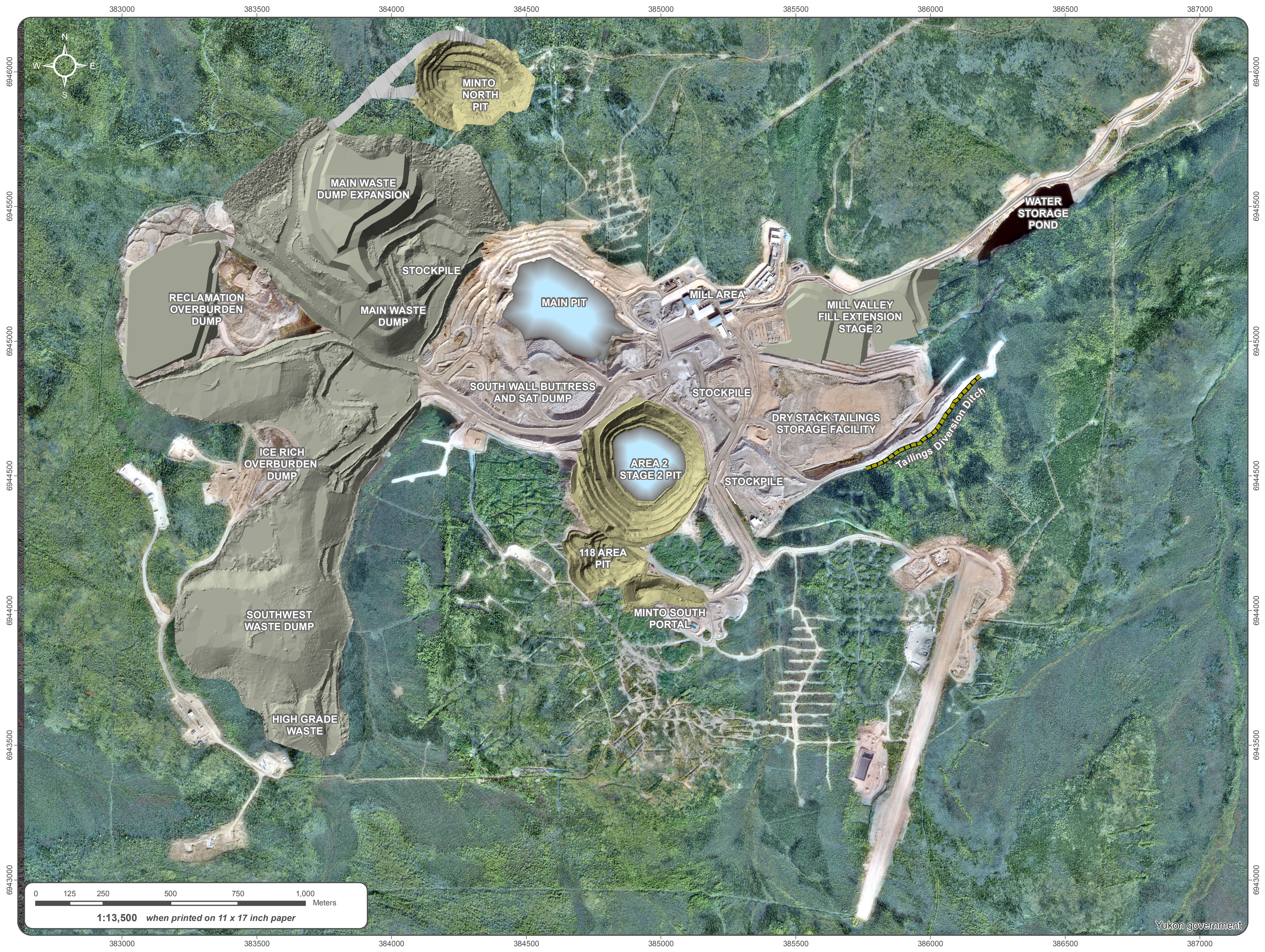
1:100,000 *when printed on 11 x 17 inch paper*

0 0.5 1 2 3 4 5 km

ALEXCO ENVIRONMENTAL GROUP

First Nation Settlement land obtained from Natural Resource Canada. Quartz claim boundaires and ownership are current as of Feb 18 th 2013. Data obtained from Mineral Resources Branch, Energy Mines and Resources Department, Government of Yukon.Site hydrology data provided by Minto Explorations Ltd, May 2009.

Datum: NAD 83 Projection: UTM Zone 8N



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MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

VEGETATION METAL UPTAKE MONITORING PROGRAM

FIGURE 1-3
SITE CONFIGURATION AND EXISTING INFRASTRUCTURE

JANUARY 2017

- Pit
- Dump
- Tailings and Water
- Minto North Access Road
- Tailings Diversion Ditch
- Mine Access Road

ALEXCO ENVIRONMENTAL GROUP

Aerial imagery obtained from Challenger Geomatics. Imagery acquired September 9 th 2014. Modelled boundary of annual TSP digitized from the map inset of figure 6 of the Minto Mine Phase V/VI Expansion Project Particulate Matter Dispersion Modelling Report by RWDI Consulting Engineers & Scientists.

Datum: NAD 83 Projection: UTM Zone 8N

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2 METHODOLOGY

The following section describes the methodology carried out in 2016 by AEG and Minto staff to meet the objectives as outlined above. It includes defining the study area and monitoring network (sample sites), selection of target vegetation species, identification of metals of concern, microsite selection and establishment, sampling procedures for vegetation and soils, laboratory analysis, and Quality Assurance/Quality Control.

2.1 STUDY AREA AND MONITORING NETWORK

The identification of a study area took the following five elements into consideration:

1. Area of direct disturbance (and reclamation) by mining activities;
2. Previous monitoring locations;
3. Prevailing wind direction;
4. Access – road/ground based access to monitored areas was preferential; and
5. Anticipated dispersal mechanisms and extent of metal contamination.

The VMU monitoring network (sampling sites) is presented in Figure 2-4 below. The sampling sites were selected in the areas anticipated to receive higher density dust fallout, and control or outlying stations were positioned outside of the projected zone of influence (based on prevailing wind direction and air dispersion modelling). The plot selection process involved utilizing, where possible and accessible, ecosystem plots established in 2010 where soil and vegetation information data were collected. The stations to be monitored are divided into 'exposure' stations (within or upon the direct mine footprint area) and 'control' stations (outside the anticipated zone of influence of the mining activities.) A review of existing documents (Table 2-1) also assisted in the establishment of the proposed monitoring network.

The meteorological data collected on site, over a five period, shows that predominant annual winder direction for the Minto site is from the northwest and the southeast with some deviation to the west as presented in Figure 2-1. The areas that have been observed to generate the greatest loads of dust are the crushing and conveying infrastructure areas near the mill. To a much lesser degree, pit blasting and waste rock dumping would also contribute to dust loading and dispersion. To this end, the VMU sampling sites have been located in vegetated areas near the perimeter of these dust sources and extend roughly along a NW to SE axis.

Air dispersion modelling was conducted by RWDI Consulting Engineers in 2013 to model particulate matter emissions from current mining conditions as of 2012 as well as predicted emission from the Phase V/VI expansion. Predicted concentration and extents for total suspended particulates (TSP) and $PM_{2.5}$ were modelled for each scenario and were compared to Yukon Ambient Air Quality Standards (RWDI, 2013). Results of annual concentration for TSP at baseline (mining as of 2012) and future (proposed phase V/VI) are presented in Figure 2-2 and Figure 2-3, respectively. Additional information regarding the particulate matter dispersion modelling is located in Appendix E.

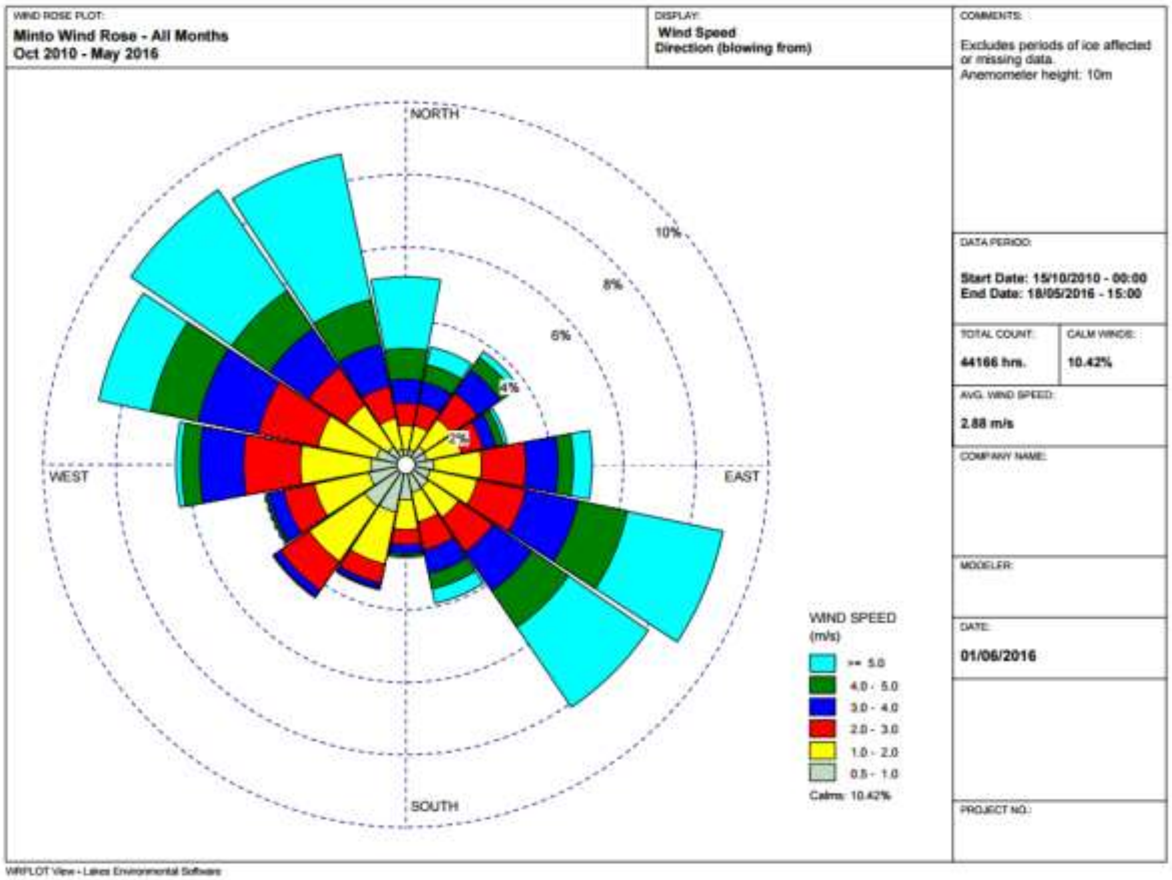

Figure 2-1: Minto Wind Rose - All months October 2010 - May 2016 (AEG)

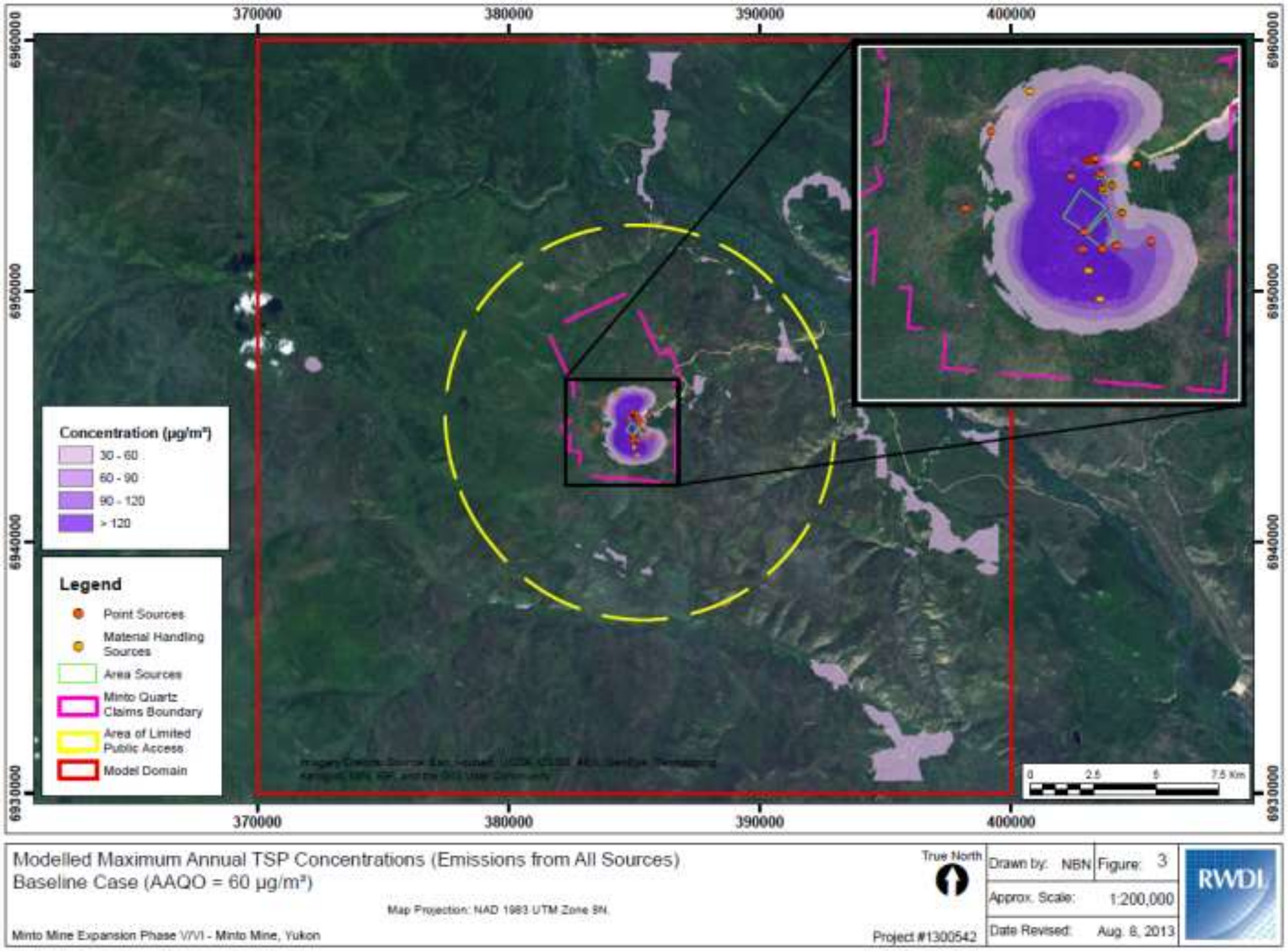

Figure 2-2: Modelled Maximum Annual TSP Concentrations Baseline Case (RWDI, 2013)

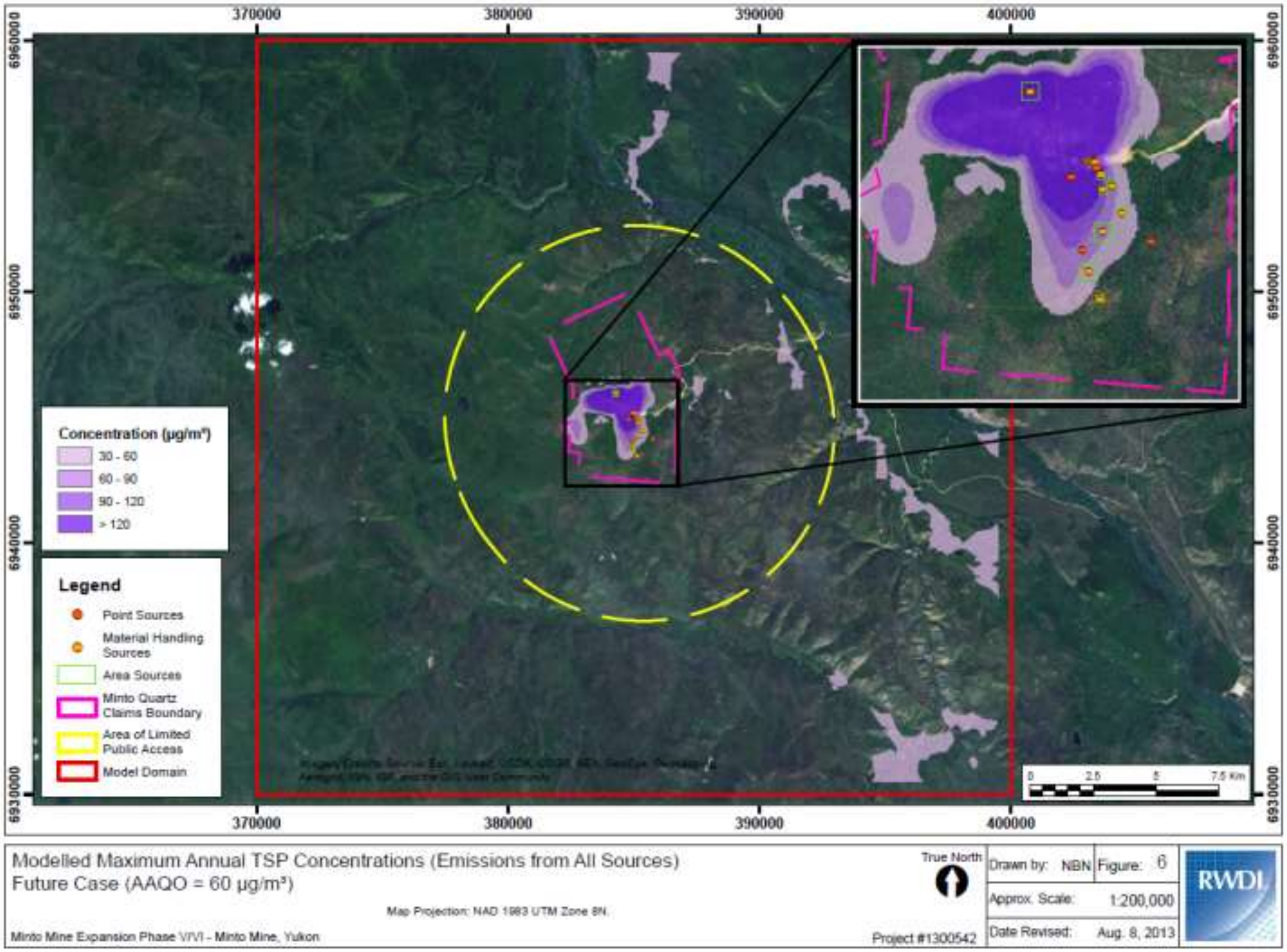

Figure 2-3: Modelled Maximum Annual TSP Concentrations Future Case (RWDI, 2013)

capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

VEGETATION METAL UPTAKE MONITORING PLAN

FIGURE 2-4
2016 VEGETATION METAL UPTAKE MONITORING NETWORK

FEBRUARY 2017

Monitoring Stations

- Control Plot
- Exposure Plot

Mine Features

- Pit
- Dump
- Tailings and Water
- Minto North Access Road
- Tailings Diversion Ditch
- Minto Access Road
- Trails

ALEXCO ENVIRONMENTAL GROUP

Aerial imagery obtained from Challenger Geomatics. Imagery acquired September 9[th] 2014. Modelled boundary of annual TSP digitized from the map inset of figure 6 of the Minto Mine Phase V/VI Expansion Project Particulate Matter Dispersion Modelling Report by RWDI Consulting Engineers & Scientists.

Datum: NAD 83 Projection: UTM Zone 8N

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Table 2-1: Documents Reviewed Prior to Vegetation Metal Uptake Program Execution

Document Reviewed	Relevant Information	Incorporation in VMU Program
Minto Mine Environmental Baseline Ecosystems and Vegetation Report (Horizon Ecosystem Consultants, 2010)	Ten soil samples were collected from the following ecological plots: M07, M29, M35, M54, M54A, M76A, M80, M84, M85, M90A, and M93. Metals analysis were not conducted on these samples but ecological site descriptions were recorded providing valuable site information	Sites were revisited when appropriate ecological conditions were present and the plant species of interest were present within the area,
2010 Reclamation Research Report by Access Consulting Group (Access Consulting Group, 2010)	Lab analysis of 12 soil samples for metals, nutrient levels and texture. Soil samples from revegetation plots. Metal analysis of grasses used in revegetation and naturally regenerating willows.	Minimal incorporation into the VMU program as samples were collected on disturbed and reclaimed soil and could not accurately represent the existing natural condition.
2007, 2008 and 2009 Revegetation Trial Reports by Stu Withers/Access Consulting Group (Access Consulting Group, 2007, 20085, 2009)	Two soil samples were collected from the overburden stockpile in late March 2007 and were analyze for texture, metals (ICP Method) and nutrients. The analysis results were similar for both samples, with both looking reasonably good for reclamation purposes. (ACG, 2007)	Data was not incorporated into VMU program. After review it was noted that the source location of the soil samples could not be accurately identified. Samples do not confidently confirm the natural soil condition.
Minto Mine Phase V/VI, YESAB Project Proposal, Minto Climate Baseline Report, 2014 (Access Consulting Group, 2014)	Provides meteorology data and climate trends, such as prevailing wind directions, precipitation and temperature.	Predominant wind direction was used in determining the location of control and exposure plots.
Minto Mine Phase V/VI Reclamation and Closure Plan version 5.1	Reclamation schedule indicates timing of closure for specific dust sources. Health and safety objectives.	Guided the VMU program objectives and contributed an understanding of projected revegetation efforts and waste cover prescriptions, that will reduce dust sources and runoff.
2013 Particulate Matter Dispersion Modelling (RWDI, 2013).	Modeled extent of TSP concentration relating to existing mining activities	Used determine the location of exposure and control plot locations.
Vegetation Metal Uptake studies completed for Casino baseline (EDI, 2013), Keno closure (Access Consulting Group, 2012) and during Red Dog (Teck, 2005) mine operations.	To ensure the degree of detail for VMU is consistent with other mineral extraction projects in northern jurisdictions.	reviewed as a means to compare VMU procedures and EMR expectations.

2.2 CONSTITUENTS (METALS) OF POTENTIAL CONCERN

Based on the Canadian Council of Ministers of the Environment (CCME), and the *Yukon Environment Act*, certain metals are identified as Constituents of Potential Concern (COPC), since exposure and/or bioaccumulation to high concentrations of these elements can result in damage to plants, aquatic organisms, terrestrial wildlife, and human health. Of these COPC's, the metals of interest that were selected for the VMU program are those known to have elevated levels specific to the minerals in the Minto deposit. It should be noted that toxic effects usually require persistent exposure to high concentrations of the metals, and that as a confirmed mineralized area, elevated metal concentrations in soil (and to some degree in vegetation) are expected in the baseline condition in the vicinity of the mine site.

Laboratory analyses were completed for the full ICP suite of metals as reported in Appendix B; however, the results discussed in Section 3 focus on the following COCPs that list that may be revised as the program is optimized in the future:

- COPCs include Antimony (Sb), Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Manganese (Mn), Molybdenum (Mo), Nickle (Ni), Selenium (Se), and Zinc (Zn); and,
- Metals related to dust include Aluminum (Al) and Iron (Fe).

2.3 SELECTED TARGET VEGETATION SPECIES

Active mine sites by their nature are often situated in highly mineralized areas. In-situ soils and vegetation growing in the soils may have naturally elevated concentrations of metals due to local mineralization of the surficial parent material or near surface lithic layers. During the development and operation of a mine site, metals can mobilize from mined material by aqueous transport into immediate aquatic environments, and dust can be transported by wind to terrestrial areas. Metals can accumulate in these receiving environments over time; while accretion processes are highly complex, plants can become intermediaries or vectors in conveying metals to higher trophic levels when consumed by herbivores, which subsequently become prey for carnivores (CCME, 2006).

The potential for bioaccumulation of metals, and the degree to which it can occur, is a function of a number of variables, and the accumulation processes is highly complex. In addition, harvesting and consumption of vegetation and mammals by people can present an exposure pathway for metals to humans. Two predominant pathways for metal uptake to occur in vegetation are uptake through plant roots from the soil and uptake through the leaves from airborne dust dispersion (Kabata-Pendias et al., 2011). Additionally, there are two effects pathways of concern from metal accumulation in vegetation: effects to wildlife, and effects to humans. There are numerous plants species that are either known or expected to be consumed directly by wildlife in the study area. To a lesser degree, there are some plant species in the study area which are known to be consumed by humans as part of traditional gathering.

Target species selection was based on a review of the vegetation metal uptake programs outlined in Table 2-1 and through consultation with Selkirk First Nation (SFN). Five species, existing within the project site, were selected to be representative of the two pathways and their effects on wildlife and humans that utilize the area. The selected species, the vegetation sample type, and the rationale are provided in Table 2-2 below.

Table 2-2: Selected Target Vegetation Species for Metal Uptake

Target Plants	Plant Part to be Collected	Rationale for Selection
Willows (*Salix* spp.)	Leaves	Willows are common in the project site. Willows hyper-accumulate cadmium (Cd) in leaves. Are important browse species for moose.
Horsetail (*Equisetum* spp.)	Plant	An accumulator of zinc (Zn). Consumed by moose and bear.
Blueberries (*Vaccinium* ssp.) or Soapberries	Fruit	Human gathering/bear and bird forage.
Labrador tea (*Rhododendron* ssp.)	Leaves	Medicinal uses. Bog Labrador teas leaves and twigs are browsed by caribou and moose in small quantities.
Lichen (*Cladonia, Cladina*, and *Stereocaulon* spp.)	Thallus	Lichen does not vary with the seasons, and accumulation of dust can occur throughout the year with the exception of snow cover. Caribou browse.

The monitoring of metal uptake in plant tissue around other mines is a typical permit requirement requested to assess potential and ongoing risks to humans and wildlife. However, the interactions between soil, plants, particulate matter and the surrounding environment are very interconnected and complex, making the understanding of metal uptake difficult. Furthermore, concentrations and metal uptake vary from species to species and vary geographically as plants adapt to their environments (Kabata-Pendias et al., 2011).

2.4 FIELD INVESTIGATION

Field site selection and collection of samples took place during the week of August 8th – 12th, 2016 by Mitchell Heynen of AEG and one of Minto's Environmental Officers. Sites selected during the initial development of the monitoring network were adjusted in the field when necessary to include multiple target vegetation species for sampling. Adjustment often involved moving 50-150 m to a position on the landscape that had a greater soil moisture regime, therefore promoting greater species diversity. The newly selected site was placed in a uniform and continuous landscape to best represent the ecosystem conditions being sampled. The geographical coordinates were recorded for future monitoring. The 2016 VMU sampling program resulted in the establishment of five control monitoring sites outside the mine effected area and sixteen exposure monitoring sites in close proximity to mine infrastructure and the access road. At each of the established monitoring sites soil and vegetation samples were collected. A summary of the site locations and associated samples to be collected are presented in Table 2-3 and Figure 2-4, respectively.

Key components of the monitoring program at each station included the following four items:

1. Selection of an appropriate microsite in the vicinity of the proposed station identified on the map;
2. Station establishment documenting location, relevant ecological attributes of the station area and photos of the established plot (see Appendix A);
3. Soil sampling at multiple horizons; and
4. Vegetation tissue sampling of relevant species within the plot location.

Table 2-3: Summary of Monitoring Sites and Samples

Site ID	Blueberry	Horsetail	Labrador Tea	Lichen	Willow	Soil horizons sampled
Control Site						
C01		X	x	x	x	X
C02		X	x	x	x	X
M80			x		x	X
M26	x		x	x	x	X
M07b		X	x	x	x	X
Exposure Site						
S03				x	x	x
S11				x	x	x
S04					x	x
S02						x
S01			x	x	x	x
S18		x	x	x	x	x
S15		x	x		x	x
S08	x		x	x	x	x
M29		x	x	x	x	x
S16		x	x		x	x
S05		x	x	x	x	x
S06			x		x	x
S07	x	x	x		x	x
S17					x	x
S19			x		x	x
S09					x	x

2.4.1 Site Selection and Establishment

Exposure and control sites were first generally located based on maps and air quality modelling, and then pinpointed in the field based on the following criteria:

- Disturbed locations were avoided where soil was exposed and vegetation damaged;
- The microsite had at least two of the plant species of interest;
- Relatively undisturbed sites were chosen where soil pedon was not fragmented and vegetation established (early successional communities were acceptable); and
- The location was chosen to be representative of the surrounding ecosystem conditions and the vegetation was of uniform composition.

The monitoring site was established once chosen. The following steps were followed to ensure that all stations were established using the same criteria and can be easily relocated for future monitoring. The steps included:

- The soil pit was situated in proximity to where the roots of the plants to be sampled were present. The soil pit was used as the center of the plot;

- For permanent plots, an aluminum pin with flagging was installed at the plot center and plot ID, date of visit and project number were recorded. For exposure plots the plot center was flagged with two pieces of flagging tape and the plot ID, date and project number were recorded; GPS coordinates were recorded for each location with station ID; and

- An ecological attribute form was completed for each station, which included the following details:

    - Mesoslope position, slope and aspect;
    - Dominant vegetation and main cover heights;
    - Plant species sampled;
    - Successional stage;
    - Signs of wildlife diggings, browsing and/or grazing;
    - Signs of site disturbance;
    - Distance from possible dust source (can be determined from map); and
    - Photographs of the soil pit and a representative shot of the site.

2.4.2 Soil Characterization and Sampling

Soil sampling was conducted at each site by digging a soil pit to a depth of greater then 60 cm or until a restricting layer such as ice or rock was encountered. Once the pit was excavated it was characterized into organic and mineral horizons based on Field Manual for Describing Terrestrial Ecosystems 2nd Edition (BC MFR and BC MOE, 2010).

Soil samples were collected from the top surface layer of mineral soil at a depth of 4–10 cm (within the rooting zone of plants to be sampled) and again at 20-30 cm. Where possible, a third sample was taken deeper than 30 cm to determine migration potential of specific metals through the pedon.

The procedure involved:

1. Characterizing the soil pit, delineating different soil horizons, taking photographs and recording field notes on standardized datasheets.

2. A composite grab sample was taken from each distinguishable horizon wearing nitrile gloves and using clean sampling equipment (spade or knife) rinsed in deionized water.

3. Approximately 300 g of soil was placed in a fresh plastic sample bag and labelled with sample site identifier, date, project number and sampler's initials.

4. Samples were kept cool and out of the light in coolers with ice packs.

2.4.3 Vegetation Sampling

Vegetation sampling was conducted adjacent to the site soil pit. When possible, the pit was placed at the roots of as many of the target species as feasible to provide accurate analysis of the soil substrate growing conditions. Vegetation samples were collected wearing clean nitrile gloves to pick the desired healthy plant parts which were placed in a sterile sealable plastic bag. Sampling of plant tissue focused on a single specimen of a species adjacent to the soil pit; however, where limited supply was encountered tissue samples were composed of the closest communities of the same species. Approximately 100-150 g of tissue was collected in the sample bag, sealed and labeled with sample site identifier, date, project number and sampler's initials. Samples were kept frozen and out of direct light until delivered to the lab.

2.5 LABORATORY ANALYSIS

Each vegetation tissue sample was homogenized by the lab and divided into two subsamples, one sample was rinsed with deionized water and the second sample left unrinsed. The two subsamples were then analyzed independently to try and understand the degree of metal contamination being contributed by dust. The rationale being the unrinsed vegetation analysis would reflect the total amount of metals both external from dust and internal from soil while the rinsed samples reflect the metals being up taken from the soil. Samples were analyzed in wet weight (mg/kg) and dry weight (mg/kg) as a means to determine percent moisture per sample. Results are presented in dry weight consistent with the British Columbia Environmental Laboratory Manual (Austin, 2015).

All soil samples analyses by the lab followed standard protocols for inductively coupled plasma mass spectrometry (ICP-MS) total metals, pH, texture and cation exchange capacity (CEC).

The ICP-MS analysis for metal concentrations is sensitive in detecting concentrations in the range of micrograms per kilogram. Due to this level of sensitivity, soil samples were carefully sampled and placed in sealed plastic bags for shipping to avoid compromising the results. The following quality control and quality assurance protocols were carried out to ensure the results were of high quality.

2.6 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

QA/QC measures were established to quantify laboratory or field variability within the data. Laboratory QA/QC were based on ALS Global standards and consisted of comparing samples to certified references material and internal reference material as well as conducting method blanks, duplicates and laboratory control sample tests. Laboratory defined Data Quality Objectives (DQO) were used to determine if laboratory duplicate results met the specific replicate criteria for QA/QC standards. DQO thresholds for vegetation samples is 40% variation in concentration of metals and for soils ranges from 30 – 40 % depending on the element.

Field variability was quantified with duplicate samples collected at a rate of one per 10 samples and submitted to the lab under a pseudonym sample number. The lab results were compared between duplicates to understand variability that was introduce by the field sampling methodology.

Relative Percent Difference (RPD) was used to determine field variability and is the difference between the sample result and replicate result, divided by the average of the sample result and replicate result and expressed as a percentage.

$$RPD = \frac{(\text{Field Sample Concentration} - \text{Duplicate Sample Concentration})}{(\text{Field Sample Concentration} + \text{Duplicate Sample Concentration})/2} \text{ X } 100\%$$

Where analyte results have RPD >25% a subsequent check was done against the laboratory detection limit (DL) to establish if the practical quantitation limit (PQL) was met. The PQL is five times the DL and is defined as the minimum concentration that can be measured within specified limits of precision and accuracy. Both the sample result and the replicate result need to be above the PQL for the analyte to be considered as 'meeting the PQL'. If one result from the sample or duplicate is greater than five times the DL and one result is less than five times the DL, then the 'PQL is not met'. An analyte with results below the PQL indicates that the constituent being analyzed is not present in a sufficient amount to be reliably quantified. Typically, as parameters approach their detection limit, high variability is more likely to occur. The RPD of 25% can be used as a benchmark whereby results with an RPD >25% warrant further comment or consideration.

3 RESULTS

Results from the 2016 VMU sampling program are separated into vegetation and soil, and compared against soil quality guidelines. These are presented in the following subsections.

3.1 SOIL GUIDELINES

The Canadian Council of Ministers of the Environment (CCME) released Canadian Environmental Quality Guidelines (CEQG) to measure parameters in soil and to provide "science based goals for the quality of atmospheric, aquatic, and terrestrial ecosystems" (CCME, 2006). The recommended Canadian soil quality guidelines are derived specifically for the protection of ecological receptors in the environment or for the protection of human health associated with four land uses: agricultural, residential and parkland, commercial, and industrial (CCME, 1999). The guidelines for metals in soil are presented in Table 3-1, and the industrial land use guidelines were chosen as the most appropriate for assessing metal concentrations reported in the soil results.

Guidelines are not currently established for comparing metal concentration in vegetation tissue.

Table 3-1: CCME Soil Quality Guidelines for the Protection of Environmental and Human Health

Chemical Name	Chemical Groups	Agricultural	Residential/ Parkland	Commercial	Industrial	Guideline Date
		Concentration (mg/kg dry weight)				
Antimony	Inorganic Metals	20	20	40	40	1991
Arsenic	Inorganic Metals	12	12	12	12	1997
Barium	Inorganic Metals	750	500	2,000	2,000	2013
Beryllium	Inorganic Metals	4	4	8	8	2015
Boron	Inorganic Metals	2	No data	No data	No data	1991
Cadmium	Inorganic Metals	1.4	10	22	22	1999
Chromium (total)	Inorganic Metals	64	64	87	87	1997
Chromium (Cr(VI))	Inorganic Metals	0.4	0.4	1.4	1.4	1999
Cobalt	Inorganic Metals	40	50	300	300	1991
Copper	Inorganic Metals	63	63	91	91	1999
Lead	Inorganic Metals	70	140	260	600	1999
Mercury	Inorganic Metals	6.6	6.6	24	50	1999

Chemical Name	Chemical Groups	Agricultural	Residential/ Parkland	Commercial	Industrial	Guideline Date
		Concentration (mg/kg dry weight)				
Molybdenum	Inorganic Metals	5	10	40	40	1991
Nickel	Inorganic Metals	45	45	89	89	2015
Selenium	Inorganic Metals	1	1	2.9	2.9	2009
Silver	Inorganic Metals	20	20	40	40	1991
Thallium	Inorganic Metals	1	1	1	1	1999
Tin	Inorganic Metals	5	50	300	300	1991
Uranium	Inorganic Metals	23	23	33	300	2007
Vanadium	Inorganic Metals	130	130	130	130	1997
Zinc	Inorganic Metals	200	200	360	360	1999

3.2 VEGETATION

Vegetation samples were analyzed for moisture and total metal concentration with results presented as dry weight concentration in milligrams per kilogram (mg/kg). A complete table of vegetation results including wet and dry weight concentrations can be found in Appendix B. Mean metal concentrations for the metals were compared between the unrinsed and rinsed samples for each vegetation species and are presented in Table 3-2. Note that statistics were calculated using half the method detection limit where results were reported as less than detection.

Table 3-2: Mean Vegetation Metal Concentration in Unrinsed and Rinsed Samples

Metal Concentration		Blueberry (n=3)			Horsetail (n=9)			Labrador Tea (n=15)			Lichen (n=12			Willow (n=21)		
Dry Weight (mg/kg)		Unrinsed	Rinsed	Mean difference[1]	Unrinsed	Rinsed	Mean difference[1]	Unrinsed	Rinsed	Mean difference[1]	Unrinsed	Rinsed	Mean difference[1]	Unrinsed	Rinsed	Mean difference[1]
Aluminum (Al)	**Mean**	**7.17**	**5.97**	**1.20**	**75.00**	**55.70**	**19.30**	**95.98**	**81.35**	**14.63**	**622.33**	**487.66**	**134.68**	**114.92**	**81.41**	**33.51**
	Std Dev	3.99	2.97		71.22	51.87		97.63	69.84		500.02	382.82		99.03	60.27	
Arsenic (As)	**Mean**	**0.01**	**0.01**	**0.00**	**0.03**	**0.03**	**0.00**	**0.03**	**0.03**	**0.00**	**0.20**	**0.17**	**0.00**	**0.04**	**0.03**	**0.00**
	Std Dev	0.00	0.00		0.02	0.02		0.03	0.02		0.11	0.09		0.03	0.02	
Cadmium (Cd)	**Mean**	**0.18**	**0.10**	**0.08**	**0.08**	**0.08**	**0.00**	**0.01**	**0.00**	**0.00**	**0.07**	**0.06**	**0.01**	**1.18**	**1.22**	**-0.05**
	Std Dev	0.06	0.04		0.06	0.06		0.00	0.00		0.06	0.03		0.92	0.92	
Chromium (Cr)	**Mean**	**0.03**	**0.03**	**0.00**	**0.05**	**0.04**	**0.00**	**0.07**	**0.08**	**0.00**	**0.53**	**0.42**	**0.00**	**0.09**	**0.06**	**0.00**
	Std Dev	0.00	0.00		0.03	0.03		0.04	0.10		0.45	0.31		0.08	0.06	
Copper (Cu)	**Mean**	**5.88**	**3.55**	**2.32**	**38.97**	**29.07**	**9.90**	**24.95**	**22.90**	**2.05**	**176.97**	**155.01**	**21.96**	**26.73**	**20.33**	**6.40**
	sd	1.86	0.28		43.94	32.02		21.05	17.89		235.98	192.46		28.05	19.28	
Iron (Fe)	**Mean**	**19.30**	**15.20**	**4.10**	**173.86**	**129.03**	**44.82**	**162.05**	**145.75**	**16.30**	**1107.17**	**902.00**	**205.17**	**217.79**	**159.87**	**57.92**
	Std Dev	5.92	5.05		156.75	104.39		148.02	115.15		974.98	760.34		169.03	107.07	
Manganese (Mn)	**Mean**	**70.07**	**37.73**	**32.33**	**212.60**	**230.70**	**-18.10**	**522.56**	**551.81**	**-29.25**	**100.35**	**91.99**	**8.36**	**404.21**	**392.85**	**11.36**
	Std Dev	35.12	19.02		121.58	123.18		450.38	473.88		37.31	39.67		529.34	581.56	
Molybdenum (Mo)	**Mean**	**0.40**	**0.23**	**0.16**	**0.57**	**0.57**	**0.00**	**0.29**	**0.32**	**-0.02**	**0.29**	**0.24**	**0.05**	**0.61**	**0.62**	**-0.01**
	Std Dev	0.25	0.18		0.57	0.51		0.21	0.23		0.30	0.20		0.54	0.53	
Nickel (Ni)	**Mean**	**0.67**	**0.39**	**0.28**	**0.86**	**0.87**	**-0.01**	**0.57**	**0.58**	**-0.01**	**0.69**	**0.68**	**0.01**	**4.22**	**4.09**	**0.13**
	Std Dev	0.31	0.25		0.48	0.53		0.55	0.57		0.41	0.48		4.37	4.40	
Lead (Pb)	**Mean**	**0.01**	**0.01**	**0.00**	**0.05**	**0.03**	**0.00**	**0.04**	**0.03**	**0.00**	**0.33**	**0.28**	**0.00**	**0.05**	**0.05**	**0.00**
	Std Dev	0.00	0.00		0.05	0.04		0.04	0.03		0.20	0.16		0.04	0.08	
Antimony (Sb)	**Mean**	**0.01**	**0.01**	**0.00**	**0.01**	**0.01**	**0.00**	**0.01**	**0.01**	**0.00**	**0.02**	**0.01**	**0.00**	**0.01**	**0.01**	**0.00**
	Std Dev	0.00	0.00		0.00	0.00		0.00	0.00		0.01	0.01		0.00	0.00	
Selenium (Se)	**Mean**	**0.03**	**0.03**	**0.00**	**0.09**	**0.07**	**0.00**	**0.03**	**0.03**	**0.00**	**0.18**	**0.16**	**0.00**	**0.11**	**0.11**	**0.00**
	Std Dev	0.00	0.00		0.14	0.10		0.01	0.01		0.20	0.17		0.16	0.16	
Zinc (Zn)	**Mean**	**16.33**	**8.55**	**7.78**	**33.71**	**35.89**	**-2.18**	**21.49**	**22.53**	**-1.04**	**16.54**	**14.74**	**1.80**	**75.55**	**73.13**	**2.42**
	Std Dev	3.70	0.61		17.15	19.63		4.35	4.52		5.63	4.03		55.19	51.82	

[1]Mean difference calculated by taking the difference between unrinsed and rinsed samples and then calculating the mean.

When comparing unrinsed to rinsed samples there was an overall decrease in COPC concentration with rinsing of samples. However, manganese, molybdenum, nickel, and zinc had slightly higher concentrations in Labrador tea, horsetail, and willow with the rinsing. This is likely a result of variation in homogenization and the lab's Data Quality Object (DQO) of 40% repeatability. The statistical package, R, was used to compare the unrinsed and rinsed samples of key metals that are cited in the literature as having the greatest potential effect on wildlife and human health (Roggeman et al., 2012; Csavina, 2012; European Commission, 2006; Australian Government, 2016). Although not a health risk, iron appeared to be affected by rinsing so was also assessed. A non-parametric statistical test was chosen since the data did not meet the requirements of normal distribution and equal variances. A paired sample Wilcoxon test was then chosen given the small sample size and each sample was both rinsed and unrinsed (i.e. paired and dependent). The tests were conducted using a significance level (p) of 0.05. If p is less than 0.05 then there is a 95% chance that the concentrations are statistically different. The results of the analyses are presented in Table 3-3.

Table 3-3: Paired Wilcoxon Results between Rinsed and Unrinsed Vegetation Samples

Metal of Concern[1]	Blueberry (n=3)[2]		Horsetail (n=9)		Labrador Tea (n=15)		Lichen (n=12		Willow (n=21)	
	Test Statistic	p-Value	Test Statistic	p-Value	Test Statistic	p-Value	Test Statistic	p-Value	Test Statistic	p-Value
Arsenic (As)	n/a	n/a	17.0	0.673	36.0	0.824	67.0	0.031	125.0	0.003
Cadmium (Cd)	6.00	0.250	27.0	0.652	24.0	0.441	51.0	0.366	64.5	0.079
Copper (Cu)	6.00	0.250	43.0	0.012	77.0	0.359	58.5	0.136	231.0	<0.001
Iron (Fe)	6.00	0.250	41.0	0.027	84.0	0.188	68.0	0.021	231.0	<0.001
Lead (Pb)	n/a	n/a	15.0	0.059	42.5	0.139	67.0	0.027	170.0	0.003
Zinc (Zn)	6.00	0.250	14.0	0.359	34.0	0.147	58.0	0.029	145.0	0.321

[1]Highlighted cells represent a $p < 0.05$ which is the significance value for accepting the null hypothesis (i.e., that there is a difference)
[2]n/a indicates that concentrations were below detection.

Results from the paired Wilcoxon test show significantly higher ($p<0.05$) in unrinsed than rinsed samples for three of the five species. Willow and lichen showed the most significant differences with four of the six metals significantly less in the rinsed samples compared to the unrinsed. Blueberry and Labrador tea showed no difference between rinsed and unrinsed samples.

Vegetation metal analyses were also compared between the control sites and the exposure sites to determine if there were any statistically significant differences between treatments. Results of this comparison are presented in Table 3-4.

Table 3-4: Mean Unrinsed Vegetation Metal Concentration Comparison between Control and Exposure sites

Metal Concentration		Blueberry			Horsetail			Labrador Tea			Lichen			Willow		
Dry Weight (mg/kg)		Control (n=1)	Exposure (n=2)	Percent Difference [1]	Control (n=3)	Exposure (n=6)	Percent Difference [1]	Control (n=5)	Exposure (n=10)	Percent Difference [1]	Control (n=4)	Exposure (n=8)	Percent Difference [1]	Control (n=5)	Exposure (n=16)	Percent Difference [1]
Aluminum (Al)	Mean	2.90	9.30	105%	12.80	106.10	157%	55.02	116.46	72%	182.00	842.50	129%	35.96	139.60	118%
	Std Dev		2.12		3.81	68.02		38.19	113.05		69.14	473.97		19.14	101.24	
Arsenic (As)	Mean	0.01	0.01	0%	0.03	0.04	34%	0.02	0.03	66%	0.11	0.25	82%	0.02	0.04	94%
	Std Dev		0.00		0.02	0.02		0.01	0.03		0.02	0.10		0.01	0.03	
Cadmium (Cd)	Mean	0.12	0.21	60%	0.09	0.08	19%	0.00	0.01	5%	0.03	0.09	108%	1.95	0.93	70%
	Std Dev		0.04		0.10	0.04		0.01	0.00		0.01	0.06		1.59	0.43	
Chromium (Cr)	Mean	0.03	0.03	0%	0.03	0.06	81%	0.07	0.07	3%	0.19	0.70	113%	0.04	0.10	89%
	Std Dev		0.00		0.00	0.04		0.04	0.05		0.04	0.47		0.02	0.09	
Copper (Cu)	Mean	4.11	6.76	49%	5.48	55.72	164%	7.16	33.85	130%	33.95	248.48	152%	8.31	32.49	119%
	Std Dev		1.48		1.60	45.60		4.20	20.44		25.04	264.02		2.76	29.97	
Iron (Fe)	Mean	12.60	22.65	57%	48.63	236.47	132%	71.84	207.16	97%	301.00	1510.25	134%	78.60	261.28	107%
	Std Dev		1.63		17.67	158.35		37.33	163.34		117.95	964.75		29.00	171.45	
Manganese (Mn)	Mean	44.00	83.10	62%	127.43	255.18	67%	536.18	515.75	4%	65.78	117.64	57%	183.80	473.09	88%
	Std Dev		38.04		74.41	122.11		689.06	323.05		42.14	20.05		115.56	590.58	
Molybdenum (Mo)	Mean	0.68	0.26	89%	0.40	0.66	50%	0.31	0.28	9%	0.08	0.39	133%	0.48	0.65	29%
	Std Dev		0.11		0.16	0.69		0.18	0.23		0.02	0.32		0.32	0.60	
Nickel (Ni)	Mean	1.02	0.49	70%	0.83	0.88	6%	0.56	0.58	3%	0.29	0.89	101%	7.12	3.32	73%
	Std Dev		0.07		0.82	0.31		0.55	0.58		0.04	0.36		7.83	2.33	
Lead (Pb)	Mean	0.01	0.01	0%	0.01	0.07	147%	0.02	0.05	84%	0.17	0.40	81%	0.02	0.06	97%
	Std Dev		0.00		0.00	0.05		0.01	0.04		0.03	0.21		0.01	0.04	
Antimony (Sb)	Mean	0.01	0.01	0%	0.01	0.01	38%	0.01	0.01	36%	0.01	0.02	40%	0.01	0.01	48%
	Std Dev		0.00		0.00	0.00		0.00	0.00		0.01	0.01		0.01	0.00	
Selenium (Se)	Mean	0.03	0.03	0%	0.03	0.12	131%	0.03	0.03	27%	0.04	0.24	139%	0.12	0.11	12%
	Std Dev		0.00		0.00	0.17		0.00	0.02		0.02	0.22		0.16	0.17	
Zinc (Zn)	Mean	12.60	18.20	36%	19.63	40.75	70%	21.52	21.47	0%	12.61	18.50	38%	121.80	61.10	66%
	Std Dev		2.55		9.14	16.09		5.81	3.80		4.26	5.38		61.43	46.03	

[1]Percent difference is the difference in mean exposure concentration from the mean control concentration divided by the average of both concentrations

Unrinsed samples were selected for comparison between exposure and control sites to avoid any variability that may have been introduced as a result of the rinsing process. Interpretation of the percent difference between control and exposure sites shows greater mean concentrations of metals in vegetation at exposure sites than the control sites. However, these data also show that exposure sites have greater standard deviation in metal concentrations when compared to controls suggesting more variability among samples. Samples size for exposure sites compared to control sites also contributed to the higher variance. Figure 3-1 to Figure 3-13 Figure 3-1 to Figure 3-13 present the mean difference in concentration and variation for respective metals by species between exposure and control sites. Error bars are +/- one standard deviation which is an indication of variation in data from the mean value.

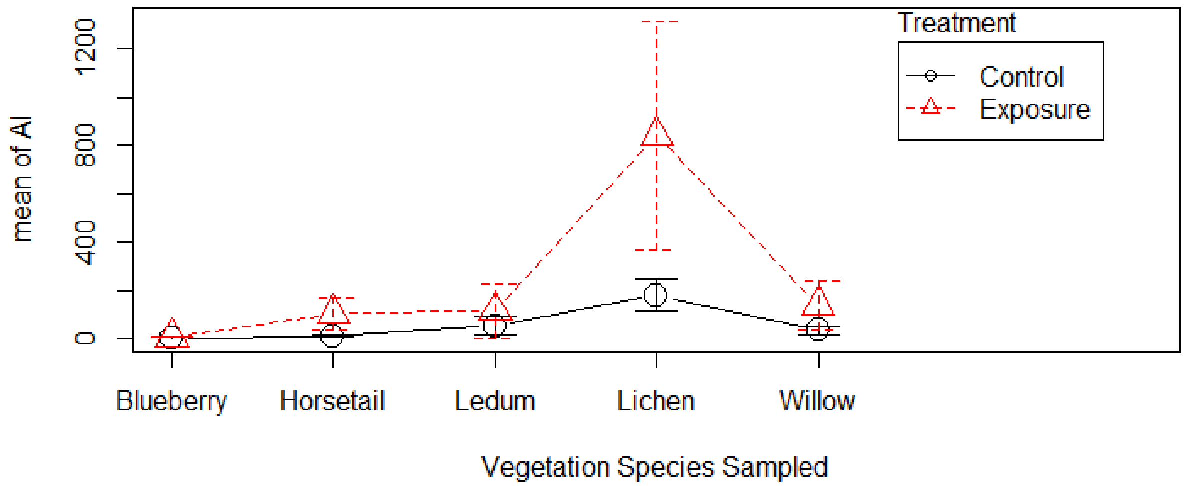

Figure 3-1: Comparison of Mean Aluminum Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

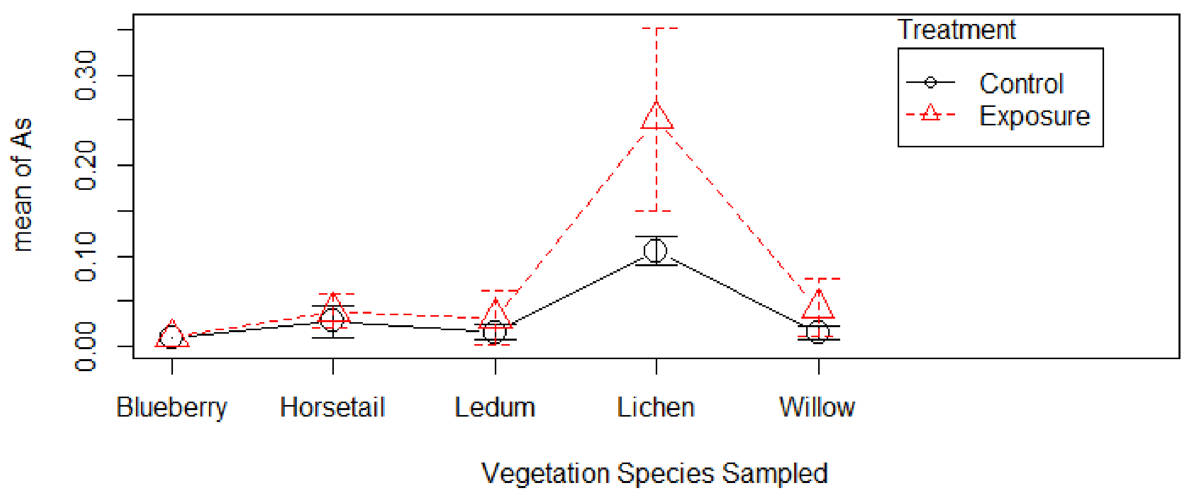

Figure 3-2: Comparison of Mean Arsenic Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

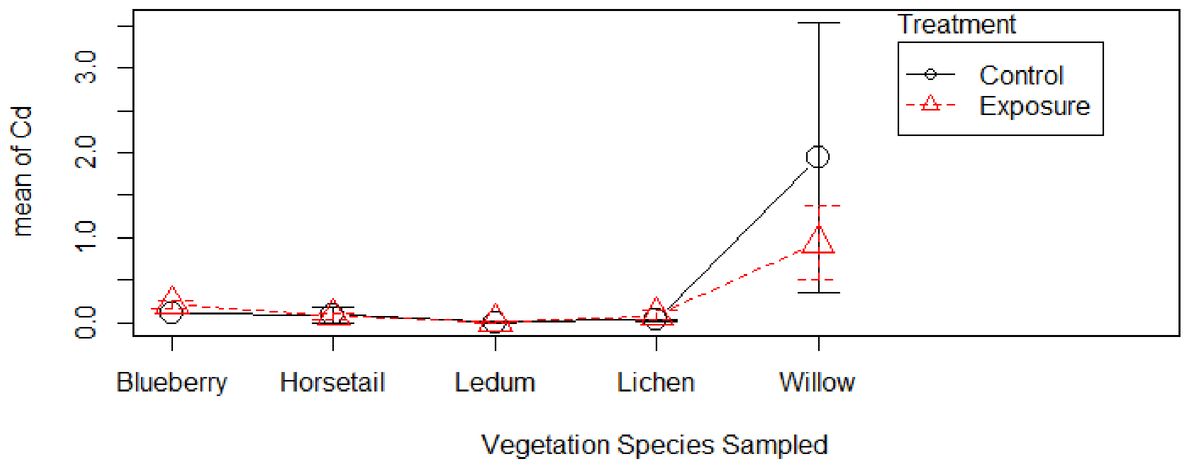

Figure 3-3: Comparison of Mean Cadmium Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

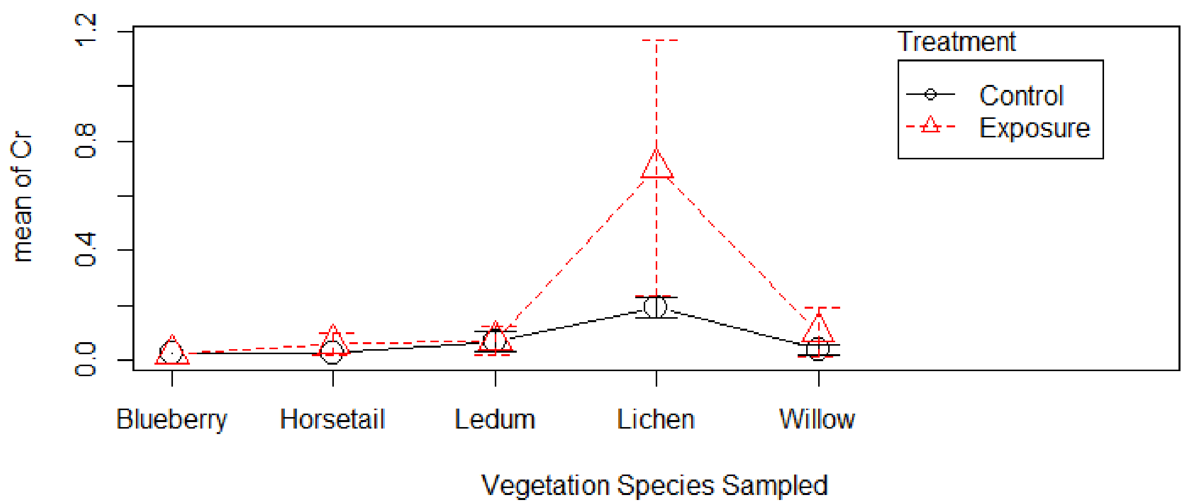

Figure 3-4: Comparison of Mean Chromium Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

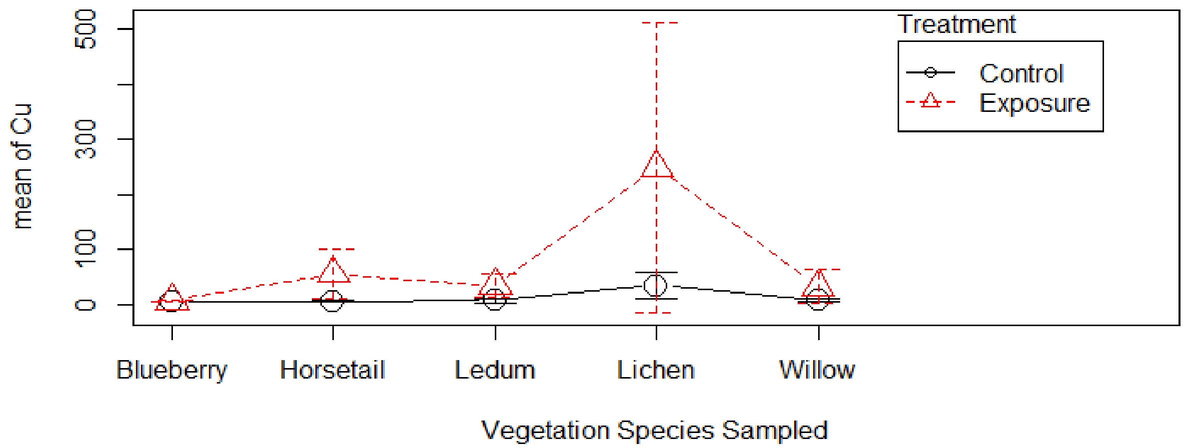

Figure 3-5: Comparison of Mean Copper Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

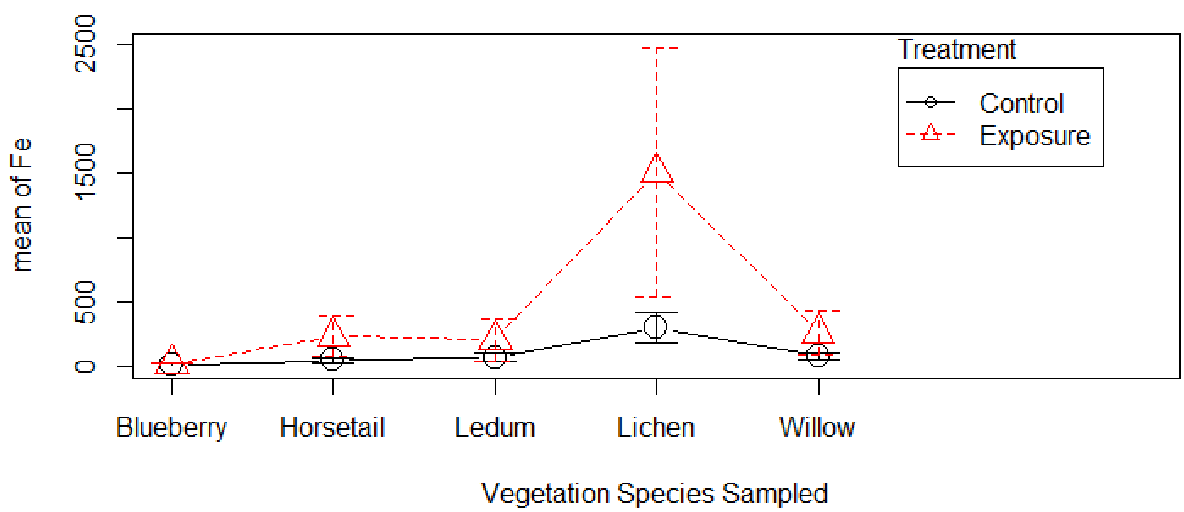

Figure 3-6: Comparison of Mean Iron Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

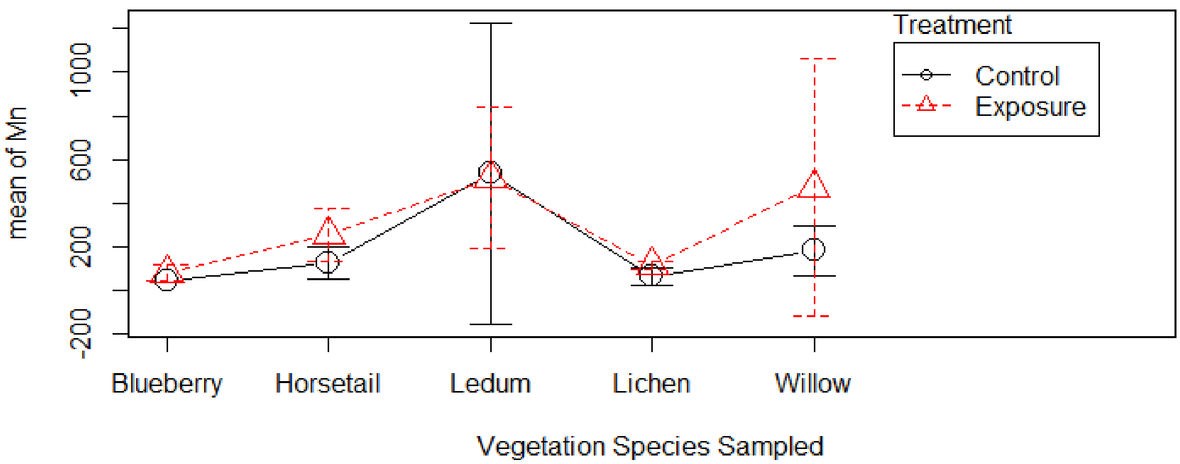

Figure 3-7: Comparison of Mean Manganese Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

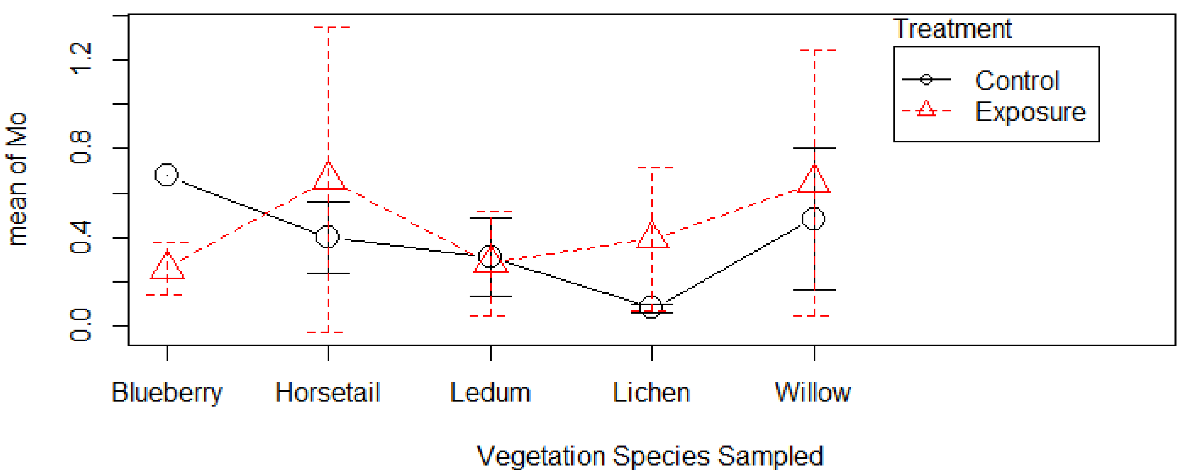

Figure 3-8: Comparison of Mean Molybdenum Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

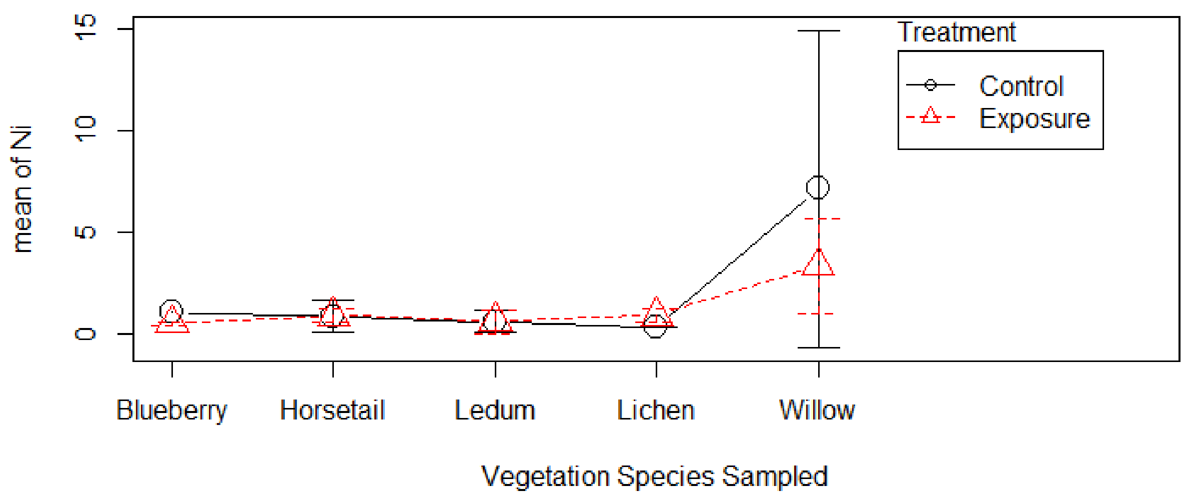

Figure 3-9: Comparison of Mean Molybdenum Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

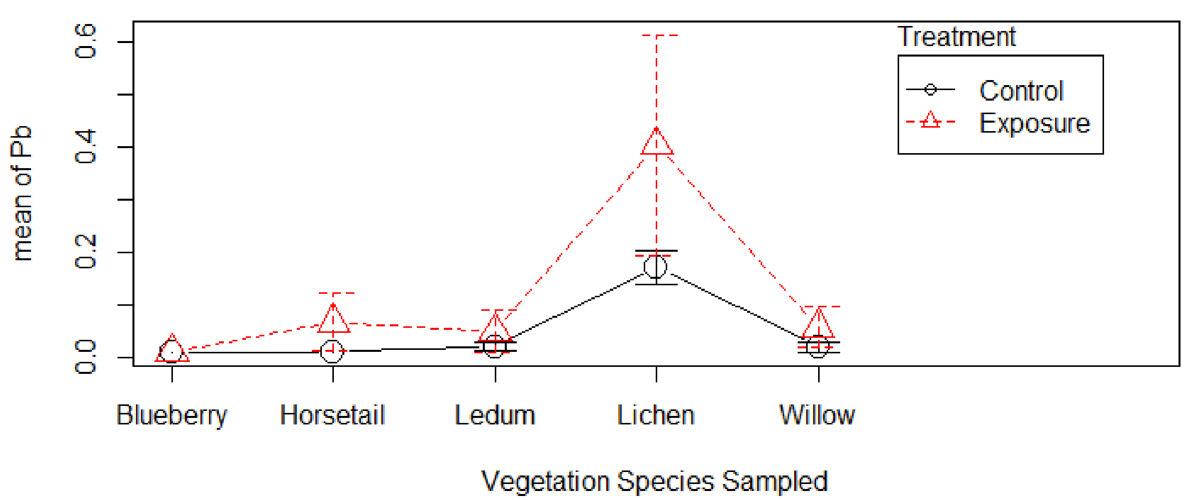

Figure 3-10: Comparison of Mean Lead Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

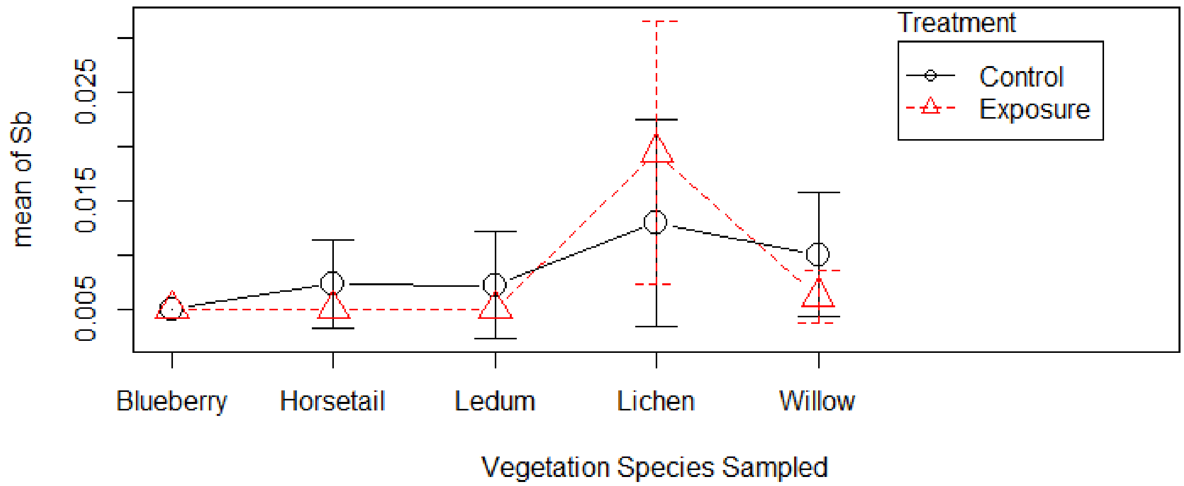

Figure 3-11: Comparison of Mean Antimony Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

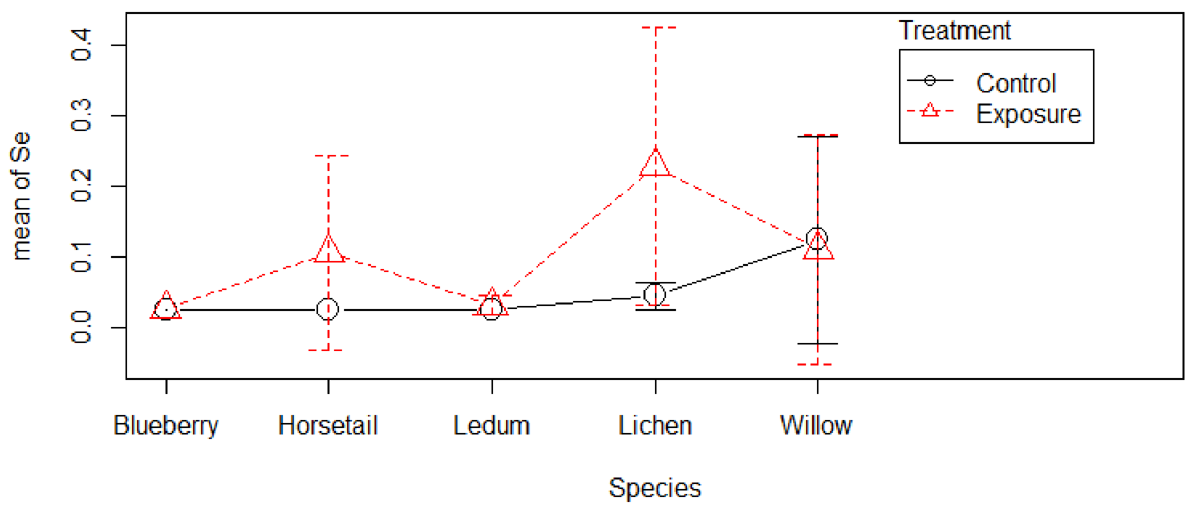

Figure 3-12: Comparison of Mean Selenium Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

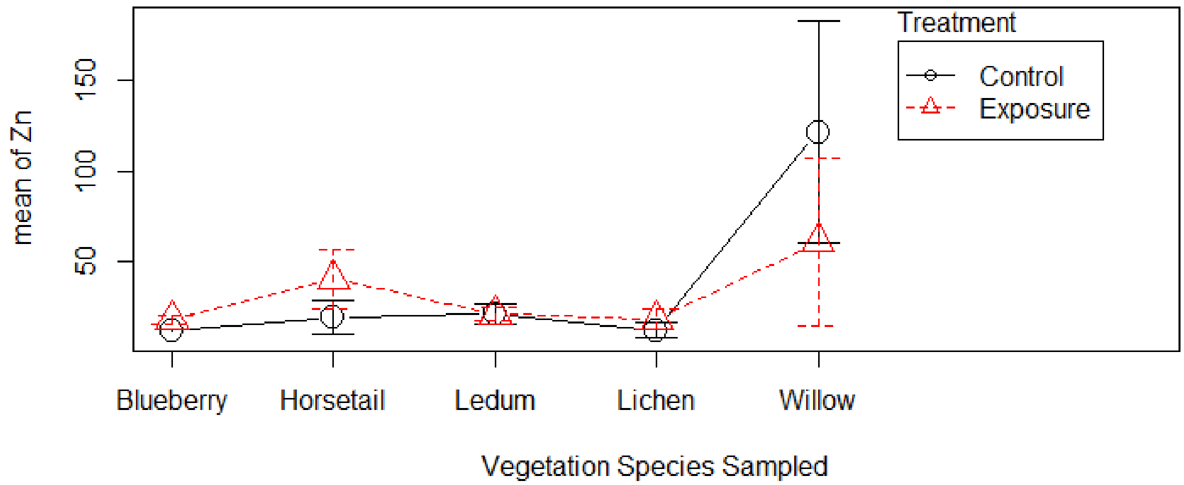

Figure 3-13: Comparison of Mean Zinc Concentration (mg/kg) between Control and Exposure Sites (Error bar +/- 1 SD)

A two sample Wilcoxon test was preformed between exposure and control sites for each species for selected metals. A two sample test was used rather than a paired test because the exposure and control samples are independent samples (i.e., not linked). Results were compared to a significance level of 0.05 and are presented in Table 3-5.

Table 3-5: Two Sample Wilcoxon Results between Exposure and Control Sites

Metal of Concern	Blueberry (n=3)		Horsetail (n=9)		Labrador Tea (n=15)		Lichen (n=12)		Willow (n=21)	
	Test Statistic[2]	p-Value	Test Statistic	p-Value	Test Statistic	p-Value	Test Statistic	p-Value	Test Statistic	p-Value
Arsenic (As)	n/a	n/a	4.50	0.298	14.5	0.206	1.0	0.008	14.0	0.034
Cadmium (Cd)	0.0	0.6667	9.00	1.000	20.0	0.534	0.0	0.004	60.0	0.107
Copper (Cu)	0.0	0.6667	0.00	0.024	2.5	0.007	5.0	0.073	60.0	0.107
Iron (Fe)	0.0	0.6667	0.00	0.024	7.0	0.028	0.0	0.004	7.0	0.007
Lead (Pb)	n/a	n/a	1.50	0.059	11.0	0.095	2.0	0.016	10.0	0.015
Zinc (Zn)	0.0	0.6667	2.0	0.0952	25.0	1	5.0	0.0727	64.0	0.05

[1]Highlighted cells represent a p-Value < 0.05 which is the significance value for accepting the null hypothesis.
[2]Test statistic represents W or the Wilcoxon test result.

Results from the analysis showed that lichen and willow were significantly higher in metals at exposure sites compared to control sites. Willow had significantly higher concentrations of arsenic, iron, and lead at the exposure sites but had lower (but not statistically significant) cadmium and zinc at the exposure sites. Labrador tea and horsetail were the only species that showed significantly higher concentrations in copper at the exposure sites.

Duplicate field samples were collected at an interval of one replicate per ten samples. Duplicates were compared and evaluated against a RPD threshold of 25% to describe any field variability between consecutive grab samples. Duplicate samples were collected for the following sites and species; duplicate S31 salix was collected at site S06, duplicate S32 ledum was collected at site S07, duplicate S33 horsetail was collected at site S07, duplicate S34 lichen was collected at site S08, duplicate S35 salix was collected at site S16, and duplicate S36 ledum was collected at site M29. Table 3-6 presents a summary of the QA/QC results for unrinsed vegetation tissue samples. Variability between simultaneous field duplicates is most likely attributed to field homogenization techniques resulting is different concentrations between samples.

Table 3-6: Summary of QA/QC Results for Vegetation Tissue Analysis

		S07 and S33 Horsetail		M29 and S36 Ledum		S07 and S32 Ledum		S08 and S34 Lichen		S16 and S35 Salix		S06and S31 Salix	
Metals (Tissue)	**5 x Detection Limit (mg/kg)**	**RPD**	**Meets PQL**	**RPD**	**Meets PQL**	**RPD**	**Meets PQL**	**RPD**	**Meets PQL**	**RPD**	**Meets PQL**	**RPD**	**Meets PQL**
Aluminum (Al)	**10**	12%		20%		3%		30%	yes	10%		11%	
Antimony (Sb)	0.05	0%		0%		0%		14%		75%	no	0%	
Arsenic (As)	0.1	0%		20%		17%		27%	yes	14%		79%	no
Barium (Ba)	0.25	2%		9%		3%		19%		9%		14%	
Beryllium (Be)	0.05	0%		0%		0%		5%		0%		7%	
Bismuth (Bi)	0.05	0%		0%		0%		20%		0%		0%	
Boron (B)	5	4%		10%		14%		10%		4%		10%	
Cadmium (Cd)	0.025	50%	yes	100%	no	0%		32%	yes	2%		13%	
Calcium (Ca)	100	9%		5%		2%		5%		3%		11%	
Cesium (Cs)	0.025	41%	no	13%		25%		23%		9%		3%	
Chromium (Cr)	0.25	0%		75%	no	11%		26%	yes	20%		75%	no
Cobalt (Co)	0.1	36%	yes	9%		13%		16%		16%		6%	
Copper (Cu)	0.5	1%		6%		17%		20%		25%		7%	
Iron (Fe)	15	16%		10%		13%		21%		11%		6%	
Lead (Pb)	0.1	4%		18%		3%		30%	yes	7%		15%	
Lithium (Li)	2.5	0%		0%		0%		9%		0%		0%	
Magnesium (Mg)	10	2%		2%		13%		27%	yes	8%		7%	
Manganese (Mn)	0.25	23%		24%		22%		21%		16%		4%	
Molybdenum (Mo)	0.1	3%		35%	yes	33%	no	11%		15%		11%	
Nickel (Ni)	1	42%	no	117%	no	25%		84%	no	5%		18%	
Phosphorus (P)	50	18%		2%		3%		20%		13%		6%	
Potassium (K)	100	10%		8%		6%		32%	yes	16%		11%	
Rubidium (Rb)	0.25	43%	yes	14%		5%		33%	yes	37%	yes	1%	
Selenium (Se)	0.25	0%		0%		0%		12%		0%		0%	
Sodium (Na)	100	0%		0%		0%		73%	no	0%		0%	
Strontium (Sr)	0.25	11%		8%		7%		10%		1%		11%	
Tellurium (Te)	0.1	0%		0%		0%		6%		0%		0%	
Thallium (Tl)	0.01	17%		39%	yes	110%	no	16%		0%		0%	
Tin (Sn)	0.5	0%		0%		0%		89%	no	0%		0%	
Uranium (U)	0.01	49%	no	129%		38%	no	12%		11%		0%	
Vanadium (V)	0.5	11%		7%		18%		25%		14%		7%	
Zinc (Zn)	2.5	0%		3%		13%		13%		8%		9%	
Zirconium (Zr)	1	0%		0%		0%		52%	no	0%		0%	

RPD = relative percent difference; PQL = practical quantitation limit

3.3 SOIL

Composite soil samples were taken at each site and represented all distinguishable horizons within the soil profile. Samples were analyzed by ALS Laboratories for total metals, texture, pH and Cation Exchange Capacity (CEC). A complete list of soil sample results can be found in Appendix B. A summary of mean total metal concentration comparing exposure to control by horizon are is presented in Table 3-7. Note that statistics were calculated using half the method detection limit where results were reported as less than detection.

Table 3-7: Soil Metal Concentration by Horizon between Control and Exposure Sites

Metal concentration		Horizon 1			Horizon 2			Horizon 3[2]
Dry Weight (mg/kg)		Control site(n=5)	Exposure Site(n=16)	Percent Difference[1]	Control Site (n=4)	Exposure Site (n=12)	Percent Difference[1]	Exposure (n=3)
Aluminum (Al)	**Mean**	**17360**	**17765**	**1%**	**15720**	**15933**	**0%**	**20167**
	Std Dev	5496	5066		8164	4324		4061
Arsenic (As)	**Mean**	**6.81**	**7.95**	**4%**	**5.77**	**8.28**	**9%**	**10.53**
	Std Dev	2.61	2.57		2.32	1.85		2.91
Cadmium (Cd)	**Mean**	**0.07**	**0.09**	**8%**	**0.07**	**0.10**	**8%**	**0.07**
	Std Dev	0.03	0.06		0.03	0.07		0.03
Chromium (Cr)	**Mean**	**32.02**	**30.07**	**2%**	**32.18**	**30.19**	**2%**	**30.67**
	Std Dev	11.50	7.74		15.36	7.64		14.39
Copper (Cu)	**Mean**	**29.44**	**144.70**	**33%**	**27.40**	**62.32**	**19%**	**328.57**
	Std Dev	12.85	244.44		11.13	74.08		520.86
Iron (Fe)	**Mean**	**25880**	**27795**	**2%**	**23800**	**27258**	**3%**	**32867**
	Std Dev	5505	5933		7795	4639		9027
Manganese (Mn)	**Mean**	**370**	**425**	**3%**	**333**	**421**	**6%**	**455**
	Std Dev	220	266		124	155		180
Molybdenum (Mo)	**Mean**	**0.53**	**1.16**	**19%**	**0.42**	**0.78**	**15%**	**0.58**
	Std Dev	0.27	1.09		0.12	0.41		0.19
Nickel (Ni)	**Mean**	**18.20**	**19.97**	**2%**	**18.45**	**23.10**	**6%**	**22.67**
	Std Dev	2.97	5.82		3.66	7.37		8.38
Lead (Pb)	**Mean**	**6.25**	**6.97**	**3%**	**6.09**	**6.12**	**0%**	**5.69**
	Std Dev	1.97	1.41		3.22	1.42		1.53
Antimony (Sb)	**Mean**	**0.46**	**0.48**	**1%**	**0.51**	**0.59**	**4%**	**0.52**
	Std Dev	0.13	0.16		0.21	0.18		0.25
Selenium (Se)	**Mean**	**0.15**	**0.21**	**10%**	**0.18**	**0.20**	**3%**	**0.18**
	Std Dev	0.10	0.16		0.10	0.14		0.14
Zinc (Zn)	**Mean**	**40.32**	**55.16**	**8%**	**40.55**	**55.67**	**8%**	**69.10**
	Std Dev	3.24	20.67		11.53	14.96		35.42
Physical properties								
CEC (meq/100g)	**Mean**	**19.32**	**17.02**	**3%**	**28.73**	**14.88**	**16%**	**9.87**
	Std Dev	8.02	6.12		24.71	5.94		3.40
pH.L	**Mean**	**5.92**	**5.98**	**0%**	**6.03**	**6.34**	**1%**	**6.58**
	Std Dev	0.89	0.63		0.73	0.90		1.56

[1]Percent difference is the difference in mean exposure concentration from the mean control concentration divided by the average of both concentrations.
[2]Horizon 3 was not encountered at any of the control site locations.

Generally, exposure sites had higher concentrations of metals when compared to controls. The most notable difference in concentrations were copper, molybdenum, selenium and zinc. Soil metal concentrations were compared to CCME Industrial Guidelines with exceedances occurring at two sites for arsenic and five sites for copper, out of a total of 21 sites (Table 3-8). For arsenic, each of the two sites had a single exceedance, resulting in two exceedances out of a total sample size of 40. For copper (sites S05, S16, and S17), there were multiple exceedances throughout the horizons of the soil profile suggesting a continuum of copper from the parent material. Ten samples exceeded CCME for copper out of a total sample size of 40. Soil pH didn't show much deviation between control and exposure sites; however, it was noted that surface topsoil horizons on average were more acidic than the lower horizons which is a typical soil profile for this area. Control site pH ranged from 4.64 to 6.9 for the top horizon and 5.27 to 6.95 for the second horizon compared with 5.08 to 7.11 for the top horizon and 4.99 to 7.57 for the second horizon at exposure sites.

Table 3-8: Soil sample concentrations compared to CCME industrial soil guidelines for metals

Element	CCME Industrial Guideline	Sites Exceeding CCME Guideline (Soil horizon)	Total sites sampled	Total number of samples (n)
Aluminum (Al)	-	-	21	40
Antimony (Sb)	40	none		
Arsenic (As)	12	S02 (Bm2), S19(Bm1)		
Cadmium (Cd)	22	none		
Chromium (Cr)	87	none		
Copper (Cu)	91	S05 (Bm1, Bm2), S06 (B), S07 (B), S16 (Bm1, Bm2), S17 (Ah, Bm1, Bm2)		
Iron (Fe)	-	-		
Lead (Pb)	600	none		
Manganese (Mn)	-	-		
Molybdenum (Mo)	40	none		
Nickel (Ni)	89	none		
Selenium (Se)	2.9	none		
Zinc (Zn)	360	none		

Soil texture at control sites ranged from clay loam to sand while exposure sites ranged from silt loam to loamy sand. Mean CEC was greater in the top two horizons at control sites as compared to exposure. Soils around the Minto site can be described as relatively shallow and young typically having one or two horizons.

During the 2016 monitoring program, field duplicates were collected at four sampling sites to determine field variability between simultaneous soil grab samples. Relative percent difference (RPD) was calculated between the duplicate soil samples and compared against the 25% threshold. Duplicate samples were collected at the following sites: duplicate sample S21 Bm2 collected at site SO1, duplicate sample S22 Bm1 was collected at site S02, duplicate sample S24 Bm1 was collected at site S11, and duplicate sample S23 B was collected at site S07. Results from the QA/QC analyses are presented in Table 3-9.

Table 3-9: Summary of QA/QC Results for Duplicate Soil Analysis

	S01 and S21 Bm2		S02 and S22 Bm1		S11 and S24 Bm1		S07 and S23 B	
Analyte	**RPD**	**Meets PQL**	**RPD**	**Meets PQL**	**RPD**	**Meets PQL**	**RPD**	**Meets PQL**
Physical Parameter								
Moisture	35%	yes	3%		5%		18%	
% Clay (<2um)	5%		9%		10%		11%	
% Sand (2.0mm - 0.05mm)	5%		2%		5%		5%	
% Silt (0.05mm - 2um)	4%		2%		1%		3%	
pH (1:2 soil:water)	1%		0%		2%		0%	
Cation Exchange Capacity	1%		8%		6%		62%	yes
Metals								
Aluminum (Al)	19%		16%		0%		32%	yes
Antimony (Sb)	9%		3%		10%		2%	
Arsenic (As)	11%		14%		10%		9%	
Barium (Ba)	3%		7%		5%		21%	
Beryllium (Be)	6%		8%		8%		10%	
Bismuth (Bi)	0%		0%		0%		0%	
Boron (B)	0%		0%		0%		0%	
Cadmium (Cd)	8%		8%		12%		4%	
Calcium (Ca)	6%		13%		9%		7%	
Chromium (Cr)	13%		8%		9%		9%	
Cobalt (Co)	7%		6%		8%		6%	
Copper (Cu)	9%		4%		6%		9%	
Iron (Fe)	15%		9%		2%		21%	
Lead (Pb)	4%		9%		7%		4%	
Lithium (Li)	2%		14%		8%		19%	
Magnesium (Mg)	11%		11%		3%		20%	
Manganese (Mn)	11%		10%		14%		16%	
Mercury (Hg)	29%	no	11%		12%		22%	
Molybdenum (Mo)	5%		2%		6%		19%	
Nickel (Ni)	20%		5%		7%		17%	
Phosphorus (P)	4%		4%		6%		1%	
Potassium (K)	16%		7%		14%		28%	yes
Selenium (Se)	79%	no	14%		0%		4%	
Silver (Ag)	0%		10%		0%		0%	
Sodium (Na)	8%		7%		2%		22%	
Strontium (Sr)	17%		15%		3%		22%	
Thallium (Tl)	1%		7%		9%		31%	no
Tin (Sn)	0%		0%		0%		0%	
Titanium (Ti)	24%		14%		18%		35%	yes
Uranium (U)	9%		8%		9%		10%	
Vanadium (V)	13%		5%		5%		21%	
Zinc (Zn)	18%		7%		7%		17%	
Zirconium (Zr)	15%		21%		14%		0%	

RPD = relative percent difference; PQL = practical quantitation limit

4 DISCUSSION

The main objectives of the vegetation metal uptake program are to utilize previously established or documented conditions, monitoring results or predictive efforts, where appropriate and possible; establish a network of plots for monitoring both soil and vegetation metal concentrations; and, allow for an ongoing evaluation of the extent and degree that metals from mining activity is affecting vegetation in proximity to the project site.

These objectives were met for this first round of the program by establishing 16 exposure sites and five control sites that will be used for monitoring every three years. At each site between one and five vegetation samples were collected along with samples of each distinguishable soil horizon. Being the preliminary sampling event, these data were described with some preliminary statistics and put into a workable database to be used for comparison with future sampling events. It is recognized that the complex nature of the vegetation metal uptake system will require a robust dataset to be able to define any trends in potential metal accumulation. Additionally, based on results from this first year of data collection some changes are recommended to improve the study design to better assess trends statistically.

Results from the 2016 monitoring event present evidence that some metals are elevated in the certain plant species near the mine when compared to control sites. As no baseline vegetation metals samples were collected during the 2009-2010 ecosystem mapping program it cannot be determined that elevated metals were not present in the pre-mining condition.

Results between the rinsed and unrinsed samples were highly variable. Results for some metals were greater for rinsed samples then unrinsed, suggesting that rinsing was not always removing dust particulates. There appeared to be other processes involved since some metals increased after rinsing. Additionally, subsampling, rinsing, and comparing vegetation samples compounded the variably within a paired sample. Rinsing affects concentrations differently depending on the type of metal. In a study by Kabatta-Pendias et al (2011) the effect of rinsing for lead concentrations can be greater, showing it to be mainly superficial compared to copper, zinc and cadmium where rinsing shows minimal change. Findings at Minto were similar to the Kabata-Pendias et al (2011) study with two significant decreases between rinsed and unrinsed samples for lead but no significant decrease for cadmium, one for zinc and two for copper between all species. Rinsing samples showed that there are some metals in the samples coming from dust on the plant; however, the results added a level of complexity and variability that does not improve the ability of the program to determine whether metals are coming from dust settling on the plant or from uptake from the soils.

Lichen and willow samples showed significantly higher metals at exposure sites compared to control sites. Lichen species are known to be good indicators of airborne metals and range from being tolerant to sensitive to airborne metals, depending on the physiological form and species (Garty, 2000; Branquinho et al., 2000; Kabata-Pendias et al., 2011). Findings around the Minto site were that lichen samples accumulated more metals than the other plant species and had significantly elevated concentrations of arsenic, cadmium, iron, and lead compared to control sites.

Willows species are known to be accumulators of heavy metals (Kosvakinka and Quigley, 2004). In particular, willows are known to uptake cadmium and zinc from surrounding soils (Tlustos et al., 2007). Willows showed significantly higher arsenic, iron and lead concentrations in exposure than control sites. Conversely and contrary to expectations, willow samples at control sites appeared to have higher (but not significantly higher) concentrations of cadmium and zinc than exposure sites. It should be noted that the non-parametric statistical tests are not as powerful as parametric tests, but had to be used because the samples did not meet the requirements of normal distribution and equal variances. This means that there is a possibility of a type II error (incorrectly retaining a null hypothesis), and the control sites might be determined to be significantly higher if more samples were taken.

Horsetail and Labrador tea appeared to have similar responses, and were both significantly higher in copper and iron at exposure than control sites, but not for arsenic, iron, or lead.

Blueberry did not show any significant difference between control and exposure sites. This may have been due to the short exposure period when the plant is producing berries.

There were some interesting trends in other metals. Soil metals in general were higher at exposure than control sites. Iron concentrations increased significantly for all plant species other than blueberry. Iron is not a COPC, but it does indicate that there were generally higher levels of dust at the exposure than control sites. Zinc concentrations were not higher at exposure than control sites which indicates that zinc was not significantly picked up into plant tissue in the area surrounding the mine. CCME exceedances in soil were limited occruing in two of the 13 metals of interest with 5% of samples for arsenic and 25% of samples for copper exceeding the industrial guideline. When present coper exceedances were often detected for the depth of the pit which reflects the mineralization of the area.

Large amounts of variation (noted by high standard deviations) are present within the data that were collected in 2016. The sources of variation are potentially attributed to natural variability in soil and plant tissue, plant species, source types and distance to exposure sample sites, field sampling conditions, and small sample size.

A main factor attributing to field variability for this sampling event was weather. The rain during the beginning of the sampling period could have affected the quantity of metals that were present on species that were more exposed compared to species in closed canopy conditions. There were scattered thunder showers for the remainder of the sampling period that could have affected parts of the study area. This variability is likely to persist through future sampling events as weather is unpredicatble and cannot always be avoided.

Variability attributed to sample size is reflected in the limited number of control sites and the number of target species present within each site. Blueberry sample size was limited for both control and exposure sites as they are less abundant across the landscape compared to the other species.

Laboratory variability was encounted by nature of the selected lab's data quality objective (DQO). The DQO implemented by the lab for tissue analysis was 40% repeatability. This threshold allows for 40% variation in concentrations between any duplicate samples. This threshold was set by that lab and is a factor of the natural variability that is present in vegetation tissue sampling. This variation is compounded when the lab homogonized, subsampled, and rinsed half of the samples for the purpose of quantifying external and internal metal concentrations. Large variation made comparisons between rinsed and unrinsed samples challanging when there were low metal concentations and minimal differences between subsamples. Additionaly, many of the results received were below the method detection limits. When this was the case, the value used to calculate statistics was half the detection limits. Including these halved detection limits is likely to have increased the variation and standard deviation for each variable.

5 CONCLUSIONS AND RECOMMENDATIONS

Overall, results show higher metal concentrations in vegetation located at exposure sites. For metals of potential wildlife and human health concern, arsenic and lead are higher at exposure than control sites for lichen and willow. Copper is higher at exposure than control sites for horsetail and Labrador tea. Blueberry showed no response. While higher concentrations at exposure sites could potentially be the result of airborne particulates from the Minto mine, the source of metals could not be determined due to the high variability associated with the data and minimal pre-mine data. As this first program provides the basis for initial comparison, subsequent studies will help establish a trend and provide ongoing evaluation of the extent and degree that metals from mining activity may be affecting vegetation in proximity to the project site.

The following recommendations should be considered for subsequent VMU sampling events based on the initial 2016 VMU program results:

- Remove blueberry from the list of species to monitor since there was no metal uptake observed and the number of available samples is too small for statistical analyses;
- Reduce the program to only unrinsed samples since results added unexplainable variability and wildlife consume the dust on the plant;
- Standardize the sampling period to periods without rain as much as possible to reduce variability;
- Increase sampling to three replicates per available species at each site to improve the ability to determine statistically valid spatial and temporal differences;
- Conduct continual periodic sampling until a temporal range of data can be analyzed to determine any significant patterns in the data; and
- Focus COPCs on potentially toxic metals that had higher concentrations in exposure sites at the Minto Mine (arsenic, copper, and lead). Aluminum and iron should also continue to be analyzed to help interpret the source of metals.

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APPENDIX A

VMU SITE SUMMARY

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ACCESS
CONSULTING GROUP

PROJECT ID: 2016 Minto VMU

WEATHER: overcast raining

PLOT #: SA03	SURVEYORS: MHCP	DATE: Aug 9, 2016	START TIME: 9:50	END TIME: 10:30
TYPE/ # OF SAMPLES: Salix, Lichen, Soil x2		PHOTO #'S:		

GPS ZONE	
08	E 0387043 N 6947177
ASPECT (%)	145
SLOPE (%)	22%
ELEVATION	786

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)	M	
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	/
ROOT REST. PAN	R	/
BEDROCK	B	/
FROZEN LAYER	F	
CARBONATES	C	/
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	✓
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
X	X	5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)								
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	T	TOE
							D	DEPRESSION
							L	LEVEL

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SOIL DESCRIPTION

HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
F	7		
ASH	1		
ZERO →			
Bm1	8	LS	
Bm2	19	SL	20
Bm3	38	SL	25
DOP	45	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

Sampled Bm1, Bm2

lots of snags

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	45
SHRUB LAYER (B)	25
HERB LAYER (C)	40
MOSS LAYER (D)	70

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Picea Glauca	1	30					
Pop tremo	2	15					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Salix sp	—	1	Pop trem	10	
Shep can		5			
Rose acicu		5			
Salix					

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C) / MOSS LAYER / LICHEN LAYER

SPECIES	%	SPECIES	%	SPECIES	%	SPECIES (MOSS)	%	SPECIES (LICHEN)	%
Geoc livi	25	grass sp				Hylo splen	60	Clad stel	10
Vac viti	15								
Viburnum edul	1								
Blue Bell mert pan	1								

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID: 2016 Minto VMU

WEATHER: Raining

PLOT #: C01	SURVEYORS: MH CP	DATE: 03/09/2016	START TIME: 8:20	END TIME: 9:15
TYPE/ # OF SAMPLES: Lichen Salix, horsetail, Ledum		PHOTO #'S: 128 129 130		

GPS ZONE	
08	E 0337429 N 6949359
ASPECT (%)	40
SLOPE (%)	3%
ELEVATION	792 m

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	
MOTTLES	M	
ROOT REST. PAN	R	
BEDROCK	B	
FROZEN LAYER	F	
CARBONATES	C	
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot: 0	Polygon: 0	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		X
BETWEEN PLOTS		

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE
SURFACE COMPOSITION (MUST EQUAL 100%)				T	TOE
ROCK, COBBLE, GRAVEL, SOIL, VEG, ORG., CWD				D	DEPRESSION
				L	LEVEL

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	2		
F	14		
Bm H	7		
Bm1	18		
Bm2	43		
DOP	45	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

ZERO →

COMMENTS/ SITE DISTURBANCES/ SAMPLES

Sample from
Bm1 Bm2
old burn

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	6
SHRUB LAYER (B)	68
HERB LAYER (C)	47
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
SB		2					
Salix		4					
Pice Glau			3				

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Alnus crisp		3			
Ledum groen		60			
Salix sp		2			
Pice Glau		3			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C) / MOSS LAYER / LICHEN LAYER

SPECIES	%	SPECIES	%	SPECIES	%	SPECIES (MOSS)	%	SPECIES (LICHEN)	%
Vac vita	20					Poly Juni	1	cladonia	1
Rosa acic	10					hylo splend?		Peltigera	1
Equi Arven	17							Cladina	3

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

Dup Horsetail

lots of snags.

Sw Regen

lots of litter

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID: 2016 Minto VMU

WEATHER: Over cast Light rain

PLOT #: 311	SURVEYORS: MH CP	DATE: Aug 9, 2016	START TIME: 11:00	END TIME: 11:53
TYPE/# OF SAMPLES: Salix, Lichen, Soil, Soil Dup		PHOTO #'S: 134-137		

GPS ZONE	
08	E 0387034 N 6947251
ASPECT (%)	225
SLOPE (%)	5°
ELEVATION	800

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)	M	
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	/
ROOT REST. PAN	R	clay?
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	X
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
0	0	5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION
←UNIFORM TO VARIABLE →

1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)							
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	
							T TOE
							D DEPRESSION
							L LEVEL

SOIL DESCRIPTION

HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
~~F~~			
L	3		
F	2		
ZERO →			
Bm1	10	SL	15
Bm2	20	SiL	20
Bm3	32	SiL	20
DOP	35	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

fire disturbance.
↳ new growth aspen

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	29
SHRUB LAYER (B)	21
HERB LAYER (C)	32
MOSS LAYER (D)	70

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Sw	7	1					
Pop trem	4	15					
Salix sp	–	2					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
pice glau		10			
Salix sp		5			
pinu cont		1			
Alnu cris		5			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)
Pice Glau	7				

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Vac viti	7					hylo splen	60	Clad stel	10
Cham Engu	1							Relt	1
Carex Livida	25								

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

Snags

Fire disturbance

10% CWD – fallen logs

Soil sample Bm1, Bm2

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID: 2016 Minto VMA

WEATHER: Overcast

cpt S02A

PLOT #: S02	SURVEYORS: MHCP	DATE: Aug 9, 2016	START TIME: 11:50	END TIME: 12:30
TYPE/ # OF SAMPLES: Salix Lichen, Soil x2 Dup soil		PHOTO #'S: 137-142.		

GPS ZONE 08	E 0387066 N 694710
ASPECT (%)	150
SLOPE (%)	15
ELEVATION	769.

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	/
ROOT REST. PAN	R	Silt Lay
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	X
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot: X	Polygon: X	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		X
BETWEEN PLOTS		

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE
				T	TOE
				D	DEPRESSION
				L	LEVEL

SURFACE COMPOSITION (MUST EQUAL 100%)

ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

SITE CLASSIFICATION

←UNIFORM TO VARIABLE →

1	2	3	4	5

SOIL DESCRIPTION

HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	2		
F	4		
B	9	LS	
Bm1	15	SL	15
Bm2	30	SiL	15
DOP	32	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

ZERO →

COMMENTS/ SITE DISTURBANCES/ SAMPLES

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	29
SHRUB LAYER (B)	18
HERB LAYER (C)	35
MOSS LAYER (D)	40

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice mari	15	3		Pinu cont	1		
Pop trem	7	2					
Pice Glac	1	1					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Shep can		15			
Salix sp	1	2			
~~pop~~					

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)
~~pop trem~~					
Pice mari	3				

HERB LAYER (C) / **MOSS LAYER** / **LICHEN LAYER**

SPECIES	%	SPECIES	%	SPECIES	%	SPECIES (Moss)	%	SPECIES (Lichen)	%
Geoc livi	25					Hylo splend	35	clad stel	5
vac viti	7								
ment pari	1								
Rosa acic	3								

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

PAGE	OF

ACCESS CONSULTING GROUP

PROJECT ID: 2016 Minto VML

WEATHER: slight rain

wpt S01 A

PLOT #: S01	SURVEYORS: MHCP	DATE: Aug 9/16	START TIME: 12:45	END TIME: 13:20
TYPE/ # OF SAMPLES: Salix, ledum, Lichen		PHOTO #'S: 143 - 149		

3x Soil bm., bm2 (dup, ~~bm~~ Soil Dup

GPS ZONE	
08	E 0387079 N 6946978
ASPECT (%)	120
SLOPE (%)	10
ELEVATION	737

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	/
ROOT REST. PAN	R	32/silt
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	X
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	X
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot: /	Polygon	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		X
BETWEEN PLOTS		

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE
				T	TOE
				D	DEPRESSION
				L	LEVEL

SURFACE COMPOSITION (MUST EQUAL 100%)						
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	7		
F	6		
ZERO →			
Bm1	11	L	2
Bm2	24	SL	4
BC	36	SiL	5
DOP	42	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

closer to valley bottom.

Rooting depth 32 cm.

Dup onta Bm2

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	16
SHRUB LAYER (B)	8
HERB LAYER (C)	29
MOSS LAYER (D)	81

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Picea Glauca	7	1					
Picea mari	4	2					
Pop Trem	1	1					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
~~Shep~~ can		3			
Rhodo Groenland		5			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C) / MOSS LAYER / LICHEN LAYER

SPECIES	%	SPECIES	%	SPECIES	%	SPECIES (MOSS)	%	SPECIES (LICHEN)	%
Empt nigg	15					Hylo splen	75	clad stel	5
Gooc Livi	7							pelt	1
Rosa acic	2								
Vac viti	4								
~~Bea~~									
Lena bore.	1								
mert pan	<1								

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ____________)

Spruce look hybirdized
↳ Tall like Sw but hairy branches

PAGE	OF

ACCESS
CONSULTING GROUP

.fixed.
* samples are called M26 (need to fix
WPT M26(A)

PROJECT ID: 2016 Minto VMC

WEATHER: overcast

PLOT #: 518	SURVEYORS: MH SB	DATE: Aug 9, 2016	START TIME: / END TIME:
TYPE/ # OF SAMPLES: Horsetail, Salix, ledum, Lichen, soil x 2		PHOTO #'S: 149 - 153	

GPS ZONE	E 386403 N 6944618
ASPECT (%)	350
SLOPE (%)	10%
ELEVATION	832

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	39
ROOT REST. PAN	R	/
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	X
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	X
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

4 2

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION

←UNIFORM TO VARIABLE →

1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)								
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	T	TOE
							D	DEPRESSION
							L	LEVEL

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	16		
F	14		
H	2		
ZERO → AH	9		
Bm1	25	SiL	5
Bm2	35	SiS	5
DOP	51	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice mari		5					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Alnu crisp		3			
Sali glau		2			
Betu Neoa	<1				
Rhod groe		65			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Arct rubr	40					hylo splend	40	Clad Stel	10
Equi scri	20								
pedi fricl	1								
Geoc Livi	3								
Vacc viti	5								
mert pan	1								

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

ACCESS CONSULTING GROUP

PAGE	OF

PROJECT ID:

WEATHER: Cloudy

PLOT #: S15	SURVEYORS: MH, SB	DATE: Aug 9, 2016	START TIME: 5:25	END TIME: 6:15
TYPE/ # OF SAMPLES: Ledum, Salix, horsetail		PHOTO #'S: 154-158		

GPS ZONE	E 386165 N 6944467
ASPECT (%)	10°
SLOPE (%)	7%
ELEVATION	843

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	/
ROOT REST. PAN	R	/
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE
				T	TOE
				D	DEPRESSION
				L	LEVEL

SURFACE COMPOSITION (MUST EQUAL 100%)						
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	15		
F	14		
H	6		
AH	6		
Bm1	13	SiL	25
Bm2	28	SiL	30
DOP	43	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

ZERO →

COMMENTS/ SITE DISTURBANCES/ SAMPLES

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice mari	10	4		Salix		1	
Betn neoa		3					
Alnu crisp		7					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Rhod Groel.		35			
Rose acic		1			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Redi frig		2				hyla splend	85	pelt aspth	3
vac viti		2							
Equi scri		4							

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID: 2016 minto uma

WEATHER: Sunny

cwpt m29PA

PLOT #: m29	SURVEYORS: MH	DATE: Aug 10, 2016	START TIME: 745	END TIME: 8:23
TYPE/ # OF SAMPLES: Salix, Ledum, Lichen, Horsetail		PHOTO #'S: 159-162		

Soil x2 Dup Ledum

GPS ZONE	
08	E 0386636 N 6945190
ASPECT (%)	340
SLOPE (%)	6%
ELEVATION	779

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	✓
ROOT REST. PAN	R	/
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		/

HUMUS FORM (ENTER X)		
MOR	MO	X
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	X
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
/	/	5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES	/	7	SUBHYDRIC
BEDROCK	/	8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION

←UNIFORM TO VARIABLE→

1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)								
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	T	TOE
							D	DEPRESSION
							L	LEVEL

SOIL DESCRIPTION

HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	14		
F	12		
H	3		
ZERO→			
Bm1	15	SiL	
Bm2	40	SiC	
DOP	54	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

lots of snags
Slow seepage

rooting 30

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	11
SHRUB LAYER (B)	87
HERB LAYER (C)	16
MOSS LAYER (D)	90

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice mari	2	7		Salix Glau			
Betu NeoA		2					
Alnu crisp		21					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Alnu crisp		10			
Rhod Groe		67			
Rose acic		5			
Pice mare		5			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C) / MOSS LAYER / LICHEN LAYER

SPECIES	%	SPECIES	%	SPECIES	%	SPECIES (MOSS)	%	SPECIES (LICHEN)	%
Equi scri	12	Grass	3			hylo splend	82	clad stel	5
mert pani	1					Pleu Sche	8		
pedi Fridg	1								
								Litter	10

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID: 2016 Minto Umd

WEATHER: Sunny 15

upt 508A

PLOT #: 508	SURVEYORS:	DATE: Aug 10/16	START TIME: 10:30	END TIME: 11:45
TYPE/ # OF SAMPLES: Salix, ledum (Dup), Lichen (Dup), Blueberry Soil x2 'Dup - lichen		PHOTO #'S: 163 - 168		

GPS ZONE	E 0385497 N 6944329
ASPECT (%)	310
SLOPE (%)	4%
ELEVATION	809

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	
MOTTLES	M	40
ROOT REST. PAN	R	
BEDROCK	B	
FROZEN LAYER	F	60
CARBONATES	C	
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	+
MORMODER	MM	
MODER	MD	+
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	+
MEDIUM	M	+
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot: x	Polygon: x	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		X
BETWEEN PLOTS		X

SITE CLASSIFICATION

←UNIFORM TO VARIABLE →

1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)

ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

T	TOE
D	DEPRESSION
L	LEVEL

SOIL DESCRIPTION

HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
F	25		
H	14		
~~AH~~ Bm1	12	SiL/S	10
Bmjz	32	SiL	10
DOP	60	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

ZERO→

COMMENTS/ SITE DISTURBANCES/ SAMPLES

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice mari	<1	5					
Salix		1					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Rhod. Groe.		40			
Vacc ulig		17			
Salix Sp		9			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Empt Nigr	1	Grass	2			hylo splen	75	clad stel	7
Arcto rubr	1					Pleu schr	10	clad rang	7
rubu cham	2							clad mit	3
mert pan	<1							~~Pelti~~	
Gree Livi	2							pelt apth	1

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

ACCESS
CONSULTING GROUP

PAGE	OF

PROJECT ID:

WEATHER: Sunny +19.

Was 381

PLOT #: S16	SURVEYORS: MH	DATE: Aug 10, 2016	START TIME: 11:30 / END TIME: 12:45
TYPE/ # OF SAMPLES: Salix, Ledum, horsetail ↳ Enough for DAP		PHOTO #'S: 169-176	

GPS ZONE 08	E 0385526	N 6945417
ASPECT (%)	170	
SLOPE (%)	7%	
ELEVATION	795	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	**SNR**	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot X	Polygon +	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION

←UNIFORM TO VARIABLE →

1	2	3	4	5

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	
MOTTLES	M	
ROOT REST. PAN	R	
BEDROCK	B	
FROZEN LAYER	F	
CARBONATES	C	
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	X
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	X
LIGHT	L	
NOT APPLICABLE	N/A	

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)						
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

T	TOE
D	DEPRESSION
L	LEVEL

SOIL DESCRIPTION

HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	40		
F	38		
H	24		
~~Bm~~ Ah	10		
Bm1	32	LS	15
DOP	72	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

ZERO →

COMMENTS/ SITE DISTURBANCES/ SAMPLES

Semi Riparian

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice mari		4					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Sali spp		19			
Rhod Grnoe.		60			
Vac ulig		13			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Equi Arve	10	Grass	5			Glow moss	40	Pelt	5
Arct rubra.	40								
								Litter	

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID:

WEATHER: Sunny

Was 26 502

PLOT #: 517	SURVEYORS: MH	DATE: 2016/08/10	START TIME: 13:30	END TIME: 14:15
TYPE/ # OF SAMPLES: Salix Soil x 3		PHOTO #'S: 177-180		

4 Dup

GPS ZONE	
08	E 0384984 N 6945259
ASPECT (%)	150
SLOPE (%)	20%
ELEVATION	835

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	—
MOTTLES	M	—
ROOT REST. PAN	R	—
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		Bed rock

HUMUS FORM (ENTER X)		
MOR	MO	/
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	/
SOIL COLOUR (ENTER X)		
DARK	D	/
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot: X	Polygon: X	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION

←UNIFORM TO VARIABLE →

1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE
				T	TOE

SURFACE COMPOSITION (MUST EQUAL 100%)						
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

D DEPRESSION
L LEVEL

SOIL DESCRIPTION

HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
ZERO→ L	3		
Ah	7		
Bm1	22	S	10
Bm2	40	S	20
DOP	43	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pinu cont	41	7					
Pop trem	6	11					
Salix Glau		2					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)
Pinu	3				

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
line bore	4	Grass	1						
Cham angu	1								
						100% Litter			

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ____________________)

old burn. 35% CWD
Snags.

PAGE	OF

ACCESS CONSULTING GROUP

PROJECT ID:

WEATHER: raining

S07A

PLOT #: S07	SURVEYORS: MH Dan	DATE: Aug 10, 2016	START TIME: 15:00	END TIME: 16:00
TYPE/ # OF SAMPLES: Salix, horsetail, Ledum, blueberry		PHOTO #'S: 181-183		

Soil w/ Dup Ledum, Horsetail Soil

GPS ZONE	
08	E 0385336 N 6943867
ASPECT (%)	30
SLOPE (%)	4
ELEVATION	840

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	20
ROOT REST. PAN	R	/
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		/

HUMUS FORM (ENTER X)		
MOR	MO	✓
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	X
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
~~A~~	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot: X	Polygon: Y	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)							PLOT POSITION MESO (cont.)	
							T	TOE
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	D	DEPRESSION
							L	LEVEL

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	2		
F	14		
H	7		
ZERO→ Bj	34	SiL	
DOP		DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

Cryosol - lots of mixing

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Dead Spruce		5					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Sali glau		10			
Rhod groe		70			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)
Pice mari	2				
Pin cont	3				

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Equi arve	15					Feathermoss	40	cladonia	15
Vacc viti	10								

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ______________)

Snags

PAGE	OF

PROJECT ID:

ACCESS
CONSULTING GROUP

WEATHER: Sunny w clouds

PLOT #: S06	SURVEYORS: MH DP	DATE: Aug 10, 2016	START TIME: 16:09 / END TIME: 15:20
TYPE/ # OF SAMPLES: Ledum Salix Soil		PHOTO #'S: 184-187	

willow Dup

GPS ZONE	
	E 0384666
	N 6943779
ASPECT (%)	75
SLOPE (%)	30
ELEVATION	949

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)	C	v
DEPTH TO (cm)		
WATER TABLE	W	
MOTTLES	M	
ROOT REST. PAN	R	
BEDROCK	B	
FROZEN LAYER	F	
CARBONATES	C	
OTHER		large colluvium

HUMUS FORM (ENTER X)		
MOR	MO	x
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	x
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
x	x	5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		x
BETWEEN PLOTS		x

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE
				T	TOE
				D	DEPRESSION
				L	LEVEL

SURFACE COMPOSITION (MUST EQUAL 100%)						
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	2		
H	3		
B	38	LS	65
DOP		DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

ZERO →

COMMENTS/ SITE DISTURBANCES/ SAMPLES

old burn.

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Betu neoal		2		Alnu Cris		1	
Pinu cont		2					
Pop trem		10					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Rhodo grnl		15			
Alnu Crisp		2			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C) / **MOSS LAYER** / **LICHEN LAYER**

SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Lyco sp	<1					Poly Juni	35	Cladonia	3

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID:

WEATHER:
Cloudy

PLOT #: 505	SURVEYORS: DPMH	DATE: Aug 10, 2016	START TIME: 17:10	END TIME: 17:45
TYPE/ # OF SAMPLES: Ledum, Lichen, Willow, horsetail.		PHOTO #'S: 188–191		

GPS ZONE	
08	E 384145 N 6944465
ASPECT (%)	
SLOPE (%)	858
ELEVATION	

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	—
MOTTLES	M	26
ROOT REST. PAN	R	—
BEDROCK	B	—
FROZEN LAYER	F	50
CARBONATES	C	
OTHER		—

HUMUS FORM (ENTER X)		
MOR	MO	✓
MORMODER	MM	
MODER	MD	✓
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	x
MEDIUM	M	x
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE
				T	TOE
				D	DEPRESSION
				L	LEVEL

SURFACE COMPOSITION (MUST EQUAL 100%)						
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	20		
F	~~18~~ 18		
H	8		
ZERO →			
Bm1	14		
Bm2	32	SiL	
DOP	50	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

Gl. Cryosol

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice mari	1	10					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Salix sp		3			
Rhod Groe		~~[illegible]~~ 70			
Betu glan		2			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C) / MOSS LAYER / LICHEN LAYER

SPECIES	%	SPECIES	%	SPECIES	%	MOSS LAYER SPECIES	%	LICHEN LAYER SPECIES	%
Equi Arve	60					hyle Sple		Clad Rang	
Vacc viti	25					Pleu ~~Sh~~ Schr		Clad mit	
Empt Nigr	10								
Rubu cham	2								
Vacc ulig	5								

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID:

WEATHER: Sunny H5

WPT M26A

10 m away from control plot

PLOT #: M26	SURVEYORS: MH DP	DATE: Aug 11, 2016	START TIME: 9:40	END TIME: 10:15
TYPE/ # OF SAMPLES: Salix, Ledum, Lichen, Blue berries, Soil		PHOTO #'S: 192-197		

GPS ZONE	
08	E 0383009 N 6942748
ASPECT (%)	220
SLOPE (%)	3
ELEVATION	846

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	/
ROOT REST. PAN	R	/
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	X
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	X
LIGHT	L	
NOT APPLICABLE	N/A	

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)								
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	T	TOE
							D	DEPRESSION
							L	LEVEL

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	14		
F	12		
H	3		
ZERO →			
AH	11		
Bm1	24	LS	5%
Bm2	36	SiL	5%
DOP		DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice Mari	✓	4					
Betu Neoa		<1					
Pop trem		<1					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Salix glau.		4			
Rhod Groe		60			
Alnu cris		1			

TREE REGENERATION <50cm

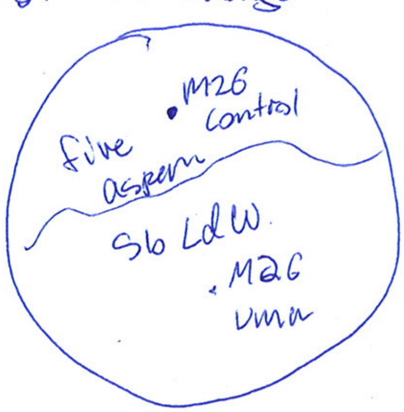
SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Vacc ulig	30					Gloas moss	20	clad rang	10
Empt Nigr	10							Cladonia	15
Geoc livi	5							clad stel	10

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

Just down slope of M26 (2010)
lots of Sb Snags



PAGE	OF

PROJECT ID:

WEATHER: Sunny 20°

ACCESS CONSULTING GROUP

PLOT #: M07b	SURVEYORS:	DATE:	START TIME: 10:50	END TIME: 12:00
TYPE/ # OF SAMPLES: salix, ledum, blue berry, Lichen, horsetail		PHOTO #'S: 198 - 202		

GPS ZONE	
06	E 382128
	N 6944211
ASPECT (%)	210
SLOPE (%)	3
ELEVATION	861

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)	F	
DEPTH TO (cm)		
WATER TABLE	W	50
MOTTLES	M	—
ROOT REST. PAN	R	—
BEDROCK	B	—
FROZEN LAYER	F	64
CARBONATES	C	—
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	X
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot ✓	Polygon ✓	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC
	Y	N	
WITHIN MAIN PLOT			
BETWEEN PLOTS			

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)								
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	T	TOE
							D	DEPRESSION
							L	LEVEL

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	31		
F	29		
H	13		
ZERO → B1	16	SiL	
B2	29	SiL	3
DOP	64	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

Cryosol

COMMENTS/ SITE DISTURBANCES/ SAMPLES

bench of stream bank
site selection based
on available species

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice mari		7					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Salix Sp		30			
Rhodo groe		30			
Betu glan		<1			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Equi arve	27					Glow moss	30	clad Vange	17
Arcto rub	15					Hylo splen	10	Shag red	11
Rubu Cham	2					Pleu Schr	10		
~~Viola~~									
Vibu Edu	<1								
Vacc ulig	10								
Empet Nigr	15								

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID:

WEATHER: Sunny / clouds

PLOT #: 509	SURVEYORS: MH DP	DATE: Aug 11, 2016	START TIME: 13:47	END TIME: 14:15
TYPE/ # OF SAMPLES: Salix, soil x1		PHOTO #'S: 203-206		

GPS ZONE 08	E 383249 N 6944263
ASPECT (%)	125
SLOPE (%)	27
ELEVATION	438

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	/
ROOT REST. PAN	R	/
BEDROCK	B	~~30~~ 15
FROZEN LAYER	F	
CARBONATES	C	
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE
				T	TOE
				D	DEPRESSION
				L	LEVEL

SURFACE COMPOSITION (MUST EQUAL 100%)						
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

SITE CLASSIFICATION

←UNIFORM TO VARIABLE →

1	2	3	4	5

SOIL DESCRIPTION

HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
~~L~~			
ZERO → L	1		
AH	4		
Bi	13	LS	
Br	20		100%
DOP	~~14~~ 21	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pinu cont		6					
Pop trem		3					
Sali		1					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Vibu edul					

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)
Pinu cont	2				
Pop trem	4				

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
arcto uva	7	Cala purp	3						
lena bore	3					Litter			
lupi arti	3								
Rosa acic	1								
Vac viti	1								

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ____________________)

ACCESS CONSULTING GROUP

PAGE	OF

PROJECT ID:

WEATHER: Sunny / cloudy

PLOT #: M40	SURVEYORS: MH DP	DATE: Aug 11, 2016	START TIME: 16:00	END TIME: 15:00
TYPE/ # OF SAMPLES: Salix Ledum Soil		PHOTO #'S: 207 - 211		

GPS ZONE	E 0384379 N 6947084
ASPECT (%)	
SLOPE (%)	
ELEVATION	817

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	/
ROOT REST. PAN	R	/
BEDROCK	B	/
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE
				T	TOE
				D	DEPRESSION
				L	LEVEL

SURFACE COMPOSITION (MUST EQUAL 100%)						
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	2		
~~H~~ F	1		
ZERO → Ah	2		
Bm1	16	LS	15
Bm2	36	S	30
DOP		DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice Pinu cont		15					
Salix Glau		3					
Pop trem	[illegible]	3					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Rhod Gres	7				

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)
Pice Glau	1				

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Vac Viti	15					Poly Juni	25	cladonia	5

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ____________________)

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID:

WEATHER: Sunny

wpt CO2A

PLOT #: CO2	SURVEYORS: MH DP	DATE: Aug 11, 2016	START TIME: 17:00	END TIME: 17:35
TYPE/ # OF SAMPLES: Salix, horsetail, ledum, Lichen		PHOTO #'S: 212-215		

GPS ZONE	E 384479 N 6947163
ASPECT (%)	360
SLOPE (%)	7
ELEVATION	799

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	35
MOTTLES	M	—
ROOT REST. PAN	R	—
BEDROCK	B	—
FROZEN LAYER	F	<1m
CARBONATES	C	—
OTHER		—

HUMUS FORM (ENTER X)		
MOR	MO	
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)							PLOT POSITION MESO	
							T	TOE
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	D	DEPRESSION
							L	LEVEL

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L			
F	12/17		
H	12		
ZERO→			
B_1	13	SL	10
B_2	24	LS	30
DOP		DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

near edge of riparian and old barn

Cryosol

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pice mari		9					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Sali glau		9			
Rhodo Groe		20			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)

HERB LAYER (C) / **MOSS LAYER** / **LICHEN LAYER**

SPECIES	%	SPECIES	%	SPECIES	%	SPECIES (MOSS)	%	SPECIES (LICHEN)	%
EQui Arve.	11	Grass	3			Pleu Schr	80	~~Pelt~~	
Emp niag	6					Glow moss	10	Pelt alth	3
Pedi frig	1							Clad ranf	4
Vacc viti	5							Spha nel.	2

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ____________________)

PAGE	OF

ACCESS
CONSULTING GROUP

PROJECT ID:

WEATHER:

wpt S19#

Was S03

PLOT #: S19	SURVEYORS: MH DP	DATE: Aug 12, 2015	START TIME: 9:00	END TIME: 10:15
TYPE/ # OF SAMPLES: Salix, ledum, Soil		PHOTO #'S: 216 - 219		

GPS ZONE	
08	E 387293 N 6945767
ASPECT (%)	320
SLOPE (%)	10
ELEVATION	981

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	/
MOTTLES	M	/
ROOT REST. PAN	R	/
BEDROCK	B	X 40
FROZEN LAYER	F	/
CARBONATES	C	/
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	X
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot: X	Polygon: X	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES	5	7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)								
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	T	TOE
							D	DEPRESSION
							L	LEVEL

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	5		
F	3		
ZERO →			
Ash	3		
Bm1	14	~~LS~~ SL	5
Bm2	34	LS	5
DOP	40	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

Old burn
near sfc bedrock

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Betu Neoa.		12		Pop trem	1		
Pinu cont		21					
Sali sp		5					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Rhod Groe.		25			
Pi					

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)
Pice ~~ba~~ mari	1				
Pinu cont	2				

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Rosa acic	1					~~Juni~~		Pelt apth	3
Vacc viti	4					Poly Juni	9	Cladonia.	4
Lyco cedar	2								
Lina bore.	1								
Cham angu.								Litter	

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = ________________)

ACCESS
CONSULTING GROUP

PAGE	OF

PROJECT ID:

WEATHER:

PLOT #: S04	SURVEYORS: MH' DP	DATE: Aug 12, 2016	START TIME: 10:00	END TIME: 1hr
TYPE/ # OF SAMPLES: Salix, Soil		PHOTO #'S: 220 - 224		

GPS ZONE 08	E 0383509 N 6945970
ASPECT (%)	270
SLOPE (%)	35
ELEVATION	962

SOIL FEATURES		
SURFICIAL MATERIAL (ENTER CODE)		
DEPTH TO (cm)		
WATER TABLE	W	–
MOTTLES	M	–
ROOT REST. PAN	R	
BEDROCK	B	32
FROZEN LAYER	F	
CARBONATES	C	
OTHER		

HUMUS FORM (ENTER X)		
MOR	MO	
MORMODER	MM	
MODER	MD	
MULLMODER	MR	
MULL	MU	
SOIL COLOUR (ENTER X)		
DARK	D	
MEDIUM	M	
LIGHT	L	
NOT APPLICABLE	N/A	

SOIL DRAINAGE		SMR	
VR	VERY RAPIDLY	A	VERY POOR
R	RAPIDLY	B	POOR
W	WELL	C	MEDIUM
MW	MODERATELY WEL	D	RICH
I	IMPERFECTLY	E	VERY RICH
P	POORLY	F	SALINE
VP	VERY POORLY	SNR	
SEEPAGE		0	VERY XERIC
P	PRESENT	1	XERIX
A	ABSENT	2	SUBXERIC
Open Water Present (%)		3	SUBMESIC
Plot	Polygon	4	MESIC
		5	SUBHYGRIC
ROCKY SUBSTRATES (%)		6	HYGRIC
COBBLES/ STONES		7	SUBHYDRIC
BEDROCK		8	HYDRIC
GULLIES IN POLYGON		9	AQUATIC

	Y	N
WITHIN MAIN PLOT		
BETWEEN PLOTS		

SITE CLASSIFICATION				
←UNIFORM TO VARIABLE →				
1	2	3	4	5

SURFACE SHAPE		MICROTOPOGRAPHY		PLOT POSITION MESO	
CV	CONCAVE	SM	SMOOTH	C	CREST
CX	CONVEX	MO	MOD. MOUNDED	UP	UPPER SLOPE
ST	STRAIGHT	ST	STRONGLY MOUNDED	MS	MID SLOPE
UN	UNDULATING	EX	EXTREMELY MOUNDED	LS	LOWER SLOPE

SURFACE COMPOSITION (MUST EQUAL 100%)								
ROCK	COBBLE	GRAVEL	SOIL	VEG	ORG.	CWD	T	TOE
							D	DEPRESSION
							L	LEVEL

SOIL DESCRIPTION			
HORIZON	DEPTH FROM 0cm	TEXTURE	% TOTAL COARSE FRAGMENTS
L	2		
ZERO→			
AH	5		
Bm,	19	LS	3
Rock	weathered	bedrock	
DOP	32	DOP = DEPTH OF PIT (DISTANCE FROM ZERO)	

COMMENTS/ SITE DISTURBANCES/ SAMPLES

Old burn

PAGE	OF

VEGETATION COVER	%
TREE LAYER (A)	
SHRUB LAYER (B)	
HERB LAYER (C)	
MOSS LAYER (D)	

WILDLIFE SIGN (SCAT, TRACKS, BROWSE, CALL, ENCOUNTER, DEN, ETC.)

TREE LAYER (A)

SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %	SPECIES	A1 (>10m) %	A2 (2m – 10m) %	A3 SUPPRESSED %
Pinu cont		5		Beta Neoa			
Pop trem		2					
salix		6					

SHRUB LAYER (B)

SPECIES	B1 (2m – 10m) %	B2 (<2m) %	SPECIES	B1 (2m – 10m) %	B2 (<2m) %
Alnu crisp					
Beta Neoa		1			

TREE REGENERATION <50cm

SPECIES	%	HEIGHT (cm)	SPECIES	%	HEIGHT (cm)
Sw					

HERB LAYER (C)						MOSS LAYER		LICHEN LAYER	
SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%	SPECIES	%
Vacc viti	5	Grass	2			Poly Juni	5	Pelt apth	2

DOMINANT TREE AGE EST. COUNT	DBH	HEIGHT	SUCCESSIONAL STAGE	STRUCTURAL STAGE

SITE SKETCH: (1 cm = __________________)

APPENDIX B

2016 VEGETATION AND SOIL LAB ANALYSIS RESULTS

Minto Explorations Ltd.
ATTN: Minto Environment
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 13-AUG-16
Report Date: 16-NOV-16 17:56 (MT)
Version: FINAL REV. 3

Client Phone: 604-759-0860

Certificate of Analysis

Lab Work Order #: L1813330
Project P.O. #: 222458
Job Reference: MIN 16-07 (2016 MINTO VMU)
C of C Numbers:
Legal Site Desc:

Comments:

21-OCT-2016 Please note, the metals data for samples #99 and #100 have been corrected as a result of a recheck re-analysis. No other data modifications were made on this revised report.

16-NOV-2016 Please note, the metals data for samples #59 and #70 have been corrected as a result of a recheck re-analysis. No other data modifications were made on this revised report.

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-1	L1813330-2	L1813330-3	L1813330-4	L1813330-5
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	C01-SALIX	C01-LICHEN	C01-HORSETAIL	C01-LEDUM	S03-SALIX
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	74.1	73.9	76.6	67.2	68.5
Metals	Aluminum (Al)-Total (mg/kg)	36.2	131	10.5	32.3	251
	Aluminum (Al)-Total (mg/kg wwt)	9.36	34.1	2.47	10.6	78.9
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	0.016	0.012
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	0.0025	<0.0020	0.0054	0.0037
	Arsenic (As)-Total (mg/kg)	<0.020	0.101	<0.020	<0.020	0.111
	Arsenic (As)-Total (mg/kg wwt)	<0.0040	0.0264	<0.0040	<0.0040	0.0349
	Barium (Ba)-Total (mg/kg)	62.0	14.4	175	57.9	103
	Barium (Ba)-Total (mg/kg wwt)	16.0	3.75	41.0	19.0	32.3
	Beryllium (Be)-Total (mg/kg)	0.011	<0.010	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	0.0029	<0.0020	<0.0020	<0.0020	0.0025
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	16.4	<1.0	10.7	21.2	12.1
	Boron (B)-Total (mg/kg wwt)	4.25	<0.20	2.51	6.93	3.81
	Cadmium (Cd)-Total (mg/kg)	4.30	0.0232	0.202	<0.0050	0.699
	Cadmium (Cd)-Total (mg/kg wwt)	1.11	0.0061	0.0473	0.0011	0.220
	Calcium (Ca)-Total (mg/kg)	16400	1640	14400	4930	28500
	Calcium (Ca)-Total (mg/kg wwt)	4250	429	3370	1620	8980
	Cesium (Cs)-Total (mg/kg)	<0.0050	0.0481	0.0841	<0.0050	0.0195
	Cesium (Cs)-Total (mg/kg wwt)	<0.0010	0.0126	0.0197	0.0016	0.0061
	Chromium (Cr)-Total (mg/kg)	0.062	0.180	<0.050	0.056	0.344
	Chromium (Cr)-Total (mg/kg wwt)	0.016	0.047	<0.010	0.018	0.108
	Cobalt (Co)-Total (mg/kg)	0.659	0.096	0.106	<0.020	0.380
	Cobalt (Co)-Total (mg/kg wwt)	0.171	0.0252	0.0248	0.0056	0.119
	Copper (Cu)-Total (mg/kg)	7.02	10.5	3.81	3.72	16.8
	Copper (Cu)-Total (mg/kg wwt)	1.82	2.74	0.893	1.22	5.30
	Iron (Fe)-Total (mg/kg)	61.3	193	28.9	40.1	440
	Iron (Fe)-Total (mg/kg wwt)	15.9	50.5	6.77	13.1	139
	Lead (Pb)-Total (mg/kg)	0.026	0.154	<0.020	0.025	0.101
	Lead (Pb)-Total (mg/kg wwt)	0.0067	0.0402	<0.0040	0.0082	0.0319
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	4730	335	3150	1090	2890
	Magnesium (Mg)-Total (mg/kg wwt)	1220	87.6	738	359	909
	Manganese (Mn)-Total (mg/kg)	386	103	98.3	662	62.1
	Manganese (Mn)-Total (mg/kg wwt)	99.9	27.0	23.0	217	19.5

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-6	L1813330-7	L1813330-8	L1813330-9	L1813330-10
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S03-LICHEN	S11-LICHEN	S11-SALIX	S02-SALIX	S02-LICHEN
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	72.2	68.1	73.3	66.5	62.1
Metals	Aluminum (Al)-Total (mg/kg)	946	294	29.6	150	1020
	Aluminum (Al)-Total (mg/kg wwt)	263	94.0	7.91	50.2	386
	Antimony (Sb)-Total (mg/kg)	0.034	0.021	<0.010	<0.010	0.038
	Antimony (Sb)-Total (mg/kg wwt)	0.0094	0.0067	<0.0020	<0.0020	0.0144
	Arsenic (As)-Total (mg/kg)	0.360	0.151	<0.020	0.058	0.398
	Arsenic (As)-Total (mg/kg wwt)	0.100	0.0482	0.0043	0.0193	0.151
	Barium (Ba)-Total (mg/kg)	39.5	40.3	103	60.6	33.8
	Barium (Ba)-Total (mg/kg wwt)	11.0	12.9	27.6	20.3	12.8
	Beryllium (Be)-Total (mg/kg)	0.023	0.010	0.011	<0.010	0.027
	Beryllium (Be)-Total (mg/kg wwt)	0.0063	0.0032	0.0029	<0.0020	0.0103
	Bismuth (Bi)-Total (mg/kg)	0.010	0.018	<0.010	<0.010	0.013
	Bismuth (Bi)-Total (mg/kg wwt)	0.0029	0.0058	<0.0020	<0.0020	0.0051
	Boron (B)-Total (mg/kg)	<1.0	<1.0	5.5	2.1	<1.0
	Boron (B)-Total (mg/kg wwt)	<0.20	<0.20	1.46	0.69	0.27
	Cadmium (Cd)-Total (mg/kg)	0.0363	0.0537	1.41	0.814	0.0618
	Cadmium (Cd)-Total (mg/kg wwt)	0.0101	0.0171	0.376	0.273	0.0235
	Calcium (Ca)-Total (mg/kg)	2110	3030	15500	20900	2480
	Calcium (Ca)-Total (mg/kg wwt)	586	967	4160	7010	942
	Cesium (Cs)-Total (mg/kg)	0.0873	0.125	0.0070	0.0156	0.174
	Cesium (Cs)-Total (mg/kg wwt)	0.0243	0.0399	0.0019	0.0052	0.0661
	Chromium (Cr)-Total (mg/kg)	1.38	0.396	0.054	0.259	1.44
	Chromium (Cr)-Total (mg/kg wwt)	0.384	0.126	0.014	0.087	0.548
	Cobalt (Co)-Total (mg/kg)	0.575	0.244	3.55	0.504	0.649
	Cobalt (Co)-Total (mg/kg wwt)	0.160	0.0778	0.949	0.169	0.246
	Copper (Cu)-Total (mg/kg)	52.6	35.7	5.67	16.4	64.0
	Copper (Cu)-Total (mg/kg wwt)	14.6	11.4	1.52	5.49	24.3
	Iron (Fe)-Total (mg/kg)	1500	467	62.8	234	1510
	Iron (Fe)-Total (mg/kg wwt)	418	149	16.8	78.5	574
	Lead (Pb)-Total (mg/kg)	0.349	0.182	0.020	0.048	0.420
	Lead (Pb)-Total (mg/kg wwt)	0.0971	0.0579	0.0055	0.0160	0.159
	Lithium (Li)-Total (mg/kg)	0.55	<0.50	<0.50	<0.50	0.72
	Lithium (Li)-Total (mg/kg wwt)	0.15	<0.10	<0.10	<0.10	0.27
	Magnesium (Mg)-Total (mg/kg)	620	414	2620	4830	751
	Magnesium (Mg)-Total (mg/kg wwt)	172	132	701	1620	285
	Manganese (Mn)-Total (mg/kg)	102	109	538	67.6	122
	Manganese (Mn)-Total (mg/kg wwt)	28.3	34.7	144	22.7	46.4

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1813330-11 TISSUE 09-AUG-16 S01-LEDUM	L1813330-12 TISSUE 09-AUG-16 S01-SALIX	L1813330-13 TISSUE 09-AUG-16 S01-LICHEN	L1813330-14 TISSUE 09-AUG-16 S18-SALIX	L1813330-15 TISSUE 09-AUG-16 S18-LICHEN
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	63.0	63.5	66.5	59.4	68.6
Metals	Aluminum (Al)-Total (mg/kg)	37.7	52.5	278	36.4	1270
	Aluminum (Al)-Total (mg/kg wwt)	13.9	19.2	93.1	14.8	398
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	0.013	<0.010	0.017
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	0.0028	0.0042	<0.0020	0.0055
	Arsenic (As)-Total (mg/kg)	<0.020	0.027	0.191	0.020	0.241
	Arsenic (As)-Total (mg/kg wwt)	0.0072	0.0099	0.0638	0.0082	0.0758
	Barium (Ba)-Total (mg/kg)	103	83.7	36.5	89.9	33.8
	Barium (Ba)-Total (mg/kg wwt)	37.9	30.5	12.2	36.5	10.6
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	0.030
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0027	<0.0020	0.0093
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	0.118
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0029	<0.0020	0.0371
	Boron (B)-Total (mg/kg)	5.4	4.5	<1.0	10.4	1.3
	Boron (B)-Total (mg/kg wwt)	1.98	1.64	<0.20	4.23	0.40
	Cadmium (Cd)-Total (mg/kg)	<0.0050	0.586	0.0344	2.11	0.133
	Cadmium (Cd)-Total (mg/kg wwt)	<0.0010	0.214	0.0115	0.859	0.0419
	Calcium (Ca)-Total (mg/kg)	6130	23200	2300	27800	2910
	Calcium (Ca)-Total (mg/kg wwt)	2270	8460	769	11300	912
	Cesium (Cs)-Total (mg/kg)	0.0453	0.0074	0.0825	0.0701	0.121
	Cesium (Cs)-Total (mg/kg wwt)	0.0167	0.0027	0.0276	0.0285	0.0381
	Chromium (Cr)-Total (mg/kg)	0.088	0.083	0.369	<0.050	0.674
	Chromium (Cr)-Total (mg/kg wwt)	0.033	0.030	0.124	0.011	0.212
	Cobalt (Co)-Total (mg/kg)	0.042	0.178	0.191	0.529	0.756
	Cobalt (Co)-Total (mg/kg wwt)	0.0154	0.0650	0.0638	0.215	0.237
	Copper (Cu)-Total (mg/kg)	8.50	8.96	49.5	20.0	788
	Copper (Cu)-Total (mg/kg wwt)	3.14	3.27	16.6	8.13	247
	Iron (Fe)-Total (mg/kg)	71.5	107	440	102	2920
	Iron (Fe)-Total (mg/kg wwt)	26.4	38.9	147	41.5	916
	Lead (Pb)-Total (mg/kg)	0.024	0.023	0.198	0.022	0.633
	Lead (Pb)-Total (mg/kg wwt)	0.0088	0.0084	0.0661	0.0088	0.199
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	0.62
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	0.19
	Magnesium (Mg)-Total (mg/kg)	1570	2690	458	6200	970
	Magnesium (Mg)-Total (mg/kg wwt)	582	980	153	2520	305
	Manganese (Mn)-Total (mg/kg)	583	54.8	109	231	130
	Manganese (Mn)-Total (mg/kg wwt)	216	20.0	36.5	93.6	40.8

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-16	L1813330-17	L1813330-18	L1813330-19	L1813330-20
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S18-LEDUM	S18-HORSETAIL	S15-SALIX	S15-LEDUM	S15-HORSETAIL
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	46.3	60.8	65.4	53.7	62.5
Metals	Aluminum (Al)-Total (mg/kg)	25.9	174	58.7	78.5	133
	Aluminum (Al)-Total (mg/kg wwt)	13.9	68.1	20.3	36.4	49.9
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	0.0039	<0.0020	<0.0020	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	<0.020	0.058	<0.020	0.025	0.030
	Arsenic (As)-Total (mg/kg wwt)	0.0071	0.0227	0.0068	0.0115	0.0114
	Barium (Ba)-Total (mg/kg)	58.7	98.0	32.0	73.6	102
	Barium (Ba)-Total (mg/kg wwt)	31.5	38.4	11.1	34.1	38.4
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	0.0023	<0.0020	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	0.014	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	0.0021	0.0057	<0.0020	0.0030	0.0035
	Boron (B)-Total (mg/kg)	12.3	14.9	2.7	11.7	10.2
	Boron (B)-Total (mg/kg wwt)	6.61	5.84	0.92	5.43	3.82
	Cadmium (Cd)-Total (mg/kg)	<0.0050	0.0893	1.06	0.0068	0.148
	Cadmium (Cd)-Total (mg/kg wwt)	0.0025	0.0350	0.367	0.0031	0.0554
	Calcium (Ca)-Total (mg/kg)	3850	15500	14200	5830	12100
	Calcium (Ca)-Total (mg/kg wwt)	2060	6060	4910	2700	4550
	Cesium (Cs)-Total (mg/kg)	0.0232	0.268	0.103	0.0270	0.246
	Cesium (Cs)-Total (mg/kg wwt)	0.0125	0.105	0.0358	0.0125	0.0925
	Chromium (Cr)-Total (mg/kg)	<0.050	0.105	<0.050	0.051	0.083
	Chromium (Cr)-Total (mg/kg wwt)	0.012	0.041	0.014	0.024	0.031
	Cobalt (Co)-Total (mg/kg)	0.020	0.304	0.865	0.048	0.308
	Cobalt (Co)-Total (mg/kg wwt)	0.0108	0.119	0.300	0.0221	0.116
	Copper (Cu)-Total (mg/kg)	20.3	112	27.3	46.1	72.9
	Copper (Cu)-Total (mg/kg wwt)	10.9	43.9	9.46	21.3	27.4
	Iron (Fe)-Total (mg/kg)	79.3	422	148	197	318
	Iron (Fe)-Total (mg/kg wwt)	42.6	166	51.1	91.0	119
	Lead (Pb)-Total (mg/kg)	<0.020	0.141	0.031	0.040	0.074
	Lead (Pb)-Total (mg/kg wwt)	0.0098	0.0555	0.0106	0.0184	0.0277
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	1130	1270	5140	1660	2380
	Magnesium (Mg)-Total (mg/kg wwt)	609	500	1780	769	894
	Manganese (Mn)-Total (mg/kg)	172	200	169	381	378
	Manganese (Mn)-Total (mg/kg wwt)	92.1	78.3	58.5	177	142

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		L1813330-21	L1813330-22	L1813330-23	L1813330-24	L1813330-25
	Sample ID	L1813330-21	L1813330-22	L1813330-23	L1813330-24	L1813330-25
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S08-SALIX	S08-LEDUM	S08-LICHEN	S08-BLUE BERRIES	M29-SALIX
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	61.5	49.6	60.5	85.0	62.7
Metals	Aluminum (Al)-Total (mg/kg)	176	114	1590	10.8	88.9
	Aluminum (Al)-Total (mg/kg wwt)	67.7	57.6	629	1.62	33.1
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	0.023	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0092	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	0.041	0.027	0.333	<0.020	0.039
	Arsenic (As)-Total (mg/kg wwt)	0.0159	0.0137	0.132	<0.0040	0.0144
	Barium (Ba)-Total (mg/kg)	16.0	99.4	35.1	8.72	18.7
	Barium (Ba)-Total (mg/kg wwt)	6.14	50.1	13.9	1.31	6.96
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	0.045	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0178	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	0.061	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0242	<0.0020	0.0026
	Boron (B)-Total (mg/kg)	4.4	15.1	1.0	8.0	5.4
	Boron (B)-Total (mg/kg wwt)	1.70	7.60	0.41	1.21	2.01
	Cadmium (Cd)-Total (mg/kg)	0.569	<0.0050	0.113	0.183	0.966
	Cadmium (Cd)-Total (mg/kg wwt)	0.219	0.0020	0.0448	0.0274	0.360
	Calcium (Ca)-Total (mg/kg)	11500	6880	2690	1100	12700
	Calcium (Ca)-Total (mg/kg wwt)	4410	3470	1060	165	4720
	Cesium (Cs)-Total (mg/kg)	0.0984	0.0249	0.101	0.0159	0.0128
	Cesium (Cs)-Total (mg/kg wwt)	0.0379	0.0125	0.0398	0.0024	0.0048
	Chromium (Cr)-Total (mg/kg)	0.099	0.084	0.739	<0.050	0.067
	Chromium (Cr)-Total (mg/kg wwt)	0.038	0.042	0.292	<0.010	0.025
	Cobalt (Co)-Total (mg/kg)	0.334	0.067	0.763	<0.020	0.379
	Cobalt (Co)-Total (mg/kg wwt)	0.129	0.0339	0.301	<0.0040	0.141
	Copper (Cu)-Total (mg/kg)	37.9	28.2	443	5.71	36.3
	Copper (Cu)-Total (mg/kg wwt)	14.6	14.2	175	0.856	13.5
	Iron (Fe)-Total (mg/kg)	373	221	2860	23.8	204
	Iron (Fe)-Total (mg/kg wwt)	143	111	1130	3.57	76.0
	Lead (Pb)-Total (mg/kg)	0.060	0.058	0.786	<0.020	0.049
	Lead (Pb)-Total (mg/kg wwt)	0.0229	0.0293	0.311	<0.0040	0.0182
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	0.68	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	0.10	<0.10	0.27	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	4050	1480	963	689	4720
	Magnesium (Mg)-Total (mg/kg wwt)	1560	746	380	103	1760
	Manganese (Mn)-Total (mg/kg)	206	337	143	56.2	149
	Manganese (Mn)-Total (mg/kg wwt)	79.4	170	56.4	8.43	55.6

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-26	L1813330-27	L1813330-28	L1813330-29	L1813330-30
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	M29-HORSETAIL	M29-LEDUM	M29-LICHEN	S16-HORSETAIL	S16-LEDUM
TISSUE						
Physical Tests	% Moisture (%)	66.7	67.8	59.1	73.2	46.3
Metals	Aluminum (Al)-Total (mg/kg)	188	436	89.9	28.8	124
	Aluminum (Al)-Total (mg/kg wwt)	62.7	140	36.8	7.71	66.7
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	<0.0020	0.0030
	Arsenic (As)-Total (mg/kg)	0.057	0.126	0.028	<0.020	0.038
	Arsenic (As)-Total (mg/kg wwt)	0.0189	0.0405	0.0115	0.0041	0.0203
	Barium (Ba)-Total (mg/kg)	124	22.3	89.4	106	54.2
	Barium (Ba)-Total (mg/kg wwt)	41.4	7.17	36.6	28.4	29.1
	Beryllium (Be)-Total (mg/kg)	<0.010	0.012	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	0.0040	<0.0020	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	0.013	0.032	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	0.0042	0.0105	0.0027	<0.0020	0.0026
	Boron (B)-Total (mg/kg)	15.7	<1.0	18.4	11.5	12.4
	Boron (B)-Total (mg/kg wwt)	5.24	0.26	7.51	3.07	6.66
	Cadmium (Cd)-Total (mg/kg)	0.0519	0.201	0.0075	0.0847	0.0081
	Cadmium (Cd)-Total (mg/kg wwt)	0.0173	0.0648	0.0031	0.0227	0.0044
	Calcium (Ca)-Total (mg/kg)	14000	1710	5430	19300	4390
	Calcium (Ca)-Total (mg/kg wwt)	4660	550	2220	5160	2360
	Cesium (Cs)-Total (mg/kg)	0.0660	0.0638	0.0210	0.0487	<0.0050
	Cesium (Cs)-Total (mg/kg wwt)	0.0220	0.0205	0.0086	0.0130	0.0024
	Chromium (Cr)-Total (mg/kg)	0.091	0.226	0.055	<0.050	0.064
	Chromium (Cr)-Total (mg/kg wwt)	0.030	0.073	0.022	<0.010	0.034
	Cobalt (Co)-Total (mg/kg)	0.378	0.253	0.045	0.108	0.066
	Cobalt (Co)-Total (mg/kg wwt)	0.126	0.0814	0.0185	0.0290	0.0356
	Copper (Cu)-Total (mg/kg)	102	271	39.4	15.1	46.4
	Copper (Cu)-Total (mg/kg wwt)	34.0	87.3	16.1	4.03	24.9
	Iron (Fe)-Total (mg/kg)	392	825	170	75.8	248
	Iron (Fe)-Total (mg/kg wwt)	131	266	69.5	20.3	133
	Lead (Pb)-Total (mg/kg)	0.119	0.284	0.049	<0.020	0.043
	Lead (Pb)-Total (mg/kg wwt)	0.0398	0.0916	0.0200	0.0044	0.0231
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	2570	414	1210	3450	1900
	Magnesium (Mg)-Total (mg/kg wwt)	855	133	497	924	1020
	Manganese (Mn)-Total (mg/kg)	338	85.1	333	147	70.5
	Manganese (Mn)-Total (mg/kg wwt)	113	27.4	136	39.5	37.8

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-31	L1813330-32	L1813330-33	L1813330-34	L1813330-35
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S16-SALIX	S05-LEDUM	S05-LICHEN	S05-HORSETAIL	S05-SALIX
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	59.1	43.0	59.9	70.7	58.6
Metals	Aluminum (Al)-Total (mg/kg)	137	119	906	65.8	144
	Aluminum (Al)-Total (mg/kg wwt)	56.1	67.9	363	19.2	59.6
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.020 DLA
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0037	<0.0020	<0.0040 DLA
	Arsenic (As)-Total (mg/kg)	0.045	0.032	0.208	0.030	<0.040 DLA
	Arsenic (As)-Total (mg/kg wwt)	0.0183	0.0180	0.0833	0.0089	0.0160
	Barium (Ba)-Total (mg/kg)	22.4	63.9	28.6	122	37.2
	Barium (Ba)-Total (mg/kg wwt)	9.17	36.4	11.5	35.7	15.4
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	0.029	<0.010	<0.020 DLA
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0116	0.0023	0.0046
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	0.033	<0.010	<0.020 DLA
	Bismuth (Bi)-Total (mg/kg wwt)	0.0028	0.0023	0.0130	<0.0020	<0.0040 DLA
	Boron (B)-Total (mg/kg)	22.3	6.5	<1.0	16.0	7.1
	Boron (B)-Total (mg/kg wwt)	9.13	3.69	0.21	4.68	2.95
	Cadmium (Cd)-Total (mg/kg)	1.00	0.0075	0.0675	0.0313	0.372
	Cadmium (Cd)-Total (mg/kg wwt)	0.410	0.0043	0.0271	0.0092	0.154
	Calcium (Ca)-Total (mg/kg)	15600	5020	1850	17800	11400
	Calcium (Ca)-Total (mg/kg wwt)	6390	2860	742	5220	4720
	Cesium (Cs)-Total (mg/kg)	0.0094	0.0137	0.0757	0.350	0.036
	Cesium (Cs)-Total (mg/kg wwt)	0.0038	0.0078	0.0303	0.102	0.0149
	Chromium (Cr)-Total (mg/kg)	0.073	0.067	0.395	<0.050	<0.10 DLA
	Chromium (Cr)-Total (mg/kg wwt)	0.030	0.038	0.158	<0.010	0.024
	Cobalt (Co)-Total (mg/kg)	0.359	0.092	0.511	1.26	5.55
	Cobalt (Co)-Total (mg/kg wwt)	0.147	0.0525	0.205	0.370	2.30
	Copper (Cu)-Total (mg/kg)	45.0	28.9	284	13.9	28.6
	Copper (Cu)-Total (mg/kg wwt)	18.4	16.5	114	4.06	11.8
	Iron (Fe)-Total (mg/kg)	285	200	1560	105	338
	Iron (Fe)-Total (mg/kg wwt)	117	114	624	30.7	140
	Lead (Pb)-Total (mg/kg)	0.059	0.041	0.370	0.026	0.057
	Lead (Pb)-Total (mg/kg wwt)	0.0242	0.0235	0.148	0.0075	0.0238
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<1.0 DLA
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	0.12	<0.10	0.21
	Magnesium (Mg)-Total (mg/kg)	3180	1160	577	2780	2430
	Magnesium (Mg)-Total (mg/kg wwt)	1300	659	231	813	1010
	Manganese (Mn)-Total (mg/kg)	235	708	141	370	2460
	Manganese (Mn)-Total (mg/kg wwt)	96.1	403	56.7	108	1020

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-36	L1813330-37	L1813330-38	L1813330-39	L1813330-40
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S06-LEDUM	S06-SALIX	S07-SALIX	S07-BLUE BERRIES	S07-HORSETAIL
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	50.0	57.1	63.1	86.2	70.3
Metals	Aluminum (Al)-Total (mg/kg)	51.6	101	166	7.8	47.0
	Aluminum (Al)-Total (mg/kg wwt)	25.8	43.2	61.3	1.07	13.9
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	<0.020	0.023	0.039	<0.020	0.047
	Arsenic (As)-Total (mg/kg wwt)	0.0053	0.0097	0.0145	<0.0040	0.0140
	Barium (Ba)-Total (mg/kg)	110	316	71.0	11.9	139
	Barium (Ba)-Total (mg/kg wwt)	55.2	136	26.2	1.64	41.3
	Beryllium (Be)-Total (mg/kg)	<0.010	0.013	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	0.0057	<0.0020	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0025	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	8.9	3.7	14.3	10.6	21.8
	Boron (B)-Total (mg/kg wwt)	4.43	1.60	5.29	1.46	6.46
	Cadmium (Cd)-Total (mg/kg)	<0.0050	1.06	1.09	0.244	0.0478
	Cadmium (Cd)-Total (mg/kg wwt)	<0.0010	0.456	0.400	0.0337	0.0142
	Calcium (Ca)-Total (mg/kg)	5750	14100	14300	907	16200
	Calcium (Ca)-Total (mg/kg wwt)	2880	6050	5270	125	4800
	Cesium (Cs)-Total (mg/kg)	0.0313	0.0060	0.0372	0.0066	0.148
	Cesium (Cs)-Total (mg/kg wwt)	0.0157	0.0026	0.0137	<0.0010	0.0438
	Chromium (Cr)-Total (mg/kg)	<0.050	<0.050	0.106	<0.050	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.011	0.017	0.039	<0.010	<0.010
	Cobalt (Co)-Total (mg/kg)	0.040	3.42	0.977	<0.020	0.166
	Cobalt (Co)-Total (mg/kg wwt)	0.0201	1.47	0.360	<0.0040	0.0494
	Copper (Cu)-Total (mg/kg)	9.78	12.5	44.7	7.81	18.4
	Copper (Cu)-Total (mg/kg wwt)	4.89	5.38	16.5	1.08	5.45
	Iron (Fe)-Total (mg/kg)	68.8	88.7	331	21.5	106
	Iron (Fe)-Total (mg/kg wwt)	34.4	38.1	122	2.97	31.4
	Lead (Pb)-Total (mg/kg)	<0.020	0.030	0.076	<0.020	0.027
	Lead (Pb)-Total (mg/kg wwt)	0.0092	0.0128	0.0280	<0.0040	0.0081
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	945	2830	6860	693	5210
	Magnesium (Mg)-Total (mg/kg wwt)	472	1210	2530	95.6	1550
	Manganese (Mn)-Total (mg/kg)	1040	777	513	110	98.1
	Manganese (Mn)-Total (mg/kg wwt)	521	333	189	15.2	29.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1813330-41 TISSUE 10-AUG-16 S07-LEDUM	L1813330-42 TISSUE 10-AUG-16 S17-SALIX	L1813330-43 TISSUE 10-AUG-16 S31-SALIX	L1813330-44 TISSUE 10-AUG-16 S32-LEDUM	L1813330-45 TISSUE 10-AUG-16 S33-HORSETAIL
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	49.0	65.0	60.9	48.3	70.9
Metals	Aluminum (Al)-Total (mg/kg)	101	234	90.3	98.5	41.8
	Aluminum (Al)-Total (mg/kg wwt)	51.7	81.9	35.3	50.9	12.1
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	0.0025	<0.0020	<0.0020	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	0.025	0.090	<0.020	0.021	0.047
	Arsenic (As)-Total (mg/kg wwt)	0.0128	0.0315	0.0067	0.0107	0.0137
	Barium (Ba)-Total (mg/kg)	73.8	154	364	71.6	142
	Barium (Ba)-Total (mg/kg wwt)	37.6	53.9	142	37.0	41.4
	Beryllium (Be)-Total (mg/kg)	<0.010	0.015	0.014	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	0.0051	0.0056	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	0.019	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	0.0023	0.0068	<0.0020	0.0023	<0.0020
	Boron (B)-Total (mg/kg)	18.9	8.3	4.1	16.5	21.0
	Boron (B)-Total (mg/kg wwt)	9.63	2.91	1.60	8.52	6.11
	Cadmium (Cd)-Total (mg/kg)	<0.0050	1.26	1.21	<0.0050	0.0795
	Cadmium (Cd)-Total (mg/kg wwt)	0.0024	0.440	0.476	0.0026	0.0231
	Calcium (Ca)-Total (mg/kg)	5320	23800	15700	5200	17700
	Calcium (Ca)-Total (mg/kg wwt)	2710	8310	6140	2690	5130
	Cesium (Cs)-Total (mg/kg)	0.0088	0.0075	0.0058	0.0113	0.224
	Cesium (Cs)-Total (mg/kg wwt)	0.0045	0.0026	0.0023	0.0058	0.0650
	Chromium (Cr)-Total (mg/kg)	0.053	0.108	0.055	0.059	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.027	0.038	0.021	0.030	0.013
	Cobalt (Co)-Total (mg/kg)	0.052	3.83	3.21	0.059	0.239
	Cobalt (Co)-Total (mg/kg wwt)	0.0265	1.34	1.26	0.0304	0.0694
	Copper (Cu)-Total (mg/kg)	32.8	121	13.4	38.8	18.3
	Copper (Cu)-Total (mg/kg wwt)	16.7	42.3	5.25	20.1	5.32
	Iron (Fe)-Total (mg/kg)	182	508	94.0	207	90.2
	Iron (Fe)-Total (mg/kg wwt)	92.5	178	36.8	107	26.2
	Lead (Pb)-Total (mg/kg)	0.062	0.106	0.035	0.060	0.026
	Lead (Pb)-Total (mg/kg wwt)	0.0316	0.0370	0.0137	0.0309	0.0076
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	1610	4270	2640	1420	5130
	Magnesium (Mg)-Total (mg/kg wwt)	819	1490	1030	734	1490
	Manganese (Mn)-Total (mg/kg)	546	587	746	437	124
	Manganese (Mn)-Total (mg/kg wwt)	278	205	292	226	35.9

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-46	L1813330-47	L1813330-48	L1813330-49	L1813330-50
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	S34-LICHEN	S35-SALIX	S36-LEDUM	C02-HORSETAIL	C02-LEDUM
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	52.8	59.4	54.4	67.0	44.4
Metals	Aluminum (Al)-Total (mg/kg)	1170	151	73.2	17.2	33.8
	Aluminum (Al)-Total (mg/kg wwt)	551	61.3	33.4	5.67	18.8
	Antimony (Sb)-Total (mg/kg)	0.020	0.011	<0.010	0.012	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	0.0096	0.0046	<0.0020	0.0039	0.0031
	Arsenic (As)-Total (mg/kg)	0.254	0.052	0.023	0.044	0.021
	Arsenic (As)-Total (mg/kg wwt)	0.120	0.0211	0.0105	0.0144	0.0115
	Barium (Ba)-Total (mg/kg)	29.0	24.5	98.0	92.1	67.6
	Barium (Ba)-Total (mg/kg wwt)	13.7	9.92	44.7	30.4	37.5
	Beryllium (Be)-Total (mg/kg)	0.043	<0.010	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	0.0203	0.0020	<0.0020	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	0.050	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	0.0235	0.0027	0.0024	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	1.1	21.5	16.6	11.0	19.4
	Boron (B)-Total (mg/kg wwt)	0.54	8.71	7.59	3.63	10.8
	Cadmium (Cd)-Total (mg/kg)	0.0817	0.981	<0.0050	0.0566	<0.0050
	Cadmium (Cd)-Total (mg/kg wwt)	0.0386	0.398	0.0014	0.0187	0.0014
	Calcium (Ca)-Total (mg/kg)	2840	16000	5180	19700	7320
	Calcium (Ca)-Total (mg/kg wwt)	1340	6500	2360	6500	4070
	Cesium (Cs)-Total (mg/kg)	0.0798	0.0103	0.0184	0.0486	0.0090
	Cesium (Cs)-Total (mg/kg wwt)	0.0377	0.0042	0.0084	0.0160	0.0050
	Chromium (Cr)-Total (mg/kg)	0.571	0.089	<0.050	<0.050	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.270	0.036	0.023	<0.010	0.024
	Cobalt (Co)-Total (mg/kg)	0.647	0.421	0.041	0.203	0.021
	Cobalt (Co)-Total (mg/kg wwt)	0.305	0.171	0.0188	0.0671	0.0118
	Copper (Cu)-Total (mg/kg)	363	57.9	37.1	7.01	8.50
	Copper (Cu)-Total (mg/kg wwt)	171	23.5	16.9	2.31	4.72
	Iron (Fe)-Total (mg/kg)	2320	319	154	54.0	73.7
	Iron (Fe)-Total (mg/kg wwt)	1100	129	70.3	17.8	41.0
	Lead (Pb)-Total (mg/kg)	0.583	0.055	0.041	<0.020	<0.020
	Lead (Pb)-Total (mg/kg wwt)	0.275	0.0222	0.0185	<0.0040	0.0109
	Lithium (Li)-Total (mg/kg)	0.62	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	0.29	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	737	3430	1230	4900	1840
	Magnesium (Mg)-Total (mg/kg wwt)	348	1390	562	1620	1020
	Manganese (Mn)-Total (mg/kg)	116	277	423	72.0	154
	Manganese (Mn)-Total (mg/kg wwt)	54.8	112	193	23.8	85.4

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-51	L1813330-52	L1813330-53	L1813330-54	L1813330-55
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	C02-LICHEN	C02-SALIX	S09-SALIX	M80-SALIX	M80-LEDUM
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	54.8	57.8	52.5	58.3	48.1
Metals	Aluminum (Al)-Total (mg/kg)	229	38.4	72.5	66.1	112
	Aluminum (Al)-Total (mg/kg wwt)	104	16.2	34.4	27.5	58.0
	Antimony (Sb)-Total (mg/kg)	0.024	0.019	0.011	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	0.0107	0.0078	0.0053	<0.0020	0.0040
	Arsenic (As)-Total (mg/kg)	0.096	0.021	0.024	0.026	0.029
	Arsenic (As)-Total (mg/kg wwt)	0.0436	0.0090	0.0114	0.0106	0.0148
	Barium (Ba)-Total (mg/kg)	13.2	56.6	152	350	149
	Barium (Ba)-Total (mg/kg wwt)	5.99	23.9	72.2	146	77.4
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	0.011	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	0.0033	<0.0020	0.0041	0.0044	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	0.0033	<0.0020	<0.0020	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	<1.0	9.7	11.3	21.9	24.7
	Boron (B)-Total (mg/kg wwt)	0.32	4.08	5.35	9.14	12.8
	Cadmium (Cd)-Total (mg/kg)	0.0235	1.22	0.704	2.61	0.0142
	Cadmium (Cd)-Total (mg/kg wwt)	0.0106	0.515	0.334	1.09	0.0074
	Calcium (Ca)-Total (mg/kg)	1290	19400	19900	26800	8260
	Calcium (Ca)-Total (mg/kg wwt)	581	8160	9440	11200	4280
	Cesium (Cs)-Total (mg/kg)	0.0174	0.0119	<0.0050	<0.0050	0.0053
	Cesium (Cs)-Total (mg/kg wwt)	0.0079	0.0050	0.0016	0.0020	0.0027
	Chromium (Cr)-Total (mg/kg)	0.213	<0.050	0.071	0.060	0.124
	Chromium (Cr)-Total (mg/kg wwt)	0.096	0.014	0.033	0.025	0.064
	Cobalt (Co)-Total (mg/kg)	0.158	0.392	1.06	1.81	0.101
	Cobalt (Co)-Total (mg/kg wwt)	0.0717	0.166	0.502	0.754	0.0525
	Copper (Cu)-Total (mg/kg)	60.6	10.5	13.3	11.9	13.9
	Copper (Cu)-Total (mg/kg wwt)	27.4	4.43	6.34	4.97	7.19
	Iron (Fe)-Total (mg/kg)	408	99.6	147	118	131
	Iron (Fe)-Total (mg/kg wwt)	185	42.0	69.7	49.2	68.2
	Lead (Pb)-Total (mg/kg)	0.146	0.023	0.026	0.029	0.029
	Lead (Pb)-Total (mg/kg wwt)	0.0662	0.0098	0.0126	0.0120	0.0150
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	299	6220	2590	3570	1370
	Magnesium (Mg)-Total (mg/kg wwt)	135	2620	1230	1490	712
	Manganese (Mn)-Total (mg/kg)	98.8	122	332	145	1690
	Manganese (Mn)-Total (mg/kg wwt)	44.7	51.3	157	60.4	876

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-56	L1813330-57	L1813330-58	L1813330-59	L1813330-61
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	M26-LEDUM	M26-SALIX	M26-LICHEN	M26-BLUEBERRIES	M07B-SALIX
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	49.9	61.7	42.2	83.9	56.5
Metals	Aluminum (Al)-Total (mg/kg)	20.8	17.0	115	2.9	22.1
	Aluminum (Al)-Total (mg/kg wwt)	10.4	6.51	66.4	0.46	9.63
	Antimony (Sb)-Total (mg/kg)	<0.010	0.010	<0.010	<0.010	0.011
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	0.0039	0.0054	<0.0020	0.0046
	Arsenic (As)-Total (mg/kg)	<0.020	<0.020	0.095	<0.020	<0.020
	Arsenic (As)-Total (mg/kg wwt)	0.0070	0.0076	0.0550	<0.0040	0.0077
	Barium (Ba)-Total (mg/kg)	59.0	51.2	9.48	10.7	20.9
	Barium (Ba)-Total (mg/kg wwt)	29.6	19.6	5.48	1.72	9.06
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0021	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0022	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	9.8	10.8	<1.0	9.6	10.3
	Boron (B)-Total (mg/kg wwt)	4.89	4.12	0.31	1.55	4.46
	Cadmium (Cd)-Total (mg/kg)	<0.0050	1.50	0.0343	0.115	0.104
	Cadmium (Cd)-Total (mg/kg wwt)	0.0018	0.574	0.0198	0.0185	0.0454
	Calcium (Ca)-Total (mg/kg)	5430	19000	1580	1130	14500
	Calcium (Ca)-Total (mg/kg wwt)	2720	7260	912	181	6320
	Cesium (Cs)-Total (mg/kg)	<0.0050	0.0062	0.0367	<0.0050	0.0283
	Cesium (Cs)-Total (mg/kg wwt)	0.0017	0.0024	0.0212	<0.0010	0.0123
	Chromium (Cr)-Total (mg/kg)	0.061	<0.050	0.151	<0.050	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.031	0.014	0.087	<0.010	<0.010
	Cobalt (Co)-Total (mg/kg)	<0.020	0.726	0.080	<0.020	0.119
	Cobalt (Co)-Total (mg/kg wwt)	0.0065	0.278	0.0463	<0.0040	0.0518
	Copper (Cu)-Total (mg/kg)	4.31	5.37	14.8	4.11	6.76
	Copper (Cu)-Total (mg/kg wwt)	2.16	2.05	8.55	0.661	2.94
	Iron (Fe)-Total (mg/kg)	39.4	48.6	205	12.6	65.5
	Iron (Fe)-Total (mg/kg wwt)	19.7	18.6	119	2.02	28.5
	Lead (Pb)-Total (mg/kg)	<0.020	<0.020	0.168	<0.020	<0.020
	Lead (Pb)-Total (mg/kg wwt)	0.0070	0.0041	0.0972	<0.0040	0.0061
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	1290	5810	305	620	4250
	Magnesium (Mg)-Total (mg/kg wwt)	646	2220	177	99.6	1850
	Manganese (Mn)-Total (mg/kg)	46.9	101	16.8	44.0	165
	Manganese (Mn)-Total (mg/kg wwt)	23.5	38.5	9.71	7.08	71.7

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-62	L1813330-63	L1813330-64	L1813330-65	L1813330-66
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	12-AUG-16	12-AUG-16
	Sampled Time					
	Client ID	M07B-HORSETAIL	M07B-LEDUM	M07B-LICHEN	S04-SALIX	S19-SALIX
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	64.7	45.2	21.1	59.5	60.2
Metals	Aluminum (Al)-Total (mg/kg)	10.7	76.2	253	107	429
	Aluminum (Al)-Total (mg/kg wwt)	3.79	41.7	199	43.3	170
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	0.018	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0141	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	0.028	<0.020	0.129	0.024	0.099
	Arsenic (As)-Total (mg/kg wwt)	0.0100	0.0084	0.102	0.0097	0.0393
	Barium (Ba)-Total (mg/kg)	111	76.9	14.9	90.0	269
	Barium (Ba)-Total (mg/kg wwt)	39.3	42.1	11.7	36.4	107
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	0.025
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0048	0.0033	0.0100
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	0.014
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0069	<0.0020	0.0054
	Boron (B)-Total (mg/kg)	18.5	11.4	<1.0	12.7	7.8
	Boron (B)-Total (mg/kg wwt)	6.54	6.24	0.53	5.13	3.12
	Cadmium (Cd)-Total (mg/kg)	0.0161	<0.0050	0.0243	0.358	0.885
	Cadmium (Cd)-Total (mg/kg wwt)	0.0057	<0.0010	0.0192	0.145	0.352
	Calcium (Ca)-Total (mg/kg)	24200	7170	1560	13000	22100
	Calcium (Ca)-Total (mg/kg wwt)	8530	3930	1230	5270	8780
	Cesium (Cs)-Total (mg/kg)	0.201	0.0082	0.0269	<0.0050	0.0128
	Cesium (Cs)-Total (mg/kg wwt)	0.0710	0.0045	0.0212	0.0013	0.0051
	Chromium (Cr)-Total (mg/kg)	<0.050	0.082	0.235	0.053	0.204
	Chromium (Cr)-Total (mg/kg wwt)	<0.010	0.045	0.185	0.021	0.081
	Cobalt (Co)-Total (mg/kg)	0.427	0.026	0.144	0.926	2.94
	Cobalt (Co)-Total (mg/kg wwt)	0.151	0.0143	0.114	0.375	1.17
	Copper (Cu)-Total (mg/kg)	5.62	5.36	49.9	8.52	76.9
	Copper (Cu)-Total (mg/kg wwt)	1.99	2.94	39.4	3.45	30.6
	Iron (Fe)-Total (mg/kg)	63.0	75.0	398	147	665
	Iron (Fe)-Total (mg/kg wwt)	22.3	41.1	314	59.3	264
	Lead (Pb)-Total (mg/kg)	<0.020	0.026	0.218	0.034	0.163
	Lead (Pb)-Total (mg/kg wwt)	<0.0040	0.0142	0.172	0.0137	0.0648
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	4190	1340	380	1730	2810
	Magnesium (Mg)-Total (mg/kg wwt)	1480	734	300	699	1120
	Manganese (Mn)-Total (mg/kg)	212	128	44.5	254	934
	Manganese (Mn)-Total (mg/kg wwt)	75.0	69.9	35.2	103	371

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-67	L1813330-68	L1813330-69	L1813330-70	L1813330-71
	Description	TISSUE	Tissue	Tissue	Tissue	Tissue
	Sampled Date	12-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S19-LEDUM	C01-SALIX (RINSED)	C01-LICHEN (RINSED)	C01-HORSETAIL (RINSED)	C01-LEDUM (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	49.7	74.5	73.1	76.7	67.5
Metals	Aluminum (Al)-Total (mg/kg)	423	27.3	92.9	10.4	32.1
	Aluminum (Al)-Total (mg/kg wwt)	213	6.97	25.0	2.42	10.4
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	0.0021	<0.0020	<0.0020	<0.0020	0.0028
	Arsenic (As)-Total (mg/kg)	0.112	<0.020	0.078	<0.020	<0.020
	Arsenic (As)-Total (mg/kg wwt)	0.0561	<0.0040	0.0210	<0.0040	0.0053
	Barium (Ba)-Total (mg/kg)	104	65.0	14.7	224	57.4
	Barium (Ba)-Total (mg/kg wwt)	52.3	16.6	3.95	52.1	18.7
	Beryllium (Be)-Total (mg/kg)	0.010	0.011	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	0.0051	0.0029	<0.0020	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	0.010	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	0.0051	<0.0020	<0.0020	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	12.6	15.5	1.2	13.1	20.1
	Boron (B)-Total (mg/kg wwt)	6.35	3.97	0.33	3.05	6.53
	Cadmium (Cd)-Total (mg/kg)	0.0085	4.18	0.0235	0.223	<0.0050
	Cadmium (Cd)-Total (mg/kg wwt)	0.0043	1.07	0.0063	0.0519	<0.0010
	Calcium (Ca)-Total (mg/kg)	6850	15900	1840	16300	5160
	Calcium (Ca)-Total (mg/kg wwt)	3440	4050	495	3800	1680
	Cesium (Cs)-Total (mg/kg)	0.0132	<0.0050	0.0709	0.0480	<0.0050
	Cesium (Cs)-Total (mg/kg wwt)	0.0067	<0.0010	0.0191	0.0112	0.0015
	Chromium (Cr)-Total (mg/kg)	0.202	<0.050	0.135	<0.050	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.102	<0.010	0.036	<0.010	0.015
	Cobalt (Co)-Total (mg/kg)	0.225	0.592	0.084	0.117	<0.020
	Cobalt (Co)-Total (mg/kg wwt)	0.113	0.151	0.0225	0.0273	0.0053
	Copper (Cu)-Total (mg/kg)	78.1	4.95	7.78	3.71	3.26
	Copper (Cu)-Total (mg/kg wwt)	39.3	1.26	2.09	0.865	1.06
	Iron (Fe)-Total (mg/kg)	634	51.5	141	29.3	42.3
	Iron (Fe)-Total (mg/kg wwt)	319	13.1	37.8	6.82	13.8
	Lead (Pb)-Total (mg/kg)	0.150	0.029	0.114	<0.020	0.027
	Lead (Pb)-Total (mg/kg wwt)	0.0753	0.0074	0.0307	<0.0040	0.0089
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	1460	4110	313	3020	1070
	Magnesium (Mg)-Total (mg/kg wwt)	734	1050	84.1	703	349
	Manganese (Mn)-Total (mg/kg)	987	334	114	97.2	632
	Manganese (Mn)-Total (mg/kg wwt)	496	85.4	30.8	22.6	206

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-72	L1813330-73	L1813330-74	L1813330-75	L1813330-76
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S03-SALIX (RINSED)	S03-LICHEN (RINSED)	S11-LICHEN(RINSED)	S11-SALIX (RINSED)	S02-SALIX (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	68.1	69.3	66.2	74.1	65.2
Metals	Aluminum (Al)-Total (mg/kg)	153	657	243	21.1	93.9
	Aluminum (Al)-Total (mg/kg wwt)	48.8	202	82.1	5.48	32.7
	Antimony (Sb)-Total (mg/kg)	<0.010	0.024	0.013	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	0.0074	0.0045	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	0.070	0.292	0.122	<0.020	0.041
	Arsenic (As)-Total (mg/kg wwt)	0.0223	0.0897	0.0412	0.0043	0.0142
	Barium (Ba)-Total (mg/kg)	100	33.3	33.3	96.7	61.3
	Barium (Ba)-Total (mg/kg wwt)	32.0	10.2	11.3	25.1	21.3
	Beryllium (Be)-Total (mg/kg)	<0.010	0.018	<0.010	0.013	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	0.0055	<0.0020	0.0035	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	0.0024	<0.0020	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	13.1	<1.0	<1.0	6.6	2.5
	Boron (B)-Total (mg/kg wwt)	4.19	<0.20	<0.20	1.71	0.86
	Cadmium (Cd)-Total (mg/kg)	0.760	0.0318	0.0421	1.42	0.799
	Cadmium (Cd)-Total (mg/kg wwt)	0.242	0.0098	0.0142	0.368	0.278
	Calcium (Ca)-Total (mg/kg)	28200	1810	1660	16700	19800
	Calcium (Ca)-Total (mg/kg wwt)	9000	556	562	4320	6880
	Cesium (Cs)-Total (mg/kg)	0.0124	0.0712	0.0891	0.0062	0.0131
	Cesium (Cs)-Total (mg/kg wwt)	0.0040	0.0219	0.0302	0.0016	0.0045
	Chromium (Cr)-Total (mg/kg)	0.238	0.961	0.340	<0.050	0.167
	Chromium (Cr)-Total (mg/kg wwt)	0.076	0.295	0.115	<0.010	0.058
	Cobalt (Co)-Total (mg/kg)	0.309	0.450	0.219	3.28	0.469
	Cobalt (Co)-Total (mg/kg wwt)	0.0984	0.138	0.0742	0.851	0.163
	Copper (Cu)-Total (mg/kg)	11.5	40.5	28.9	4.69	10.9
	Copper (Cu)-Total (mg/kg wwt)	3.66	12.5	9.79	1.22	3.78
	Iron (Fe)-Total (mg/kg)	252	1050	402	48.6	168
	Iron (Fe)-Total (mg/kg wwt)	80.2	323	136	12.6	58.5
	Lead (Pb)-Total (mg/kg)	0.069	0.276	0.156	<0.020	0.036
	Lead (Pb)-Total (mg/kg wwt)	0.0220	0.0848	0.0528	0.0043	0.0125
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	0.11	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	2590	509	361	2500	3690
	Magnesium (Mg)-Total (mg/kg wwt)	825	156	122	648	1280
	Manganese (Mn)-Total (mg/kg)	57.8	92.3	85.9	476	67.2
	Manganese (Mn)-Total (mg/kg wwt)	18.4	28.3	29.1	123	23.4

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-77	L1813330-78	L1813330-79	L1813330-80	L1813330-81
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S02-LICHEN (RINSED)	S01-LEDUM (RINSED)	S01-SALIX (RINSED)	S01-LICHEN (RINSED)	S18-SALIX (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	64.8	62.0	63.6	65.4	58.5
Metals	Aluminum (Al)-Total (mg/kg)	741	37.3	38.7	208	31.3
	Aluminum (Al)-Total (mg/kg wwt)	261	14.2	14.1	72.0	13.0
	Antimony (Sb)-Total (mg/kg)	0.028	<0.010	0.011	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	0.0099	0.0033	0.0041	0.0031	<0.0020
	Arsenic (As)-Total (mg/kg)	0.308	0.028	0.029	0.123	<0.020
	Arsenic (As)-Total (mg/kg wwt)	0.108	0.0107	0.0105	0.0425	0.0049
	Barium (Ba)-Total (mg/kg)	31.1	111	93.5	33.8	95.2
	Barium (Ba)-Total (mg/kg wwt)	10.9	42.3	34.0	11.7	39.5
	Beryllium (Be)-Total (mg/kg)	0.022	<0.010	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	0.0078	<0.0020	<0.0020	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	0.011	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	0.0038	<0.0020	<0.0020	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	<1.0	5.9	4.9	<1.0	9.2
	Boron (B)-Total (mg/kg wwt)	<0.20	2.23	1.80	<0.20	3.84
	Cadmium (Cd)-Total (mg/kg)	0.0621	<0.0050	0.690	0.0379	2.32
	Cadmium (Cd)-Total (mg/kg wwt)	0.0218	0.0010	0.251	0.0131	0.961
	Calcium (Ca)-Total (mg/kg)	2570	6640	24600	1660	29100
	Calcium (Ca)-Total (mg/kg wwt)	903	2520	8930	573	12100
	Cesium (Cs)-Total (mg/kg)	0.122	0.0466	0.0065	0.0716	0.0715
	Cesium (Cs)-Total (mg/kg wwt)	0.0428	0.0177	0.0024	0.0248	0.0297
	Chromium (Cr)-Total (mg/kg)	1.05	0.082	0.060	0.277	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.369	0.031	0.022	0.096	<0.010
	Cobalt (Co)-Total (mg/kg)	0.534	0.041	0.190	0.158	0.510
	Cobalt (Co)-Total (mg/kg wwt)	0.188	0.0157	0.0689	0.0546	0.211
	Copper (Cu)-Total (mg/kg)	50.9	9.48	7.59	39.4	17.8
	Copper (Cu)-Total (mg/kg wwt)	17.9	3.60	2.76	13.6	7.37
	Iron (Fe)-Total (mg/kg)	1070	74.5	87.0	344	92.0
	Iron (Fe)-Total (mg/kg wwt)	377	28.3	31.6	119	38.2
	Lead (Pb)-Total (mg/kg)	0.351	<0.020	<0.020	0.153	<0.020
	Lead (Pb)-Total (mg/kg wwt)	0.124	0.0075	0.0064	0.0528	0.0075
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	0.17	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	647	1710	2850	347	6830
	Magnesium (Mg)-Total (mg/kg wwt)	228	651	1040	120	2830
	Manganese (Mn)-Total (mg/kg)	134	696	60.5	124	255
	Manganese (Mn)-Total (mg/kg wwt)	47.1	265	22.0	42.8	106

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-82	L1813330-83	L1813330-84	L1813330-85	L1813330-86
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S18-LICHEN (RINSED)	S18-LEDUM (RINSED)	S18-HORSETAIL (RINSED)	S15-SALIX (RINSED)	S15-LEDUM (RINSED)
TISSUE						
Physical Tests	% Moisture (%)	69.8	45.9	59.9	65.4	51.9
Metals	Aluminum (Al)-Total (mg/kg)	811	24.9	133	46.0	83.4
	Aluminum (Al)-Total (mg/kg wwt)	245	13.5	53.2	15.9	40.1
	Antimony (Sb)-Total (mg/kg)	0.016	0.012	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	0.0049	0.0063	<0.0020	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	0.185	0.020	0.038	0.025	0.029
	Arsenic (As)-Total (mg/kg wwt)	0.0559	0.0108	0.0154	0.0087	0.0137
	Barium (Ba)-Total (mg/kg)	26.4	85.7	100	41.2	89.2
	Barium (Ba)-Total (mg/kg wwt)	7.99	46.4	40.1	14.3	42.9
	Beryllium (Be)-Total (mg/kg)	0.022	<0.010	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	0.0065	<0.0020	<0.0020	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	0.086	<0.010	0.011	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	0.0259	<0.0020	0.0044	<0.0020	0.0025
	Boron (B)-Total (mg/kg)	1.1	14.7	18.4	3.1	11.0
	Boron (B)-Total (mg/kg wwt)	0.33	7.94	7.39	1.07	5.27
	Cadmium (Cd)-Total (mg/kg)	0.116	0.0091	0.0749	1.26	0.0051
	Cadmium (Cd)-Total (mg/kg wwt)	0.0350	0.0050	0.0300	0.435	0.0024
	Calcium (Ca)-Total (mg/kg)	2620	5430	15900	15700	5920
	Calcium (Ca)-Total (mg/kg wwt)	790	2940	6380	5430	2850
	Cesium (Cs)-Total (mg/kg)	0.0890	0.0440	0.244	0.0970	0.0275
	Cesium (Cs)-Total (mg/kg wwt)	0.0269	0.0238	0.0979	0.0336	0.0132
	Chromium (Cr)-Total (mg/kg)	0.421	<0.050	0.099	<0.050	0.073
	Chromium (Cr)-Total (mg/kg wwt)	0.127	<0.010	0.040	0.016	0.035
	Cobalt (Co)-Total (mg/kg)	0.483	<0.020	0.331	0.930	0.051
	Cobalt (Co)-Total (mg/kg wwt)	0.146	0.0106	0.133	0.322	0.0243
	Copper (Cu)-Total (mg/kg)	596	22.3	85.1	27.0	41.7
	Copper (Cu)-Total (mg/kg wwt)	180	12.1	34.1	9.36	20.1
	Iron (Fe)-Total (mg/kg)	1950	83.2	315	142	179
	Iron (Fe)-Total (mg/kg wwt)	590	45.0	126	49.1	86.2
	Lead (Pb)-Total (mg/kg)	0.482	<0.020	0.109	0.021	0.038
	Lead (Pb)-Total (mg/kg wwt)	0.146	0.0082	0.0437	0.0072	0.0185
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	0.12	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	700	1490	1290	5560	1820
	Magnesium (Mg)-Total (mg/kg wwt)	212	804	518	1930	876
	Manganese (Mn)-Total (mg/kg)	103	261	215	204	501
	Manganese (Mn)-Total (mg/kg wwt)	31.1	141	86.2	70.6	241

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-87	L1813330-88	L1813330-89	L1813330-90	L1813330-91
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	09-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S15-HORSETAIL (RINSED)	S08-SALIX (RINSED)	S08-LEDUM (RINSED)	S08-LICHEN (RINSED)	S08-BLUE BERRIES (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	62.2	60.4	47.2	57.6	84.9
Metals	Aluminum (Al)-Total (mg/kg)	73.3	116	101	1220	6.4
	Aluminum (Al)-Total (mg/kg wwt)	27.7	45.9	53.3	519	0.97
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	0.019	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	0.0082	<0.0020
	Arsenic (As)-Total (mg/kg)	0.022	0.028	0.026	0.266	<0.020
	Arsenic (As)-Total (mg/kg wwt)	0.0082	0.0111	0.0136	0.113	<0.0040
	Barium (Ba)-Total (mg/kg)	98.4	16.1	96.1	26.1	5.27
	Barium (Ba)-Total (mg/kg wwt)	37.2	6.38	50.8	11.1	0.795
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	0.036	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	0.0152	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	0.049	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	0.0209	<0.0020
	Boron (B)-Total (mg/kg)	11.4	4.3	13.9	<1.0	4.3
	Boron (B)-Total (mg/kg wwt)	4.29	1.72	7.34	0.34	0.65
	Cadmium (Cd)-Total (mg/kg)	0.135	0.547	<0.0050	0.0980	0.0909
	Cadmium (Cd)-Total (mg/kg wwt)	0.0512	0.217	0.0023	0.0416	0.0137
	Calcium (Ca)-Total (mg/kg)	11900	11900	6560	2200	579
	Calcium (Ca)-Total (mg/kg wwt)	4480	4730	3460	932	87.5
	Cesium (Cs)-Total (mg/kg)	0.227	0.0854	0.0233	0.0842	0.0070
	Cesium (Cs)-Total (mg/kg wwt)	0.0857	0.0338	0.0123	0.0357	0.0011
	Chromium (Cr)-Total (mg/kg)	<0.050	0.065	0.058	0.611	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.016	0.026	0.030	0.259	<0.010
	Cobalt (Co)-Total (mg/kg)	0.280	0.316	0.057	0.649	<0.020
	Cobalt (Co)-Total (mg/kg wwt)	0.106	0.125	0.0299	0.275	<0.0040
	Copper (Cu)-Total (mg/kg)	40.4	25.8	23.0	383	3.25
	Copper (Cu)-Total (mg/kg wwt)	15.3	10.2	12.1	163	0.491
	Iron (Fe)-Total (mg/kg)	180	249	183	2280	15.1
	Iron (Fe)-Total (mg/kg wwt)	68.1	98.8	96.7	969	2.27
	Lead (Pb)-Total (mg/kg)	0.044	0.044	0.046	0.604	<0.020
	Lead (Pb)-Total (mg/kg wwt)	0.0165	0.0175	0.0242	0.256	<0.0040
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	0.60	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	0.25	<0.10
	Magnesium (Mg)-Total (mg/kg)	2220	3950	1500	847	309
	Magnesium (Mg)-Total (mg/kg wwt)	839	1560	794	359	46.7
	Manganese (Mn)-Total (mg/kg)	321	205	352	104	26.7
	Manganese (Mn)-Total (mg/kg wwt)	121	81.4	186	44.2	4.03

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-92	L1813330-93	L1813330-94	L1813330-95	L1813330-96
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	M29-SALIX (RINSED)	M29-HORSETAIL (RINSED)	M29-LEDUM (RINSED)	M29-LICHEN (RINSED)	S16-HORSETAIL (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	63.4	65.5	63.5	59.7	68.2
Metals	Aluminum (Al)-Total (mg/kg)	72.2	143	305	64.0	24.6
	Aluminum (Al)-Total (mg/kg wwt)	26.5	49.2	111	25.8	7.82
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	0.032	0.045	0.083	<0.020	<0.020
	Arsenic (As)-Total (mg/kg wwt)	0.0119	0.0157	0.0302	0.0071	0.0042
	Barium (Ba)-Total (mg/kg)	15.8	114	15.7	85.3	90.3
	Barium (Ba)-Total (mg/kg wwt)	5.79	39.3	5.75	34.4	28.7
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0038	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	0.010	0.024	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	0.0035	0.0088	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	5.2	15.3	<1.0	18.9	16.4
	Boron (B)-Total (mg/kg wwt)	1.89	5.27	0.24	7.61	5.21
	Cadmium (Cd)-Total (mg/kg)	1.11	0.0455	0.0798	<0.0050	0.0816
	Cadmium (Cd)-Total (mg/kg wwt)	0.407	0.0157	0.0291	0.0018	0.0259
	Calcium (Ca)-Total (mg/kg)	11400	13400	1500	5340	23400
	Calcium (Ca)-Total (mg/kg wwt)	4160	4600	546	2150	7420
	Cesium (Cs)-Total (mg/kg)	0.0126	0.0580	0.0567	0.0240	0.0514
	Cesium (Cs)-Total (mg/kg wwt)	0.0046	0.0200	0.0207	0.0097	0.0163
	Chromium (Cr)-Total (mg/kg)	<0.050	0.070	0.162	0.051	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.015	0.024	0.059	0.021	<0.010
	Cobalt (Co)-Total (mg/kg)	0.353	0.330	0.202	0.035	0.174
	Cobalt (Co)-Total (mg/kg wwt)	0.129	0.114	0.0736	0.0140	0.0553
	Copper (Cu)-Total (mg/kg)	32.0	79.2	211	27.4	12.2
	Copper (Cu)-Total (mg/kg wwt)	11.7	27.3	77.1	11.1	3.87
	Iron (Fe)-Total (mg/kg)	170	279	642	125	65.9
	Iron (Fe)-Total (mg/kg wwt)	62.2	96.3	234	50.4	20.9
	Lead (Pb)-Total (mg/kg)	0.035	0.084	0.221	0.031	<0.020
	Lead (Pb)-Total (mg/kg wwt)	0.0127	0.0290	0.0806	0.0124	0.0042
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	4940	2370	327	1220	3770
	Magnesium (Mg)-Total (mg/kg wwt)	1810	817	119	493	1200
	Manganese (Mn)-Total (mg/kg)	124	303	62.5	362	183
	Manganese (Mn)-Total (mg/kg wwt)	45.5	105	22.8	146	58.3

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-97	L1813330-98	L1813330-99	L1813330-100	L1813330-101
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S16-LEDUM (RINSED)	S16-SALIX (RINSED)	S05-LEDUM (RINSED)	S05-LICHEN (RINSED)	S05-HORSETAIL (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	47.6	59.1	43.2	53.8	69.6
Metals	Aluminum (Al)-Total (mg/kg)	110	93.3	146	1010	60.2
	Aluminum (Al)-Total (mg/kg wwt)	57.5	38.2	83.1	465	18.3
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	0.0045	<0.0020
	Arsenic (As)-Total (mg/kg)	0.031	0.028	0.036	0.251	0.024
	Arsenic (As)-Total (mg/kg wwt)	0.0162	0.0113	0.0207	0.116	0.0072
	Barium (Ba)-Total (mg/kg)	44.8	20.6	73.9	25.6	133
	Barium (Ba)-Total (mg/kg wwt)	23.5	8.44	42.0	11.8	40.4
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	0.031	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0022	0.0141	0.0023
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	0.046	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	0.0025	0.0020	0.0031	0.0214	<0.0020
	Boron (B)-Total (mg/kg)	15.3	21.3	6.8	<1.0	15.4
	Boron (B)-Total (mg/kg wwt)	8.02	8.70	3.86	0.28	4.69
	Cadmium (Cd)-Total (mg/kg)	0.0053	0.898	0.0073	0.0861	0.0287
	Cadmium (Cd)-Total (mg/kg wwt)	0.0028	0.368	0.0042	0.0398	0.0087
	Calcium (Ca)-Total (mg/kg)	5600	14800	6170	2170	17400
	Calcium (Ca)-Total (mg/kg wwt)	2930	6070	3510	1000	5290
	Cesium (Cs)-Total (mg/kg)	0.0051	0.0085	0.0143	0.0780	0.307
	Cesium (Cs)-Total (mg/kg wwt)	0.0027	0.0035	0.0081	0.0360	0.0933
	Chromium (Cr)-Total (mg/kg)	<0.050	<0.050	0.084	0.486	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.026	0.019	0.048	0.224	<0.010
	Cobalt (Co)-Total (mg/kg)	0.054	0.318	0.115	0.589	1.38
	Cobalt (Co)-Total (mg/kg wwt)	0.0281	0.130	0.0654	0.272	0.419
	Copper (Cu)-Total (mg/kg)	36.2	30.8	39.0	368	11.9
	Copper (Cu)-Total (mg/kg wwt)	19.0	12.6	22.2	170	3.63
	Iron (Fe)-Total (mg/kg)	202	198	265	1950	89.6
	Iron (Fe)-Total (mg/kg wwt)	106	81.1	150	902	27.3
	Lead (Pb)-Total (mg/kg)	0.045	0.041	0.061	0.467	<0.020
	Lead (Pb)-Total (mg/kg wwt)	0.0237	0.0169	0.0345	0.216	0.0060
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	0.19	<0.10
	Magnesium (Mg)-Total (mg/kg)	1660	2760	1140	757	2930
	Magnesium (Mg)-Total (mg/kg wwt)	868	1130	646	350	892
	Manganese (Mn)-Total (mg/kg)	75.7	202	892	151	391
	Manganese (Mn)-Total (mg/kg wwt)	39.6	82.8	507	69.9	119

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-102	L1813330-103	L1813330-104	L1813330-105	L1813330-106
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S05-SALIX (RINSED)	S06-LEDUM (RINSED)	S06-SALIX (RINSED)	S07-SALIX (RINSED)	S07-BLUE BERRIES (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	58.9	48.7	58.1	61.9	87.5
Metals	Aluminum (Al)-Total (mg/kg)	149	41.5	83.2	118	8.7
	Aluminum (Al)-Total (mg/kg wwt)	61.3	21.3	34.9	45.0	1.09
	Antimony (Sb)-Total (mg/kg)	DLA <0.020	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	DLA <0.0040	<0.0020	<0.0020	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	DLA <0.040	<0.020	<0.020	0.036	<0.020
	Arsenic (As)-Total (mg/kg wwt)	0.0163	0.0057	0.0048	0.0137	<0.0040
	Barium (Ba)-Total (mg/kg)	46.6	88.3	338	58.3	8.84
	Barium (Ba)-Total (mg/kg wwt)	19.2	45.3	142	22.2	1.10
	Beryllium (Be)-Total (mg/kg)	DLA <0.020	<0.010	0.014	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	0.0046	<0.0020	0.0060	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	DLA <0.020	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	DLA <0.0040	<0.0020	<0.0020	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	7.4	8.3	3.8	19.9	6.4
	Boron (B)-Total (mg/kg wwt)	3.04	4.25	1.60	7.59	0.80
	Cadmium (Cd)-Total (mg/kg)	0.573	<0.0050	1.13	1.12	0.141
	Cadmium (Cd)-Total (mg/kg wwt)	0.236	<0.0010	0.473	0.428	0.0177
	Calcium (Ca)-Total (mg/kg)	11100	5280	15300	14900	534
	Calcium (Ca)-Total (mg/kg wwt)	4580	2700	6430	5660	66.7
	Cesium (Cs)-Total (mg/kg)	0.035	0.0297	<0.0050	0.0180	<0.0050
	Cesium (Cs)-Total (mg/kg wwt)	0.0145	0.0152	0.0020	0.0069	<0.0010
	Chromium (Cr)-Total (mg/kg)	DLA <0.10	<0.050	<0.050	0.073	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.026	0.012	0.010	0.028	<0.010
	Cobalt (Co)-Total (mg/kg)	6.40	0.032	3.27	0.697	<0.020
	Cobalt (Co)-Total (mg/kg wwt)	2.63	0.0165	1.37	0.266	<0.0040
	Copper (Cu)-Total (mg/kg)	28.5	7.54	9.74	31.9	3.80
	Copper (Cu)-Total (mg/kg wwt)	11.7	3.86	4.08	12.2	0.475
	Iron (Fe)-Total (mg/kg)	329	53.2	67.9	246	20.3
	Iron (Fe)-Total (mg/kg wwt)	135	27.3	28.5	93.9	2.53
	Lead (Pb)-Total (mg/kg)	0.049	<0.020	0.025	0.061	<0.020
	Lead (Pb)-Total (mg/kg wwt)	0.0203	0.0061	0.0106	0.0233	<0.0040
	Lithium (Li)-Total (mg/kg)	DLA <1.0	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	0.20	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	2710	833	2660	7140	369
	Magnesium (Mg)-Total (mg/kg wwt)	1110	427	1110	2720	46.1
	Manganese (Mn)-Total (mg/kg)	2770	831	739	301	59.7
	Manganese (Mn)-Total (mg/kg wwt)	1140	426	310	115	7.46

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-107	L1813330-108	L1813330-109	L1813330-110	L1813330-111
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S07-HORSETAIL (RINSED)	S07-LEDUM (RINSED)	S17-SALIX (RINSED)	S31-SALIX (RINSED)	S32-LEDUM (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	72.9	51.5	59.9	60.2	47.0
Metals	Aluminum (Al)-Total (mg/kg)	37.4	85.8	162	88.6	79.4
	Aluminum (Al)-Total (mg/kg wwt)	10.1	41.6	65.1	35.3	42.1
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Arsenic (As)-Total (mg/kg)	0.044	<0.020	0.058	<0.020	0.021
	Arsenic (As)-Total (mg/kg wwt)	0.0120	0.0095	0.0231	0.0068	0.0112
	Barium (Ba)-Total (mg/kg)	140	71.8	133	355	74.3
	Barium (Ba)-Total (mg/kg wwt)	37.8	34.8	53.4	141	39.4
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	0.012	0.014	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0049	0.0054	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	0.021	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	0.0085	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	21.8	18.8	8.5	4.5	16.7
	Boron (B)-Total (mg/kg wwt)	5.89	9.10	3.43	1.77	8.84
	Cadmium (Cd)-Total (mg/kg)	0.0413	0.0059	1.32	1.18	0.0056
	Cadmium (Cd)-Total (mg/kg wwt)	0.0112	0.0029	0.531	0.468	0.0030
	Calcium (Ca)-Total (mg/kg)	16300	5620	22100	14900	5510
	Calcium (Ca)-Total (mg/kg wwt)	4410	2720	8880	5940	2920
	Cesium (Cs)-Total (mg/kg)	0.161	0.0095	0.0059	<0.0050	0.0098
	Cesium (Cs)-Total (mg/kg wwt)	0.0436	0.0046	0.0024	0.0019	0.0052
	Chromium (Cr)-Total (mg/kg)	<0.050	0.066	0.058	<0.050	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	<0.010	0.032	0.023	0.016	0.026
	Cobalt (Co)-Total (mg/kg)	0.167	0.054	2.95	3.27	0.049
	Cobalt (Co)-Total (mg/kg wwt)	0.0452	0.0261	1.18	1.30	0.0260
	Copper (Cu)-Total (mg/kg)	16.8	33.9	81.4	12.6	31.1
	Copper (Cu)-Total (mg/kg wwt)	4.55	16.4	32.6	5.00	16.5
	Iron (Fe)-Total (mg/kg)	85.2	189	335	77.2	176
	Iron (Fe)-Total (mg/kg wwt)	23.1	91.7	134	30.7	93.1
	Lead (Pb)-Total (mg/kg)	0.023	0.057	0.082	0.030	0.050
	Lead (Pb)-Total (mg/kg wwt)	0.0062	0.0277	0.0328	0.0120	0.0267
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	5100	1440	3460	2960	1310
	Magnesium (Mg)-Total (mg/kg wwt)	1380	699	1390	1180	695
	Manganese (Mn)-Total (mg/kg)	96.2	527	448	770	446
	Manganese (Mn)-Total (mg/kg wwt)	26.0	255	180	306	236

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-112	L1813330-113	L1813330-114	L1813330-115	L1813330-116
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	S33-HORSETAIL (RINSED)	S34-LICHEN (RINSED)	S35-SALIX (RINSED)	S36-LEDUM (RINSED)	C02-HORSETAIL (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	70.5	42.7	60.7	55.7	68.3
Metals	Aluminum (Al)-Total (mg/kg)	37.0	1080	96.8	77.0	11.8
	Aluminum (Al)-Total (mg/kg wwt)	10.9	621	38.0	34.1	3.75
	Antimony (Sb)-Total (mg/kg)	<0.010	0.016	0.014	<0.010	0.011
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	0.0090	0.0056	<0.0020	0.0036
	Arsenic (As)-Total (mg/kg)	0.056	0.256	0.042	0.022	0.057
	Arsenic (As)-Total (mg/kg wwt)	0.0164	0.147	0.0165	0.0097	0.0181
	Barium (Ba)-Total (mg/kg)	140	29.8	24.1	93.5	108
	Barium (Ba)-Total (mg/kg wwt)	41.4	17.1	9.46	41.4	34.3
	Beryllium (Be)-Total (mg/kg)	<0.010	0.029	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	0.0165	<0.0020	<0.0020	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	0.047	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	0.0269	<0.0020	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	19.9	<1.0	22.2	18.1	12.3
	Boron (B)-Total (mg/kg wwt)	5.89	0.41	8.71	8.01	3.90
	Cadmium (Cd)-Total (mg/kg)	0.0658	0.0756	0.976	<0.0050	0.0661
	Cadmium (Cd)-Total (mg/kg wwt)	0.0194	0.0433	0.383	0.0013	0.0210
	Calcium (Ca)-Total (mg/kg)	17500	2060	14900	5430	21400
	Calcium (Ca)-Total (mg/kg wwt)	5180	1180	5850	2410	6800
	Cesium (Cs)-Total (mg/kg)	0.217	0.0722	0.0083	0.0157	0.0453
	Cesium (Cs)-Total (mg/kg wwt)	0.0641	0.0414	0.0032	0.0070	0.0144
	Chromium (Cr)-Total (mg/kg)	<0.050	0.535	0.060	<0.050	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	<0.010	0.307	0.024	0.017	<0.010
	Cobalt (Co)-Total (mg/kg)	0.229	0.563	0.379	0.038	0.253
	Cobalt (Co)-Total (mg/kg wwt)	0.0675	0.322	0.149	0.0170	0.0804
	Copper (Cu)-Total (mg/kg)	17.1	338	38.6	30.6	6.19
	Copper (Cu)-Total (mg/kg wwt)	5.06	193	15.2	13.6	1.97
	Iron (Fe)-Total (mg/kg)	85.2	2000	221	130	48.7
	Iron (Fe)-Total (mg/kg wwt)	25.1	1150	87.0	57.7	15.5
	Lead (Pb)-Total (mg/kg)	0.021	0.601	0.040	0.037	<0.020
	Lead (Pb)-Total (mg/kg wwt)	0.0061	0.344	0.0157	0.0163	<0.0040
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	0.26	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	5200	699	3390	1250	5230
	Magnesium (Mg)-Total (mg/kg wwt)	1530	400	1330	552	1660
	Manganese (Mn)-Total (mg/kg)	119	98.8	244	319	86.9
	Manganese (Mn)-Total (mg/kg wwt)	35.2	56.6	95.9	141	27.6

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-117	L1813330-118	L1813330-119	L1813330-120	L1813330-121
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	C02-LEDUM (RINSED)	C02-LICHEN (RINSED)	C02-SALIX (RINSED)	S09-SALIX (RINSED)	M80-SALIX (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	43.3	55.9	55.2	52.4	58.9
Metals	Aluminum (Al)-Total (mg/kg)	30.9	198	32.1	58.7	50.5
	Aluminum (Al)-Total (mg/kg wwt)	17.5	87.4	14.4	27.9	20.7
	Antimony (Sb)-Total (mg/kg)	0.010	0.012	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	0.0058	0.0052	0.0036	<0.0020	0.0027
	Arsenic (As)-Total (mg/kg)	0.028	0.100	<0.020	<0.020	<0.020
	Arsenic (As)-Total (mg/kg wwt)	0.0161	0.0439	0.0065	0.0052	0.0065
	Barium (Ba)-Total (mg/kg)	64.4	13.6	56.6	130	308
	Barium (Ba)-Total (mg/kg wwt)	36.5	5.98	25.3	62.0	127
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	0.013
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	0.0027	<0.0020	0.0034	0.0051
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	0.0030	<0.0020	<0.0020	<0.0020
	Boron (B)-Total (mg/kg)	20.7	<1.0	13.0	11.6	22.7
	Boron (B)-Total (mg/kg wwt)	11.7	0.28	5.84	5.53	9.32
	Cadmium (Cd)-Total (mg/kg)	<0.0050	0.0232	1.30	0.635	2.86
	Cadmium (Cd)-Total (mg/kg wwt)	0.0014	0.0102	0.583	0.302	1.17
	Calcium (Ca)-Total (mg/kg)	7010	1290	20200	17800	27700
	Calcium (Ca)-Total (mg/kg wwt)	3980	569	9030	8480	11400
	Cesium (Cs)-Total (mg/kg)	0.0098	0.0162	0.0163	<0.0050	<0.0050
	Cesium (Cs)-Total (mg/kg wwt)	0.0055	0.0071	0.0073	0.0014	0.0019
	Chromium (Cr)-Total (mg/kg)	<0.050	0.153	<0.050	<0.050	0.060
	Chromium (Cr)-Total (mg/kg wwt)	0.025	0.068	<0.010	0.023	0.025
	Cobalt (Co)-Total (mg/kg)	0.020	0.135	0.355	0.973	2.12
	Cobalt (Co)-Total (mg/kg wwt)	0.0115	0.0596	0.159	0.463	0.869
	Copper (Cu)-Total (mg/kg)	9.01	54.5	8.58	10.8	9.83
	Copper (Cu)-Total (mg/kg wwt)	5.11	24.0	3.84	5.16	4.04
	Iron (Fe)-Total (mg/kg)	67.0	367	91.3	115	91.5
	Iron (Fe)-Total (mg/kg wwt)	38.0	162	40.9	54.5	37.6
	Lead (Pb)-Total (mg/kg)	<0.020	0.142	<0.020	0.386	0.021
	Lead (Pb)-Total (mg/kg wwt)	0.0091	0.0626	0.0083	0.184	0.0086
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	1840	282	6520	2510	3520
	Magnesium (Mg)-Total (mg/kg wwt)	1040	124	2920	1200	1440
	Manganese (Mn)-Total (mg/kg)	153	84.6	143	309	226
	Manganese (Mn)-Total (mg/kg wwt)	86.5	37.3	63.9	147	92.9

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1813330-122	L1813330-123	L1813330-124	L1813330-125	L1813330-126
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	M80-LEDUM (RINSED)	M26-LEDUM (RINSED)	M26-SALIX (RINSED)	M26-LICHEN (RINSED)	M26-BLUEBERRIES (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	48.5	51.5	62.0	39.0	83.3
Metals	Aluminum (Al)-Total (mg/kg)	110	26.4	13.4	117	2.8
	Aluminum (Al)-Total (mg/kg wwt)	56.5	12.8	5.08	71.6	0.47
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	0.0037	<0.0020
	Arsenic (As)-Total (mg/kg)	0.023	<0.020	<0.020	0.108	<0.020
	Arsenic (As)-Total (mg/kg wwt)	0.0116	0.0056	<0.0040	0.0660	<0.0040
	Barium (Ba)-Total (mg/kg)	141	63.6	50.7	11.3	9.21
	Barium (Ba)-Total (mg/kg wwt)	72.7	30.8	19.2	6.88	1.54
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	0.0029	<0.0020
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	0.0024	<0.0020
	Boron (B)-Total (mg/kg)	24.8	12.2	8.3	<1.0	6.0
	Boron (B)-Total (mg/kg wwt)	12.8	5.94	3.14	0.33	1.00
	Cadmium (Cd)-Total (mg/kg)	0.0054	<0.0050	1.26	0.0416	0.0730
	Cadmium (Cd)-Total (mg/kg wwt)	0.0028	0.0013	0.479	0.0254	0.0122
	Calcium (Ca)-Total (mg/kg)	8280	6820	16700	2240	807
	Calcium (Ca)-Total (mg/kg wwt)	4270	3310	6340	1360	135
	Cesium (Cs)-Total (mg/kg)	0.0053	<0.0050	0.0057	0.0345	<0.0050
	Cesium (Cs)-Total (mg/kg wwt)	0.0027	0.0021	0.0022	0.0211	<0.0010
	Chromium (Cr)-Total (mg/kg)	0.115	<0.050	<0.050	0.151	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	0.059	0.024	<0.010	0.092	<0.010
	Cobalt (Co)-Total (mg/kg)	0.108	<0.020	0.647	0.082	<0.020
	Cobalt (Co)-Total (mg/kg wwt)	0.0558	0.0061	0.246	0.0498	<0.0040
	Copper (Cu)-Total (mg/kg)	15.3	4.37	4.22	17.1	3.61
	Copper (Cu)-Total (mg/kg wwt)	7.87	2.12	1.60	10.5	0.604
	Iron (Fe)-Total (mg/kg)	120	41.0	42.9	196	10.2
	Iron (Fe)-Total (mg/kg wwt)	62.0	19.9	16.3	120	1.71
	Lead (Pb)-Total (mg/kg)	0.029	<0.020	<0.020	0.138	<0.020
	Lead (Pb)-Total (mg/kg wwt)	0.0149	0.0082	<0.0040	0.0843	<0.0040
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	<0.10	<0.10
	Magnesium (Mg)-Total (mg/kg)	1380	1350	4890	401	375
	Magnesium (Mg)-Total (mg/kg wwt)	710	657	1860	245	62.8
	Manganese (Mn)-Total (mg/kg)	1900	49.5	77.4	15.3	26.8
	Manganese (Mn)-Total (mg/kg wwt)	979	24.0	29.4	9.33	4.49

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-127	L1813330-128	L1813330-129	L1813330-130	L1813330-131
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	12-AUG-16
	Sampled Time					
	Client ID	M07B-SALIX (RINSED)	M07B-HORSETAIL (RINSED)	M07B-LEDUM (RINSED)	M07B-LICHEN (RINSED)	S04-SALIX (RINSED)
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	57.5	61.2	47.8	18.3	56.5
Metals	Aluminum (Al)-Total (mg/kg)	14.9	7.6	33.9	249	85.1
	Aluminum (Al)-Total (mg/kg wwt)	6.32	2.94	17.7	203	37.0
	Antimony (Sb)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Antimony (Sb)-Total (mg/kg wwt)	0.0020	<0.0020	0.0029	0.0067	<0.0020
	Arsenic (As)-Total (mg/kg)	<0.020	0.047	<0.020	0.121	0.021
	Arsenic (As)-Total (mg/kg wwt)	<0.0040	0.0183	0.0075	0.0991	0.0091
	Barium (Ba)-Total (mg/kg)	23.6	107	91.9	11.6	99.2
	Barium (Ba)-Total (mg/kg wwt)	10.0	41.6	48.0	9.46	43.2
	Beryllium (Be)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Beryllium (Be)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	0.0054	0.0038
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010	<0.010	<0.010	<0.010
	Bismuth (Bi)-Total (mg/kg wwt)	<0.0020	<0.0020	<0.0020	0.0081	<0.0020
	Boron (B)-Total (mg/kg)	10.9	20.7	11.7	<1.0	10.6
	Boron (B)-Total (mg/kg wwt)	4.63	8.04	6.10	0.37	4.61
	Cadmium (Cd)-Total (mg/kg)	0.120	0.0202	<0.0050	0.0224	0.348
	Cadmium (Cd)-Total (mg/kg wwt)	0.0508	0.0078	0.0011	0.0183	0.151
	Calcium (Ca)-Total (mg/kg)	15000	27000	7620	1670	13600
	Calcium (Ca)-Total (mg/kg wwt)	6360	10500	3980	1360	5910
	Cesium (Cs)-Total (mg/kg)	0.0291	0.610	0.0053	0.0313	<0.0050
	Cesium (Cs)-Total (mg/kg wwt)	0.0124	0.237	0.0028	0.0256	0.0013
	Chromium (Cr)-Total (mg/kg)	<0.050	<0.050	0.418	0.233	<0.050
	Chromium (Cr)-Total (mg/kg wwt)	<0.010	<0.010	0.218	0.190	0.018
	Cobalt (Co)-Total (mg/kg)	0.120	0.454	0.026	0.154	0.855
	Cobalt (Co)-Total (mg/kg wwt)	0.0510	0.176	0.0137	0.125	0.372
	Copper (Cu)-Total (mg/kg)	5.56	6.14	5.23	63.0	7.47
	Copper (Cu)-Total (mg/kg wwt)	2.36	2.38	2.73	51.5	3.25
	Iron (Fe)-Total (mg/kg)	55.5	68.6	80.1	432	113
	Iron (Fe)-Total (mg/kg wwt)	23.6	26.6	41.8	353	49.2
	Lead (Pb)-Total (mg/kg)	<0.020	<0.020	<0.020	0.220	0.029
	Lead (Pb)-Total (mg/kg wwt)	0.0042	<0.0040	0.0084	0.180	0.0125
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10	<0.10	0.11	<0.10
	Magnesium (Mg)-Total (mg/kg)	4670	4550	1480	379	1830
	Magnesium (Mg)-Total (mg/kg wwt)	1980	1770	773	310	795
	Manganese (Mn)-Total (mg/kg)	169	383	134	33.3	264
	Manganese (Mn)-Total (mg/kg wwt)	71.8	149	70.2	27.2	115

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-132	L1813330-133			
	Description	Tissue	Tissue			
	Sampled Date	12-AUG-16	12-AUG-16			
	Sampled Time					
	Client ID	S19-SALIX (RINSED)	S19-LEDUM (RINSED)			
Grouping	**Analyte**					
TISSUE						
Physical Tests	% Moisture (%)	63.1	50.1			
Metals	Aluminum (Al)-Total (mg/kg)	250	293			
	Aluminum (Al)-Total (mg/kg wwt)	92.4	146			
	Antimony (Sb)-Total (mg/kg)	0.018	0.011			
	Antimony (Sb)-Total (mg/kg wwt)	0.0065	0.0055			
	Arsenic (As)-Total (mg/kg)	0.056	0.107			
	Arsenic (As)-Total (mg/kg wwt)	0.0206	0.0536			
	Barium (Ba)-Total (mg/kg)	275	90.1			
	Barium (Ba)-Total (mg/kg wwt)	101	44.9			
	Beryllium (Be)-Total (mg/kg)	0.022	<0.010			
	Beryllium (Be)-Total (mg/kg wwt)	0.0080	0.0042			
	Bismuth (Bi)-Total (mg/kg)	<0.010	<0.010			
	Bismuth (Bi)-Total (mg/kg wwt)	0.0029	0.0040			
	Boron (B)-Total (mg/kg)	7.1	13.5			
	Boron (B)-Total (mg/kg wwt)	2.63	6.71			
	Cadmium (Cd)-Total (mg/kg)	1.02	0.0060			
	Cadmium (Cd)-Total (mg/kg wwt)	0.377	0.0030			
	Calcium (Ca)-Total (mg/kg)	20600	7140			
	Calcium (Ca)-Total (mg/kg wwt)	7600	3560			
	Cesium (Cs)-Total (mg/kg)	0.0070	0.0108			
	Cesium (Cs)-Total (mg/kg wwt)	0.0026	0.0054			
	Chromium (Cr)-Total (mg/kg)	0.126	0.136			
	Chromium (Cr)-Total (mg/kg wwt)	0.046	0.068			
	Cobalt (Co)-Total (mg/kg)	2.76	0.174			
	Cobalt (Co)-Total (mg/kg wwt)	1.02	0.0869			
	Copper (Cu)-Total (mg/kg)	56.0	65.8			
	Copper (Cu)-Total (mg/kg wwt)	20.7	32.8			
	Iron (Fe)-Total (mg/kg)	412	482			
	Iron (Fe)-Total (mg/kg wwt)	152	240			
	Lead (Pb)-Total (mg/kg)	0.120	0.122			
	Lead (Pb)-Total (mg/kg wwt)	0.0444	0.0607			
	Lithium (Li)-Total (mg/kg)	<0.50	<0.50			
	Lithium (Li)-Total (mg/kg wwt)	<0.10	<0.10			
	Magnesium (Mg)-Total (mg/kg)	2770	1410			
	Magnesium (Mg)-Total (mg/kg wwt)	1020	705			
	Manganese (Mn)-Total (mg/kg)	818	911			
	Manganese (Mn)-Total (mg/kg wwt)	302	454			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-1	L1813330-2	L1813330-3	L1813330-4	L1813330-5
	Sample ID	L1813330-1	L1813330-2	L1813330-3	L1813330-4	L1813330-5
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	C01-SALIX	C01-LICHEN	C01-HORSETAIL	C01-LEDUM	S03-SALIX
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.587	0.053	0.218	0.343	0.245
	Molybdenum (Mo)-Total (mg/kg wwt)	0.152	0.0139	0.0512	0.112	0.0770
	Nickel (Ni)-Total (mg/kg)	11.2	0.31	1.77	0.56	3.45
	Nickel (Ni)-Total (mg/kg wwt)	2.90	0.081	0.415	0.184	1.09
	Phosphorus (P)-Total (mg/kg)	7110	491	1130	974	3410
	Phosphorus (P)-Total (mg/kg wwt)	1840	128	264	319	1070
	Potassium (K)-Total (mg/kg)	14000	1310	26800	3440	8060
	Potassium (K)-Total (mg/kg wwt)	3640	341	6280	1130	2540
	Rubidium (Rb)-Total (mg/kg)	1.45	1.85	22.8	1.04	2.18
	Rubidium (Rb)-Total (mg/kg wwt)	0.374	0.484	5.33	0.340	0.685
	Selenium (Se)-Total (mg/kg)	<0.050	<0.050	<0.050	<0.050	0.227
	Selenium (Se)-Total (mg/kg wwt)	<0.010	<0.010	<0.010	<0.010	0.072
	Sodium (Na)-Total (mg/kg)	22	21	22	42	<20
	Sodium (Na)-Total (mg/kg wwt)	5.8	5.5	5.1	13.8	5.8
	Strontium (Sr)-Total (mg/kg)	103	5.85	76.1	11.2	97.3
	Strontium (Sr)-Total (mg/kg wwt)	26.8	1.53	17.8	3.67	30.6
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	<0.0020	0.0024	<0.0020	0.0089	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	<0.00040	0.00061	<0.00040	0.00291	0.00056
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	<0.0020	0.0070	<0.0020	<0.0020	0.0089
	Uranium (U)-Total (mg/kg wwt)	<0.00040	0.00183	<0.00040	<0.00040	0.00280
	Vanadium (V)-Total (mg/kg)	<0.10	0.39	<0.10	<0.10	0.92
	Vanadium (V)-Total (mg/kg wwt)	0.022	0.103	<0.020	<0.020	0.291
	Zinc (Zn)-Total (mg/kg)	209	18.7	24.5	21.0	20.1
	Zinc (Zn)-Total (mg/kg wwt)	54.2	4.89	5.74	6.89	6.32
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	0.047

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-6	L1813330-7	L1813330-8	L1813330-9	L1813330-10
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S03-LICHEN	S11-LICHEN	S11-SALIX	S02-SALIX	S02-LICHEN
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.113	0.089	0.788	0.773	0.188
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0316	0.0283	0.211	0.259	0.0715
	Nickel (Ni)-Total (mg/kg)	1.19	0.53	5.94	6.64	1.27
	Nickel (Ni)-Total (mg/kg wwt)	0.331	0.170	1.59	2.23	0.482
	Phosphorus (P)-Total (mg/kg)	690	719	3810	3480	773
	Phosphorus (P)-Total (mg/kg wwt)	192	230	1020	1170	293
	Potassium (K)-Total (mg/kg)	1630	1710	11400	8370	2010
	Potassium (K)-Total (mg/kg wwt)	454	547	3040	2810	762
	Rubidium (Rb)-Total (mg/kg)	2.76	3.79	4.11	2.16	5.25
	Rubidium (Rb)-Total (mg/kg wwt)	0.767	1.21	1.10	0.724	1.99
	Selenium (Se)-Total (mg/kg)	0.078	0.065	<0.050	0.659	0.094
	Selenium (Se)-Total (mg/kg wwt)	0.022	0.021	0.010	0.221	0.036
	Sodium (Na)-Total (mg/kg)	27	<20	<20	<20	38
	Sodium (Na)-Total (mg/kg wwt)	7.4	5.1	<4.0	4.6	14.4
	Strontium (Sr)-Total (mg/kg)	9.82	14.6	102	82.6	11.2
	Strontium (Sr)-Total (mg/kg wwt)	2.73	4.66	27.2	27.7	4.24
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0093	0.0182	<0.0020	<0.0020	0.0096
	Thallium (Tl)-Total (mg/kg wwt)	0.00259	0.00581	<0.00040	<0.00040	0.00363
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0326	0.0115	<0.0020	0.0040	0.0331
	Uranium (U)-Total (mg/kg wwt)	0.00906	0.00367	<0.00040	0.00134	0.0126
	Vanadium (V)-Total (mg/kg)	3.49	1.01	<0.10	0.48	3.55
	Vanadium (V)-Total (mg/kg wwt)	0.971	0.324	0.023	0.161	1.35
	Zinc (Zn)-Total (mg/kg)	14.9	16.4	36.0	15.8	18.2
	Zinc (Zn)-Total (mg/kg wwt)	4.14	5.24	9.61	5.29	6.91
	Zirconium (Zr)-Total (mg/kg)	0.44	<0.20	<0.20	<0.20	0.46
	Zirconium (Zr)-Total (mg/kg wwt)	0.123	0.050	<0.040	<0.040	0.173

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	Sample ID	L1813330-11	L1813330-12	L1813330-13	L1813330-14	L1813330-15
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S01-LEDUM	S01-SALIX	S01-LICHEN	S18-SALIX	S18-LICHEN
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.232	0.135	0.121	1.66	0.830
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0859	0.0492	0.0404	0.674	0.260
	Nickel (Ni)-Total (mg/kg)	2.10	8.50	0.56	5.19	0.97
	Nickel (Ni)-Total (mg/kg wwt)	0.778	3.10	0.189	2.11	0.304
	Phosphorus (P)-Total (mg/kg)	1130	3110	701	1120	642
	Phosphorus (P)-Total (mg/kg wwt)	417	1140	235	453	202
	Potassium (K)-Total (mg/kg)	4250	11200	1520	5420	1320
	Potassium (K)-Total (mg/kg wwt)	1570	4100	508	2200	415
	Rubidium (Rb)-Total (mg/kg)	5.77	3.40	3.90	3.56	5.25
	Rubidium (Rb)-Total (mg/kg wwt)	2.13	1.24	1.31	1.45	1.65
	Selenium (Se)-Total (mg/kg)	0.051	0.261	0.080	<0.050	0.689
	Selenium (Se)-Total (mg/kg wwt)	0.019	0.095	0.027	0.019	0.216
	Sodium (Na)-Total (mg/kg)	<20	<20	<20	<20	22
	Sodium (Na)-Total (mg/kg wwt)	<4.0	<4.0	6.2	<4.0	7.0
	Strontium (Sr)-Total (mg/kg)	11.2	101	14.1	107	11.9
	Strontium (Sr)-Total (mg/kg wwt)	4.15	37.0	4.71	43.3	3.73
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	0.057
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	0.0179
	Thallium (Tl)-Total (mg/kg)	0.0061	<0.0020	0.0059	0.0078	0.0162
	Thallium (Tl)-Total (mg/kg wwt)	0.00225	<0.00040	0.00196	0.00315	0.00509
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	0.032
	Uranium (U)-Total (mg/kg)	<0.0020	<0.0020	0.0111	<0.0020	0.0370
	Uranium (U)-Total (mg/kg wwt)	0.00046	0.00069	0.00371	0.00042	0.0116
	Vanadium (V)-Total (mg/kg)	0.12	0.18	0.90	0.15	5.26
	Vanadium (V)-Total (mg/kg wwt)	0.044	0.065	0.299	0.060	1.65
	Zinc (Zn)-Total (mg/kg)	19.1	12.9	12.4	82.7	24.2
	Zinc (Zn)-Total (mg/kg wwt)	7.05	4.70	4.16	33.6	7.59
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	0.23
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	0.045	<0.040	0.071

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-16	L1813330-17	L1813330-18	L1813330-19	L1813330-20
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S18-LEDUM	S18-HORSETAIL	S15-SALIX	S15-LEDUM	S15-HORSETAIL
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.490	0.284	0.468	0.213	0.217
	Molybdenum (Mo)-Total (mg/kg wwt)	0.263	0.112	0.162	0.0988	0.0814
	Nickel (Ni)-Total (mg/kg)	0.21	0.80	4.65	0.27	0.57
	Nickel (Ni)-Total (mg/kg wwt)	0.114	0.313	1.61	0.126	0.215
	Phosphorus (P)-Total (mg/kg)	1010	820	2000	1370	1500
	Phosphorus (P)-Total (mg/kg wwt)	540	321	694	633	562
	Potassium (K)-Total (mg/kg)	3530	8120	15500	4070	16100
	Potassium (K)-Total (mg/kg wwt)	1890	3180	5380	1890	6050
	Rubidium (Rb)-Total (mg/kg)	4.43	19.1	18.6	6.69	48.8
	Rubidium (Rb)-Total (mg/kg wwt)	2.38	7.47	6.44	3.10	18.3
	Selenium (Se)-Total (mg/kg)	<0.050	0.448	0.055	<0.050	0.073
	Selenium (Se)-Total (mg/kg wwt)	0.012	0.176	0.019	0.021	0.027
	Sodium (Na)-Total (mg/kg)	<20	35	<20	<20	33
	Sodium (Na)-Total (mg/kg wwt)	<4.0	13.7	<4.0	<4.0	12.2
	Strontium (Sr)-Total (mg/kg)	6.92	54.2	57.1	7.12	46.9
	Strontium (Sr)-Total (mg/kg wwt)	3.71	21.2	19.8	3.30	17.6
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	0.0054	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0055	0.0037	0.0045	0.0082	0.0020
	Thallium (Tl)-Total (mg/kg wwt)	0.00294	0.00145	0.00158	0.00379	0.00077
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	<0.0020	0.0090	<0.0020	<0.0020	0.0053
	Uranium (U)-Total (mg/kg wwt)	0.00043	0.00353	0.00054	0.00085	0.00198
	Vanadium (V)-Total (mg/kg)	0.10	0.76	0.22	0.31	0.59
	Vanadium (V)-Total (mg/kg wwt)	0.056	0.299	0.075	0.145	0.223
	Zinc (Zn)-Total (mg/kg)	14.6	26.8	45.8	23.8	48.1
	Zinc (Zn)-Total (mg/kg wwt)	7.86	10.5	15.9	11.0	18.1
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

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	Sample ID	L1813330-21	L1813330-22	L1813330-23	L1813330-24	L1813330-25
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S08-SALIX	S08-LEDUM	S08-LICHEN	S08-BLUE BERRIES	M29-SALIX
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.362	0.144	0.891	0.340	2.36
	Molybdenum (Mo)-Total (mg/kg wwt)	0.139	0.0725	0.352	0.0510	0.879
	Nickel (Ni)-Total (mg/kg)	1.94	0.36	1.08	0.54	3.23
	Nickel (Ni)-Total (mg/kg wwt)	0.746	0.183	0.427	0.081	1.20
	Phosphorus (P)-Total (mg/kg)	817	745	690	1190	1750
	Phosphorus (P)-Total (mg/kg wwt)	314	376	273	179	650
	Potassium (K)-Total (mg/kg)	6640	2760	1840	7080	10400
	Potassium (K)-Total (mg/kg wwt)	2560	1390	725	1060	3860
	Rubidium (Rb)-Total (mg/kg)	7.25	3.79	5.48	7.03	2.76
	Rubidium (Rb)-Total (mg/kg wwt)	2.79	1.91	2.16	1.05	1.03
	Selenium (Se)-Total (mg/kg)	<0.050	<0.050	0.435	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.017	0.022	0.172	<0.010	0.018
	Sodium (Na)-Total (mg/kg)	<20	<20	95	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	<4.0	<4.0	37.4	<4.0	6.2
	Strontium (Sr)-Total (mg/kg)	42.4	14.0	16.5	3.60	47.2
	Strontium (Sr)-Total (mg/kg wwt)	16.3	7.06	6.50	0.540	17.6
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	0.036	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	0.0144	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	<0.0020	0.0081	0.0190	<0.0020	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	0.00059	0.00407	0.00752	<0.00040	0.00067
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	0.13	1.04	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	0.050	0.156	<0.020
	Uranium (U)-Total (mg/kg)	0.0040	0.0039	0.0487	<0.0020	0.0026
	Uranium (U)-Total (mg/kg wwt)	0.00155	0.00198	0.0192	<0.00040	0.00097
	Vanadium (V)-Total (mg/kg)	0.73	0.46	6.52	<0.10	0.35
	Vanadium (V)-Total (mg/kg wwt)	0.281	0.230	2.58	<0.020	0.129
	Zinc (Zn)-Total (mg/kg)	53.3	20.3	28.5	20.0	118
	Zinc (Zn)-Total (mg/kg wwt)	20.5	10.2	11.3	3.00	43.8
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	0.39	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	0.152	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-26	L1813330-27	L1813330-28	L1813330-29	L1813330-30
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	M29-HORSETAIL	M29-LEDUM	M29-LICHEN	S16-HORSETAIL	S16-LEDUM
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	2.04	0.461	0.857	0.382	0.142
	Molybdenum (Mo)-Total (mg/kg wwt)	0.679	0.149	0.351	0.102	0.0761
	Nickel (Ni)-Total (mg/kg)	0.83	0.34	0.38	1.10	<0.20
	Nickel (Ni)-Total (mg/kg wwt)	0.276	0.111	0.156	0.294	0.088
	Phosphorus (P)-Total (mg/kg)	1170	767	1020	996	1140
	Phosphorus (P)-Total (mg/kg wwt)	389	247	418	267	612
	Potassium (K)-Total (mg/kg)	11000	1840	3330	17300	3930
	Potassium (K)-Total (mg/kg wwt)	3680	594	1360	4630	2110
	Rubidium (Rb)-Total (mg/kg)	11.6	3.43	2.38	13.8	2.77
	Rubidium (Rb)-Total (mg/kg wwt)	3.85	1.10	0.976	3.70	1.49
	Selenium (Se)-Total (mg/kg)	0.118	0.230	<0.050	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.039	0.074	0.015	<0.010	0.026
	Sodium (Na)-Total (mg/kg)	56	41	<20	23	<20
	Sodium (Na)-Total (mg/kg wwt)	18.6	13.2	5.5	6.1	<4.0
	Strontium (Sr)-Total (mg/kg)	58.2	9.04	7.82	76.5	10.3
	Strontium (Sr)-Total (mg/kg wwt)	19.4	2.91	3.20	20.5	5.55
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	0.0060	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0027	0.0071	0.0221	<0.0020	0.0021
	Thallium (Tl)-Total (mg/kg wwt)	0.00091	0.00228	0.00906	<0.00040	0.00115
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0065	0.0154	0.0046	<0.0020	0.0029
	Uranium (U)-Total (mg/kg wwt)	0.00218	0.00497	0.00187	<0.00040	0.00155
	Vanadium (V)-Total (mg/kg)	0.74	1.65	0.31	0.11	0.50
	Vanadium (V)-Total (mg/kg wwt)	0.247	0.531	0.125	0.030	0.268
	Zinc (Zn)-Total (mg/kg)	53.3	18.8	24.2	62.7	20.6
	Zinc (Zn)-Total (mg/kg wwt)	17.8	6.05	9.89	16.8	11.0
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID		L1813330-31	L1813330-32	L1813330-33	L1813330-34	L1813330-35
Description		TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
Sampled Date		10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
Sampled Time						
Client ID		S16-SALIX	S05-LEDUM	S05-LICHEN	S05-HORSETAIL	S05-SALIX
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	1.05	0.077	0.440	0.445	0.451
	Molybdenum (Mo)-Total (mg/kg wwt)	0.432	0.0438	0.176	0.130	0.187
	Nickel (Ni)-Total (mg/kg)	0.99	0.47	1.17	1.38	1.78
	Nickel (Ni)-Total (mg/kg wwt)	0.405	0.270	0.470	0.403	0.736
	Phosphorus (P)-Total (mg/kg)	960	960	645	948	1060
	Phosphorus (P)-Total (mg/kg wwt)	393	547	258	278	440
	Potassium (K)-Total (mg/kg)	11300	3520	1600	10400	5840
	Potassium (K)-Total (mg/kg wwt)	4620	2010	643	3050	2420
	Rubidium (Rb)-Total (mg/kg)	7.88	4.70	4.46	41.9	7.57
	Rubidium (Rb)-Total (mg/kg wwt)	3.22	2.68	1.79	12.3	3.14
	Selenium (Se)-Total (mg/kg)	<0.050	<0.050	0.257	<0.050	<0.10 DLA
	Selenium (Se)-Total (mg/kg wwt)	0.014	0.016	0.103	<0.010	<0.020 DLA
	Sodium (Na)-Total (mg/kg)	<20	<20	59	<20	95
	Sodium (Na)-Total (mg/kg wwt)	4.0	<4.0	23.6	<4.0	39.5
	Strontium (Sr)-Total (mg/kg)	60.1	8.52	11.9	102	65.1
	Strontium (Sr)-Total (mg/kg wwt)	24.6	4.85	4.78	29.8	27.0
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	0.023	<0.020	<0.040 DLA
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	0.0092	<0.0040	<0.0080 DLA
	Thallium (Tl)-Total (mg/kg)	<0.0020	0.0183	0.0106	0.0048	<0.0040 DLA
	Thallium (Tl)-Total (mg/kg wwt)	0.00048	0.0104	0.00424	0.00139	<0.00080 DLA
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.20 DLA
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	0.025	<0.020	<0.040 DLA
	Uranium (U)-Total (mg/kg)	0.0035	0.0031	0.0283	<0.0020	<0.0040 DLA
	Uranium (U)-Total (mg/kg wwt)	0.00142	0.00178	0.0113	0.00052	0.00127
	Vanadium (V)-Total (mg/kg)	0.54	0.40	3.66	0.18	0.45
	Vanadium (V)-Total (mg/kg wwt)	0.219	0.226	1.47	0.053	0.188
	Zinc (Zn)-Total (mg/kg)	182	19.0	14.6	23.9	21.0
	Zinc (Zn)-Total (mg/kg wwt)	74.6	10.8	5.87	6.98	8.70
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.40 DLA
	Zirconium (Zr)-Total (mg/kg wwt)	0.046	<0.040	0.063	<0.040	<0.080 DLA

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

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Sample ID / Description / Sampled Date / Sampled Time / Client ID		L1813330-36	L1813330-37	L1813330-38	L1813330-39	L1813330-40
Description		TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
Sampled Date		10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
Sampled Time						
Client ID		S06-LEDUM	S06-SALIX	S07-SALIX	S07-BLUE BERRIES	S07-HORSETAIL
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.253	0.357	0.536	0.178	0.591
	Molybdenum (Mo)-Total (mg/kg wwt)	0.127	0.153	0.198	0.0245	0.175
	Nickel (Ni)-Total (mg/kg)	0.66	2.03	2.01	0.44	0.58
	Nickel (Ni)-Total (mg/kg wwt)	0.332	0.872	0.743	0.061	0.173
	Phosphorus (P)-Total (mg/kg)	1400	3310	1430	1280	962
	Phosphorus (P)-Total (mg/kg wwt)	701	1420	527	176	285
	Potassium (K)-Total (mg/kg)	5510	8140	9480	7840	13300
	Potassium (K)-Total (mg/kg wwt)	2760	3490	3500	1080	3950
	Rubidium (Rb)-Total (mg/kg)	11.8	6.59	9.71	5.40	26.0
	Rubidium (Rb)-Total (mg/kg wwt)	5.90	2.83	3.58	0.744	7.72
	Selenium (Se)-Total (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.010	0.019	0.015	<0.010	<0.010
	Sodium (Na)-Total (mg/kg)	<20	<20	21	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	<4.0	<4.0	7.7	<4.0	<4.0
	Strontium (Sr)-Total (mg/kg)	13.5	166	63.5	2.58	79.2
	Strontium (Sr)-Total (mg/kg wwt)	6.76	71.1	23.4	0.356	23.5
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0987	<0.0020	0.0020	<0.0020	0.0075
	Thallium (Tl)-Total (mg/kg wwt)	0.0494	<0.00040	0.00074	<0.00040	0.00221
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	0.75	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	0.104	<0.020
	Uranium (U)-Total (mg/kg)	<0.0020	<0.0020	0.0040	<0.0020	0.0042
	Uranium (U)-Total (mg/kg wwt)	<0.00040	0.00047	0.00148	<0.00040	0.00126
	Vanadium (V)-Total (mg/kg)	0.10	0.15	0.71	<0.10	0.19
	Vanadium (V)-Total (mg/kg wwt)	0.052	0.065	0.263	<0.020	0.056
	Zinc (Zn)-Total (mg/kg)	24.4	86.5	94.4	16.4	29.7
	Zinc (Zn)-Total (mg/kg wwt)	12.2	37.1	34.8	2.26	8.80
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-41	L1813330-42	L1813330-43	L1813330-44	L1813330-45
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S07-LEDUM	S17-SALIX	S31-SALIX	S32-LEDUM	S33-HORSETAIL
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.128	0.197	0.398	0.092	0.571
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0654	0.0689	0.156	0.0475	0.166
	Nickel (Ni)-Total (mg/kg)	0.32	3.86	1.69	0.25	0.89
	Nickel (Ni)-Total (mg/kg wwt)	0.161	1.35	0.660	0.129	0.258
	Phosphorus (P)-Total (mg/kg)	1020	3790	3130	992	1150
	Phosphorus (P)-Total (mg/kg wwt)	521	1330	1220	513	335
	Potassium (K)-Total (mg/kg)	3840	10500	7320	3630	14700
	Potassium (K)-Total (mg/kg wwt)	1960	3670	2870	1870	4260
	Rubidium (Rb)-Total (mg/kg)	3.03	2.45	6.63	2.89	40.1
	Rubidium (Rb)-Total (mg/kg wwt)	1.54	0.858	2.60	1.50	11.7
	Selenium (Se)-Total (mg/kg)	<0.050	0.188	<0.050	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.014	0.066	0.019	0.017	<0.010
	Sodium (Na)-Total (mg/kg)	<20	<20	<20	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	4.8	6.4	<4.0	<4.0	5.8
	Strontium (Sr)-Total (mg/kg)	8.38	223	186	7.82	88.5
	Strontium (Sr)-Total (mg/kg wwt)	4.27	77.9	72.7	4.04	25.7
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0107	0.0029	<0.0020	0.0031	0.0063
	Thallium (Tl)-Total (mg/kg wwt)	0.00545	0.00102	<0.00040	0.00161	0.00184
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0021	0.0040	<0.0020	0.0031	0.0069
	Uranium (U)-Total (mg/kg wwt)	0.00108	0.00141	0.00043	0.00159	0.00201
	Vanadium (V)-Total (mg/kg)	0.48	0.96	0.14	0.40	0.17
	Vanadium (V)-Total (mg/kg wwt)	0.243	0.334	0.056	0.208	0.048
	Zinc (Zn)-Total (mg/kg)	20.4	33.4	94.3	18.0	29.6
	Zinc (Zn)-Total (mg/kg wwt)	10.4	11.7	36.9	9.29	8.61
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-46	L1813330-47	L1813330-48	L1813330-49	L1813330-50
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	S34-LICHEN	S35-SALIX	S36-LEDUM	C02-HORSETAIL	C02-LEDUM
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.798	0.907	0.602	0.529	0.455
	Molybdenum (Mo)-Total (mg/kg wwt)	0.377	0.368	0.274	0.175	0.253
	Nickel (Ni)-Total (mg/kg)	0.44	1.04	<0.20	0.42	0.27
	Nickel (Ni)-Total (mg/kg wwt)	0.206	0.424	0.076	0.138	0.148
	Phosphorus (P)-Total (mg/kg)	562	1090	1040	1050	964
	Phosphorus (P)-Total (mg/kg wwt)	265	441	476	347	535
	Potassium (K)-Total (mg/kg)	1330	13300	3590	16400	3360
	Potassium (K)-Total (mg/kg wwt)	630	5420	1640	5400	1870
	Rubidium (Rb)-Total (mg/kg)	3.93	11.5	2.75	6.98	2.17
	Rubidium (Rb)-Total (mg/kg wwt)	1.85	4.66	1.25	2.31	1.21
	Selenium (Se)-Total (mg/kg)	0.384	<0.050	<0.050	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.181	0.017	0.014	<0.010	<0.010
	Sodium (Na)-Total (mg/kg)	44	<20	<20	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	20.6	<4.0	<4.0	4.9	<4.0
	Strontium (Sr)-Total (mg/kg)	14.9	60.8	7.22	83.8	18.1
	Strontium (Sr)-Total (mg/kg wwt)	7.05	24.7	3.29	27.7	10.1
	Tellurium (Te)-Total (mg/kg)	0.034	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	0.0160	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0162	<0.0020	0.0149	0.0027	0.0082
	Thallium (Tl)-Total (mg/kg wwt)	0.00766	0.00055	0.00678	0.00088	0.00458
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	0.047	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0430	0.0039	<0.0020	<0.0020	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.0203	0.00158	0.00073	<0.00040	0.00078
	Vanadium (V)-Total (mg/kg)	5.07	0.62	0.29	<0.10	0.13
	Vanadium (V)-Total (mg/kg wwt)	2.40	0.253	0.134	0.022	0.071
	Zinc (Zn)-Total (mg/kg)	24.9	168	25.0	9.09	20.1
	Zinc (Zn)-Total (mg/kg wwt)	11.8	68.4	11.4	3.00	11.2
	Zirconium (Zr)-Total (mg/kg)	0.23	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	0.106	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-51	L1813330-52	L1813330-53	L1813330-54	L1813330-55
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	C02-LICHEN	C02-SALIX	S09-SALIX	M80-SALIX	M80-LEDUM
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.088	0.962	0.292	0.276	0.460
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0396	0.406	0.138	0.115	0.239
	Nickel (Ni)-Total (mg/kg)	0.33	1.68	0.50	2.96	1.50
	Nickel (Ni)-Total (mg/kg wwt)	0.151	0.710	0.239	1.23	0.776
	Phosphorus (P)-Total (mg/kg)	417	2020	4160	4420	1360
	Phosphorus (P)-Total (mg/kg wwt)	188	850	1970	1840	704
	Potassium (K)-Total (mg/kg)	1030	9550	11100	8430	3960
	Potassium (K)-Total (mg/kg wwt)	467	4030	5250	3520	2050
	Rubidium (Rb)-Total (mg/kg)	1.20	2.91	1.22	1.96	2.56
	Rubidium (Rb)-Total (mg/kg wwt)	0.543	1.23	0.580	0.817	1.33
	Selenium (Se)-Total (mg/kg)	0.064	<0.050	<0.050	0.145	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.029	0.011	0.017	0.061	0.023
	Sodium (Na)-Total (mg/kg)	22	<20	<20	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	10.0	<4.0	<4.0	4.2	<4.0
	Strontium (Sr)-Total (mg/kg)	4.20	89.0	226	212	15.6
	Strontium (Sr)-Total (mg/kg wwt)	1.90	37.5	107	88.4	8.09
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	0.0090	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0033	<0.0020	<0.0020	<0.0020	0.0074
	Thallium (Tl)-Total (mg/kg wwt)	0.00148	0.00041	<0.00040	<0.00040	0.00383
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0081	0.0025	<0.0020	<0.0020	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00365	0.00104	0.00064	0.00050	0.00085
	Vanadium (V)-Total (mg/kg)	0.82	0.14	0.24	0.22	0.22
	Vanadium (V)-Total (mg/kg wwt)	0.373	0.058	0.115	0.090	0.114
	Zinc (Zn)-Total (mg/kg)	10.5	123	54.6	82.3	30.0
	Zinc (Zn)-Total (mg/kg wwt)	4.77	51.9	25.9	34.3	15.6
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	0.042	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-56	L1813330-57	L1813330-58	L1813330-59	L1813330-61
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	M26-LEDUM	M26-SALIX	M26-LICHEN	M26-BLUEBERRIES	M07B-SALIX
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.247	0.445	0.084	0.677	0.141
	Molybdenum (Mo)-Total (mg/kg wwt)	0.124	0.170	0.0485	0.109	0.0611
	Nickel (Ni)-Total (mg/kg)	0.37	19.0	0.25	1.02	0.75
	Nickel (Ni)-Total (mg/kg wwt)	0.188	7.26	0.144	0.163	0.327
	Phosphorus (P)-Total (mg/kg)	1170	3760	420	1480	785
	Phosphorus (P)-Total (mg/kg wwt)	587	1440	243	237	341
	Potassium (K)-Total (mg/kg)	4090	16500	933	7060	7430
	Potassium (K)-Total (mg/kg wwt)	2050	6320	540	1140	3230
	Rubidium (Rb)-Total (mg/kg)	2.02	5.10	1.26	3.04	2.96
	Rubidium (Rb)-Total (mg/kg wwt)	1.01	1.95	0.731	0.489	1.29
	Selenium (Se)-Total (mg/kg)	<0.050	0.404	<0.050	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	<0.010	0.155	0.021	<0.010	<0.010
	Sodium (Na)-Total (mg/kg)	<20	<20	<20	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	<4.0	<4.0	7.4	<4.0	<4.0
	Strontium (Sr)-Total (mg/kg)	20.6	131	8.85	8.11	68.9
	Strontium (Sr)-Total (mg/kg wwt)	10.3	50.1	5.12	1.30	29.9
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	0.0052	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0022	<0.0020	0.0023	0.0075	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	0.00108	<0.00040	0.00132	0.00120	<0.00040
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	1.25	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	0.200	<0.020
	Uranium (U)-Total (mg/kg)	<0.0020	<0.0020	0.0066	<0.0020	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00046	<0.00040	0.00384	<0.00040	<0.00040
	Vanadium (V)-Total (mg/kg)	<0.10	<0.10	0.44	<0.10	<0.10
	Vanadium (V)-Total (mg/kg wwt)	0.031	0.025	0.255	<0.020	0.037
	Zinc (Zn)-Total (mg/kg)	13.8	48.7	9.05	12.6	146
	Zinc (Zn)-Total (mg/kg wwt)	6.94	18.6	5.23	2.03	63.3
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	0.046	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-62	L1813330-63	L1813330-64	L1813330-65	L1813330-66
	Description	TISSUE	TISSUE	TISSUE	TISSUE	TISSUE
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	12-AUG-16	12-AUG-16
	Sampled Time					
	Client ID	M07B-HORSETAIL	M07B-LEDUM	M07B-LICHEN	S04-SALIX	S19-SALIX
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.442	0.033	0.091	0.373	0.295
	Molybdenum (Mo)-Total (mg/kg wwt)	0.156	0.0179	0.0718	0.151	0.117
	Nickel (Ni)-Total (mg/kg)	0.29	<0.20	0.28	0.49	1.87
	Nickel (Ni)-Total (mg/kg wwt)	0.102	0.046	0.222	0.198	0.744
	Phosphorus (P)-Total (mg/kg)	1160	835	369	4190	6660
	Phosphorus (P)-Total (mg/kg wwt)	409	457	292	1690	2650
	Potassium (K)-Total (mg/kg)	21100	3760	999	11900	17700
	Potassium (K)-Total (mg/kg wwt)	7460	2060	789	4800	7050
	Rubidium (Rb)-Total (mg/kg)	45.2	2.23	1.14	2.53	10.7
	Rubidium (Rb)-Total (mg/kg wwt)	16.0	1.22	0.901	1.02	4.27
	Selenium (Se)-Total (mg/kg)	<0.050	<0.050	0.059	<0.050	0.101
	Selenium (Se)-Total (mg/kg wwt)	<0.010	<0.010	0.047	0.014	0.040
	Sodium (Na)-Total (mg/kg)	24	<20	29	<20	29
	Sodium (Na)-Total (mg/kg wwt)	8.6	6.6	22.7	<4.0	11.5
	Strontium (Sr)-Total (mg/kg)	120	18.5	7.58	160	214
	Strontium (Sr)-Total (mg/kg wwt)	42.3	10.1	5.98	64.7	85.2
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	0.0049
	Thallium (Tl)-Total (mg/kg)	<0.0020	0.0023	0.0031	<0.0020	0.0028
	Thallium (Tl)-Total (mg/kg wwt)	0.00067	0.00124	0.00249	<0.00040	0.00110
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	<0.0020	0.0028	0.0086	<0.0020	0.0080
	Uranium (U)-Total (mg/kg wwt)	<0.00040	0.00154	0.00680	0.00076	0.00317
	Vanadium (V)-Total (mg/kg)	<0.10	0.25	0.93	0.33	1.53
	Vanadium (V)-Total (mg/kg wwt)	<0.020	0.139	0.737	0.134	0.609
	Zinc (Zn)-Total (mg/kg)	25.3	22.7	12.2	26.6	94.5
	Zinc (Zn)-Total (mg/kg wwt)	8.93	12.4	9.64	10.8	37.6
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	0.044	0.074	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-67	L1813330-68	L1813330-69	L1813330-70	L1813330-71
	Description	TISSUE	Tissue	Tissue	Tissue	Tissue
	Sampled Date	12-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S19-LEDUM	C01-SALIX (RINSED)	C01-LICHEN (RINSED)	C01-HORSETAIL (RINSED)	C01-LEDUM (RINSED)
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.279	0.575	0.107	0.215	0.325
	Molybdenum (Mo)-Total (mg/kg wwt)	0.140	0.147	0.0287	0.0501	0.106
	Nickel (Ni)-Total (mg/kg)	0.90	10.3	0.23	1.86	0.51
	Nickel (Ni)-Total (mg/kg wwt)	0.452	2.64	0.063	0.433	0.166
	Phosphorus (P)-Total (mg/kg)	1500	6170	565	1220	1000
	Phosphorus (P)-Total (mg/kg wwt)	753	1580	152	285	326
	Potassium (K)-Total (mg/kg)	4950	12100	1450	22100	2960
	Potassium (K)-Total (mg/kg wwt)	2490	3080	391	5150	962
	Rubidium (Rb)-Total (mg/kg)	5.62	1.25	2.45	13.4	0.976
	Rubidium (Rb)-Total (mg/kg wwt)	2.83	0.320	0.660	3.11	0.317
	Selenium (Se)-Total (mg/kg)	0.077	<0.050	<0.050	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.039	<0.010	<0.010	<0.010	<0.010
	Sodium (Na)-Total (mg/kg)	38	23	<20	30	34
	Sodium (Na)-Total (mg/kg wwt)	19.3	5.9	5.0	7.0	11.0
	Strontium (Sr)-Total (mg/kg)	14.8	102	6.26	82.8	12.1
	Strontium (Sr)-Total (mg/kg wwt)	7.42	26.1	1.68	19.3	3.93
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0879	<0.0020	0.0021	<0.0020	0.0099
	Thallium (Tl)-Total (mg/kg wwt)	0.0442	<0.00040	0.00057	<0.00040	0.00322
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0090	<0.0020	0.0058	<0.0020	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00452	<0.00040	0.00156	<0.00040	<0.00040
	Vanadium (V)-Total (mg/kg)	1.40	<0.10	0.29	<0.10	<0.10
	Vanadium (V)-Total (mg/kg wwt)	0.702	<0.020	0.078	<0.020	0.020
	Zinc (Zn)-Total (mg/kg)	28.3	193	17.1	27.8	20.5
	Zinc (Zn)-Total (mg/kg wwt)	14.2	49.2	4.61	6.47	6.67
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-72	L1813330-73	L1813330-74	L1813330-75	L1813330-76
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S03-SALIX (RINSED)	S03-LICHEN (RINSED)	S11-LICHEN(RINSED)	S11-SALIX (RINSED)	S02-SALIX (RINSED)
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.253	0.103	0.118	0.893	0.789
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0807	0.0315	0.0399	0.232	0.274
	Nickel (Ni)-Total (mg/kg)	2.98	0.99	0.53	5.33	6.21
	Nickel (Ni)-Total (mg/kg wwt)	0.949	0.305	0.179	1.38	2.16
	Phosphorus (P)-Total (mg/kg)	3030	708	669	3420	2830
	Phosphorus (P)-Total (mg/kg wwt)	965	218	226	887	984
	Potassium (K)-Total (mg/kg)	6270	1580	1700	9040	6860
	Potassium (K)-Total (mg/kg wwt)	2000	485	576	2350	2390
	Rubidium (Rb)-Total (mg/kg)	1.70	2.59	3.74	3.47	1.82
	Rubidium (Rb)-Total (mg/kg wwt)	0.543	0.796	1.27	0.900	0.632
	Selenium (Se)-Total (mg/kg)	0.234	0.062	0.057	<0.050	0.652
	Selenium (Se)-Total (mg/kg wwt)	0.075	0.019	0.019	<0.010	0.227
	Sodium (Na)-Total (mg/kg)	29	25	21	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	9.2	7.7	7.0	<4.0	<4.0
	Strontium (Sr)-Total (mg/kg)	100	8.28	9.29	113	79.9
	Strontium (Sr)-Total (mg/kg wwt)	31.9	2.54	3.14	29.4	27.8
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	<0.0020	0.0074	0.0056	<0.0020	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	<0.00040	0.00226	0.00191	<0.00040	<0.00040
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0048	0.0218	0.0089	<0.0020	0.0029
	Uranium (U)-Total (mg/kg wwt)	0.00154	0.00670	0.00301	<0.00040	0.00101
	Vanadium (V)-Total (mg/kg)	0.51	2.40	0.84	<0.10	0.32
	Vanadium (V)-Total (mg/kg wwt)	0.162	0.737	0.286	<0.020	0.110
	Zinc (Zn)-Total (mg/kg)	19.4	14.2	14.2	34.1	13.2
	Zinc (Zn)-Total (mg/kg wwt)	6.20	4.35	4.79	8.85	4.58
	Zirconium (Zr)-Total (mg/kg)	<0.20	0.31	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	0.094	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-77	L1813330-78	L1813330-79	L1813330-80	L1813330-81
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S02-LICHEN (RINSED)	S01-LEDUM (RINSED)	S01-SALIX (RINSED)	S01-LICHEN (RINSED)	S18-SALIX (RINSED)
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.150	0.228	0.136	0.094	1.64
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0527	0.0866	0.0494	0.0325	0.681
	Nickel (Ni)-Total (mg/kg)	1.17	2.18	9.09	0.86	4.87
	Nickel (Ni)-Total (mg/kg wwt)	0.412	0.828	3.30	0.298	2.02
	Phosphorus (P)-Total (mg/kg)	707	1150	3180	633	1190
	Phosphorus (P)-Total (mg/kg wwt)	249	436	1160	219	492
	Potassium (K)-Total (mg/kg)	1730	4230	11500	1510	5040
	Potassium (K)-Total (mg/kg wwt)	608	1610	4180	524	2090
	Rubidium (Rb)-Total (mg/kg)	4.02	6.36	3.68	3.94	3.23
	Rubidium (Rb)-Total (mg/kg wwt)	1.41	2.42	1.34	1.36	1.34
	Selenium (Se)-Total (mg/kg)	0.085	<0.050	0.282	0.061	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.030	0.018	0.102	0.021	0.019
	Sodium (Na)-Total (mg/kg)	44	<20	<20	24	<20
	Sodium (Na)-Total (mg/kg wwt)	15.4	<4.0	5.6	8.2	4.8
	Strontium (Sr)-Total (mg/kg)	11.0	12.0	108	9.97	113
	Strontium (Sr)-Total (mg/kg wwt)	3.87	4.55	39.3	3.45	46.8
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0072	0.0081	<0.0020	0.0047	0.0078
	Thallium (Tl)-Total (mg/kg wwt)	0.00253	0.00309	<0.00040	0.00164	0.00322
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0245	<0.0020	<0.0020	0.0144	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00862	<0.00040	<0.00040	0.00499	0.00047
	Vanadium (V)-Total (mg/kg)	2.49	0.12	0.13	0.71	0.12
	Vanadium (V)-Total (mg/kg wwt)	0.877	0.045	0.046	0.246	0.050
	Zinc (Zn)-Total (mg/kg)	17.1	23.8	13.7	11.3	92.9
	Zinc (Zn)-Total (mg/kg wwt)	6.03	9.06	4.99	3.92	38.5
	Zirconium (Zr)-Total (mg/kg)	0.34	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	0.121	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-82	L1813330-83	L1813330-84	L1813330-85	L1813330-86
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S18-LICHEN (RINSED)	S18-LEDUM (RINSED)	S18-HORSETAIL (RINSED)	S15-SALIX (RINSED)	S15-LEDUM (RINSED)
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.416	0.551	0.213	0.509	0.233
	Molybdenum (Mo)-Total (mg/kg wwt)	0.126	0.298	0.0854	0.176	0.112
	Nickel (Ni)-Total (mg/kg)	1.85	0.26	0.84	4.86	0.33
	Nickel (Ni)-Total (mg/kg wwt)	0.558	0.142	0.335	1.68	0.158
	Phosphorus (P)-Total (mg/kg)	632	1280	828	2240	1530
	Phosphorus (P)-Total (mg/kg wwt)	191	692	332	776	734
	Potassium (K)-Total (mg/kg)	1260	4180	7370	17200	4490
	Potassium (K)-Total (mg/kg wwt)	381	2260	2950	5940	2160
	Rubidium (Rb)-Total (mg/kg)	4.17	5.99	18.2	17.7	7.22
	Rubidium (Rb)-Total (mg/kg wwt)	1.26	3.24	7.29	6.11	3.47
	Selenium (Se)-Total (mg/kg)	0.523	<0.050	0.325	0.057	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.158	0.012	0.130	0.020	0.017
	Sodium (Na)-Total (mg/kg)	37	<20	47	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	11.2	<4.0	18.7	5.5	6.4
	Strontium (Sr)-Total (mg/kg)	10.3	10.0	55.2	60.4	7.08
	Strontium (Sr)-Total (mg/kg wwt)	3.12	5.41	22.1	20.9	3.41
	Tellurium (Te)-Total (mg/kg)	0.043	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	0.0131	<0.0040	0.0048	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0114	0.0104	0.0032	0.0043	0.0095
	Thallium (Tl)-Total (mg/kg wwt)	0.00345	0.00564	0.00129	0.00149	0.00455
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	0.021	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0309	<0.0020	0.0066	<0.0020	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00934	<0.00040	0.00265	<0.00040	0.00078
	Vanadium (V)-Total (mg/kg)	3.29	0.10	0.56	0.19	0.33
	Vanadium (V)-Total (mg/kg wwt)	0.994	0.056	0.226	0.065	0.159
	Zinc (Zn)-Total (mg/kg)	19.9	21.0	29.6	47.7	25.5
	Zinc (Zn)-Total (mg/kg wwt)	6.02	11.3	11.9	16.5	12.3
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	0.043	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-87	L1813330-88	L1813330-89	L1813330-90	L1813330-91
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	09-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S15-HORSETAIL (RINSED)	S08-SALIX (RINSED)	S08-LEDUM (RINSED)	S08-LICHEN (RINSED)	S08-BLUE BERRIES (RINSED)
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.196	0.349	0.190	0.699	0.166
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0741	0.138	0.100	0.296	0.0251
	Nickel (Ni)-Total (mg/kg)	0.48	1.83	0.39	0.74	0.24
	Nickel (Ni)-Total (mg/kg wwt)	0.182	0.723	0.206	0.313	<0.040
	Phosphorus (P)-Total (mg/kg)	1420	812	832	617	617
	Phosphorus (P)-Total (mg/kg wwt)	538	321	439	262	93.3
	Potassium (K)-Total (mg/kg)	14300	6270	2860	1510	3080
	Potassium (K)-Total (mg/kg wwt)	5420	2480	1510	638	465
	Rubidium (Rb)-Total (mg/kg)	42.7	6.41	3.69	4.66	3.04
	Rubidium (Rb)-Total (mg/kg wwt)	16.1	2.54	1.95	1.98	0.459
	Selenium (Se)-Total (mg/kg)	0.055	<0.050	<0.050	0.374	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.021	0.011	0.022	0.158	<0.010
	Sodium (Na)-Total (mg/kg)	34	<20	<20	35	<20
	Sodium (Na)-Total (mg/kg wwt)	13.0	4.7	<4.0	14.8	<4.0
	Strontium (Sr)-Total (mg/kg)	48.2	44.3	13.9	12.9	2.36
	Strontium (Sr)-Total (mg/kg wwt)	18.2	17.5	7.33	5.47	0.356
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	0.029	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	0.0125	<0.0040
	Thallium (Tl)-Total (mg/kg)	<0.0020	<0.0020	0.0075	0.0145	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	0.00054	0.00042	0.00395	0.00613	<0.00040
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	0.81
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	0.040	0.122
	Uranium (U)-Total (mg/kg)	0.0023	0.0027	0.0032	0.0387	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00088	0.00106	0.00171	0.0164	<0.00040
	Vanadium (V)-Total (mg/kg)	0.30	0.48	0.39	5.14	<0.10
	Vanadium (V)-Total (mg/kg wwt)	0.114	0.192	0.204	2.18	<0.020
	Zinc (Zn)-Total (mg/kg)	40.1	53.0	20.8	21.3	9.03
	Zinc (Zn)-Total (mg/kg wwt)	15.2	21.0	11.0	9.03	1.36
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	0.21	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	0.089	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-92	L1813330-93	L1813330-94	L1813330-95	L1813330-96
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	M29-SALIX (RINSED)	M29-HORSETAIL (RINSED)	M29-LEDUM (RINSED)	M29-LICHEN (RINSED)	S16-HORSETAIL (RINSED)
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	2.17	1.84	0.275	0.920	0.422
	Molybdenum (Mo)-Total (mg/kg wwt)	0.794	0.635	0.100	0.371	0.134
	Nickel (Ni)-Total (mg/kg)	2.87	0.68	0.28	0.25	1.18
	Nickel (Ni)-Total (mg/kg wwt)	1.05	0.236	0.101	0.099	0.375
	Phosphorus (P)-Total (mg/kg)	2080	1140	677	1140	1050
	Phosphorus (P)-Total (mg/kg wwt)	764	392	247	460	335
	Potassium (K)-Total (mg/kg)	11200	9730	1560	3390	12900
	Potassium (K)-Total (mg/kg wwt)	4120	3350	569	1370	4090
	Rubidium (Rb)-Total (mg/kg)	3.24	10.7	2.89	2.62	11.9
	Rubidium (Rb)-Total (mg/kg wwt)	1.19	3.67	1.05	1.06	3.78
	Selenium (Se)-Total (mg/kg)	<0.050	0.094	0.172	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.016	0.033	0.063	<0.010	<0.010
	Sodium (Na)-Total (mg/kg)	<20	67	23	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	5.4	22.9	8.2	<4.0	5.7
	Strontium (Sr)-Total (mg/kg)	42.7	56.0	7.14	7.30	93.3
	Strontium (Sr)-Total (mg/kg wwt)	15.6	19.3	2.61	2.95	29.7
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	0.0052	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	<0.0020	0.0027	0.0048	0.0321	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	0.00043	0.00095	0.00176	0.0130	<0.00040
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	<0.0020	0.0046	0.0117	<0.0020	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00062	0.00158	0.00428	0.00070	<0.00040
	Vanadium (V)-Total (mg/kg)	0.25	0.58	1.12	0.22	<0.10
	Vanadium (V)-Total (mg/kg wwt)	0.093	0.199	0.409	0.087	0.027
	Zinc (Zn)-Total (mg/kg)	110	51.4	12.8	24.6	79.2
	Zinc (Zn)-Total (mg/kg wwt)	40.3	17.7	4.65	9.93	25.2
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-97	L1813330-98	L1813330-99	L1813330-100	L1813330-101
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S16-LEDUM (RINSED)	S16-SALIX (RINSED)	S05-LEDUM (RINSED)	S05-LICHEN (RINSED)	S05-HORSETAIL (RINSED)
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.162	1.03	0.088	0.532	0.466
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0849	0.423	0.0502	0.246	0.142
	Nickel (Ni)-Total (mg/kg)	<0.20	1.01	0.80	0.58	1.48
	Nickel (Ni)-Total (mg/kg wwt)	0.084	0.415	0.457	0.266	0.451
	Phosphorus (P)-Total (mg/kg)	1030	904	971	844	989
	Phosphorus (P)-Total (mg/kg wwt)	537	370	552	390	301
	Potassium (K)-Total (mg/kg)	3670	10100	3620	2010	9870
	Potassium (K)-Total (mg/kg wwt)	1920	4130	2060	930	3000
	Rubidium (Rb)-Total (mg/kg)	2.40	7.72	4.62	5.37	40.8
	Rubidium (Rb)-Total (mg/kg wwt)	1.26	3.16	2.63	2.48	12.4
	Selenium (Se)-Total (mg/kg)	<0.050	<0.050	<0.050	0.391	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.020	0.012	0.024	0.181	<0.010
	Sodium (Na)-Total (mg/kg)	<20	<20	<20	38	<20
	Sodium (Na)-Total (mg/kg wwt)	<4.0	4.8	7.0	17.4	<4.0
	Strontium (Sr)-Total (mg/kg)	12.8	57.3	10.1	12.5	101
	Strontium (Sr)-Total (mg/kg wwt)	6.68	23.4	5.76	5.77	30.7
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	0.036	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	0.0168	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0021	<0.0020	0.0257	0.0131	0.0050
	Thallium (Tl)-Total (mg/kg wwt)	0.00110	0.00041	0.0146	0.00604	0.00153
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	0.038	<0.020
	Uranium (U)-Total (mg/kg)	0.0028	0.0025	0.0043	0.0301	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00146	0.00102	0.00247	0.0139	0.00046
	Vanadium (V)-Total (mg/kg)	0.40	0.36	0.53	4.16	0.15
	Vanadium (V)-Total (mg/kg wwt)	0.210	0.145	0.301	1.92	0.046
	Zinc (Zn)-Total (mg/kg)	18.3	153	20.3	18.4	23.1
	Zinc (Zn)-Total (mg/kg wwt)	9.58	62.5	11.6	8.51	7.04
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	0.083	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-102	L1813330-103	L1813330-104	L1813330-105	L1813330-106
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S05-SALIX (RINSED)	S06-LEDUM (RINSED)	S06-SALIX (RINSED)	S07-SALIX (RINSED)	S07-BLUE BERRIES (RINSED)
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.364	0.203	0.407	0.606	0.101
	Molybdenum (Mo)-Total (mg/kg wwt)	0.150	0.104	0.171	0.231	0.0126
	Nickel (Ni)-Total (mg/kg)	1.92	0.48	1.85	1.72	0.24
	Nickel (Ni)-Total (mg/kg wwt)	0.789	0.246	0.775	0.656	<0.040
	Phosphorus (P)-Total (mg/kg)	1220	1300	3020	1400	782
	Phosphorus (P)-Total (mg/kg wwt)	502	667	1270	534	97.7
	Potassium (K)-Total (mg/kg)	5900	4760	7150	9000	4060
	Potassium (K)-Total (mg/kg wwt)	2430	2440	3000	3430	508
	Rubidium (Rb)-Total (mg/kg)	7.50	10.2	5.98	4.20	2.76
	Rubidium (Rb)-Total (mg/kg wwt)	3.08	5.22	2.51	1.60	0.345
	Selenium (Se)-Total (mg/kg)	<0.10 DLA	<0.050	<0.050	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	<0.020 DLA	<0.010	0.019	0.011	<0.010
	Sodium (Na)-Total (mg/kg)	122	<20	<20	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	50.2	<4.0	4.8	6.2	<4.0
	Strontium (Sr)-Total (mg/kg)	66.1	11.6	182	68.7	1.81
	Strontium (Sr)-Total (mg/kg wwt)	27.2	5.95	76.4	26.2	0.226
	Tellurium (Te)-Total (mg/kg)	<0.040 DLA	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0080 DLA	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	<0.0040 DLA	0.0841	<0.0020	<0.0020	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	<0.00080 DLA	0.0431	<0.00040	0.00050	<0.00040
	Tin (Sn)-Total (mg/kg)	<0.20 DLA	<0.10	<0.10	<0.10	0.40
	Tin (Sn)-Total (mg/kg wwt)	<0.040 DLA	<0.020	<0.020	<0.020	0.050
	Uranium (U)-Total (mg/kg)	<0.0040 DLA	<0.0020	<0.0020	0.0029	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00118	<0.00040	<0.00040	0.00112	<0.00040
	Vanadium (V)-Total (mg/kg)	0.44	<0.10	<0.10	0.49	<0.10
	Vanadium (V)-Total (mg/kg wwt)	0.183	0.037	0.041	0.188	<0.020
	Zinc (Zn)-Total (mg/kg)	25.3	21.6	85.1	96.1	8.75
	Zinc (Zn)-Total (mg/kg wwt)	10.4	11.1	35.7	36.6	1.09
	Zirconium (Zr)-Total (mg/kg)	<0.40 DLA	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.080 DLA	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-107	L1813330-108	L1813330-109	L1813330-110	L1813330-111
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S07-HORSETAIL (RINSED)	S07-LEDUM (RINSED)	S17-SALIX (RINSED)	S31-SALIX (RINSED)	S32-LEDUM (RINSED)
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.600	0.087	0.201	0.394	0.069
	Molybdenum (Mo)-Total (mg/kg wwt)	0.162	0.0423	0.0806	0.157	0.0363
	Nickel (Ni)-Total (mg/kg)	0.58	0.26	3.37	1.83	0.34
	Nickel (Ni)-Total (mg/kg wwt)	0.156	0.128	1.35	0.729	0.179
	Phosphorus (P)-Total (mg/kg)	943	918	3080	3470	830
	Phosphorus (P)-Total (mg/kg wwt)	255	445	1230	1380	440
	Potassium (K)-Total (mg/kg)	12200	3140	8200	7770	2860
	Potassium (K)-Total (mg/kg wwt)	3310	1520	3290	3090	1520
	Rubidium (Rb)-Total (mg/kg)	28.0	2.44	1.87	6.69	2.25
	Rubidium (Rb)-Total (mg/kg wwt)	7.57	1.18	0.750	2.66	1.19
	Selenium (Se)-Total (mg/kg)	<0.050	<0.050	0.147	0.053	<0.050
	Selenium (Se)-Total (mg/kg wwt)	<0.010	0.014	0.059	0.021	0.015
	Sodium (Na)-Total (mg/kg)	21	<20	<20	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	5.8	4.4	8.0	4.3	<4.0
	Strontium (Sr)-Total (mg/kg)	81.7	8.19	210	178	8.28
	Strontium (Sr)-Total (mg/kg wwt)	22.1	3.97	84.3	70.8	4.39
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	0.0052	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0068	0.0072	0.0071	<0.0020	0.0030
	Thallium (Tl)-Total (mg/kg wwt)	0.00185	0.00350	0.00285	<0.00040	0.00161
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0052	0.0024	0.0039	<0.0020	0.0025
	Uranium (U)-Total (mg/kg wwt)	0.00140	0.00118	0.00156	0.00043	0.00132
	Vanadium (V)-Total (mg/kg)	0.15	0.37	0.59	0.12	0.35
	Vanadium (V)-Total (mg/kg wwt)	0.040	0.182	0.236	0.046	0.184
	Zinc (Zn)-Total (mg/kg)	29.0	18.8	30.3	97.1	16.9
	Zinc (Zn)-Total (mg/kg wwt)	7.85	9.12	12.1	38.7	8.97
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-112	L1813330-113	L1813330-114	L1813330-115	L1813330-116
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	S33-HORSETAIL (RINSED)	S34-LICHEN (RINSED)	S35-SALIX (RINSED)	S36-LEDUM (RINSED)	C02-HORSETAIL (RINSED)
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.587	0.741	0.832	0.884	0.587
	Molybdenum (Mo)-Total (mg/kg wwt)	0.173	0.425	0.327	0.392	0.186
	Nickel (Ni)-Total (mg/kg)	0.96	0.66	1.03	0.27	0.48
	Nickel (Ni)-Total (mg/kg wwt)	0.284	0.378	0.405	0.118	0.152
	Phosphorus (P)-Total (mg/kg)	1050	544	1060	1040	1050
	Phosphorus (P)-Total (mg/kg wwt)	309	311	417	460	334
	Potassium (K)-Total (mg/kg)	13300	1410	11800	3210	14300
	Potassium (K)-Total (mg/kg wwt)	3920	810	4620	1420	4540
	Rubidium (Rb)-Total (mg/kg)	36.7	4.69	9.63	2.19	6.71
	Rubidium (Rb)-Total (mg/kg wwt)	10.8	2.69	3.78	0.970	2.13
	Selenium (Se)-Total (mg/kg)	<0.050	0.349	<0.050	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	<0.010	0.200	0.011	0.012	<0.010
	Sodium (Na)-Total (mg/kg)	22	56	<20	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	6.5	31.9	4.0	8.0	5.3
	Strontium (Sr)-Total (mg/kg)	88.9	13.0	56.6	8.29	89.9
	Strontium (Sr)-Total (mg/kg wwt)	26.3	7.44	22.2	3.68	28.5
	Tellurium (Te)-Total (mg/kg)	<0.020	0.026	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	0.0152	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0062	0.0130	<0.0020	0.0168	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	0.00184	0.00743	<0.00040	0.00744	<0.00040
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	0.051	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	0.0050	0.0362	0.0027	<0.0020	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00148	0.0207	0.00107	0.00084	<0.00040
	Vanadium (V)-Total (mg/kg)	0.15	4.50	0.38	0.29	<0.10
	Vanadium (V)-Total (mg/kg wwt)	0.043	2.58	0.151	0.128	<0.020
	Zinc (Zn)-Total (mg/kg)	27.6	19.3	171	23.4	11.1
	Zinc (Zn)-Total (mg/kg wwt)	8.16	11.1	67.1	10.4	3.53
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	0.108	<0.040	<0.040	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-117	L1813330-118	L1813330-119	L1813330-120	L1813330-121
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	C02-LEDUM (RINSED)	C02-LICHEN (RINSED)	C02-SALIX (RINSED)	S09-SALIX (RINSED)	M80-SALIX (RINSED)
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.462	0.156	1.29	0.300	0.286
	Molybdenum (Mo)-Total (mg/kg wwt)	0.262	0.0688	0.576	0.143	0.117
	Nickel (Ni)-Total (mg/kg)	0.33	0.30	1.71	0.49	3.04
	Nickel (Ni)-Total (mg/kg wwt)	0.186	0.132	0.766	0.235	1.25
	Phosphorus (P)-Total (mg/kg)	1070	369	1640	4100	5000
	Phosphorus (P)-Total (mg/kg wwt)	605	163	732	1950	2050
	Potassium (K)-Total (mg/kg)	3510	812	9030	10100	8590
	Potassium (K)-Total (mg/kg wwt)	1990	358	4040	4820	3530
	Rubidium (Rb)-Total (mg/kg)	2.42	0.971	3.11	1.03	2.56
	Rubidium (Rb)-Total (mg/kg wwt)	1.37	0.428	1.39	0.492	1.05
	Selenium (Se)-Total (mg/kg)	<0.050	0.054	<0.050	<0.050	0.172
	Selenium (Se)-Total (mg/kg wwt)	<0.010	0.024	<0.010	0.014	0.071
	Sodium (Na)-Total (mg/kg)	<20	<20	<20	<20	<20
	Sodium (Na)-Total (mg/kg wwt)	<4.0	8.6	6.0	6.7	5.6
	Strontium (Sr)-Total (mg/kg)	16.8	4.14	87.5	207	218
	Strontium (Sr)-Total (mg/kg wwt)	9.52	1.83	39.2	98.4	89.4
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	0.0040	<0.0040	0.0077
	Thallium (Tl)-Total (mg/kg)	0.0074	0.0031	<0.0020	<0.0020	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	0.00421	0.00137	<0.00040	<0.00040	<0.00040
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	<0.0020	0.0077	<0.0020	<0.0020	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00089	0.00340	0.00046	0.00055	0.00041
	Vanadium (V)-Total (mg/kg)	0.12	0.67	0.12	0.19	0.16
	Vanadium (V)-Total (mg/kg wwt)	0.070	0.295	0.055	0.091	0.065
	Zinc (Zn)-Total (mg/kg)	21.0	9.68	86.4	48.9	102
	Zinc (Zn)-Total (mg/kg wwt)	11.9	4.27	38.7	23.2	41.7
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	<0.040	<0.040

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-122	L1813330-123	L1813330-124	L1813330-125	L1813330-126
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	M80-LEDUM (RINSED)	M26-LEDUM (RINSED)	M26-SALIX (RINSED)	M26-LICHEN (RINSED)	M26-BLUEBERRIES (RINSED)
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.548	0.359	0.443	0.103	0.435
	Molybdenum (Mo)-Total (mg/kg wwt)	0.282	0.174	0.168	0.0629	0.0728
	Nickel (Ni)-Total (mg/kg)	1.56	0.39	19.4	0.31	0.68
	Nickel (Ni)-Total (mg/kg wwt)	0.806	0.191	7.37	0.190	0.114
	Phosphorus (P)-Total (mg/kg)	1300	1190	3680	492	1020
	Phosphorus (P)-Total (mg/kg wwt)	668	579	1400	301	171
	Potassium (K)-Total (mg/kg)	3720	4100	15700	1020	3680
	Potassium (K)-Total (mg/kg wwt)	1920	1990	5950	621	616
	Rubidium (Rb)-Total (mg/kg)	2.65	2.04	4.65	1.39	1.63
	Rubidium (Rb)-Total (mg/kg wwt)	1.37	0.992	1.76	0.851	0.272
	Selenium (Se)-Total (mg/kg)	<0.050	<0.050	0.363	<0.050	<0.050
	Selenium (Se)-Total (mg/kg wwt)	0.022	<0.010	0.138	0.020	<0.010
	Sodium (Na)-Total (mg/kg)	<20	<20	<20	22	<20
	Sodium (Na)-Total (mg/kg wwt)	<4.0	5.1	<4.0	13.2	<4.0
	Strontium (Sr)-Total (mg/kg)	14.9	26.6	117	13.4	6.30
	Strontium (Sr)-Total (mg/kg wwt)	7.66	12.9	44.5	8.18	1.05
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
	Thallium (Tl)-Total (mg/kg)	0.0069	0.0026	<0.0020	0.0022	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	0.00356	0.00128	<0.00040	0.00131	<0.00040
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	1.54
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	0.258
	Uranium (U)-Total (mg/kg)	<0.0020	<0.0020	<0.0020	0.0068	<0.0020
	Uranium (U)-Total (mg/kg wwt)	0.00080	0.00072	<0.00040	0.00416	<0.00040
	Vanadium (V)-Total (mg/kg)	0.22	<0.10	<0.10	0.56	<0.10
	Vanadium (V)-Total (mg/kg wwt)	0.112	0.034	<0.020	0.343	<0.020
	Zinc (Zn)-Total (mg/kg)	33.4	14.8	44.8	8.70	7.87
	Zinc (Zn)-Total (mg/kg wwt)	17.2	7.17	17.0	5.31	1.32
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	0.043	<0.040

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813330-127	L1813330-128	L1813330-129	L1813330-130	L1813330-131
	Description	Tissue	Tissue	Tissue	Tissue	Tissue
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	12-AUG-16
	Sampled Time					
	Client ID	M07B-SALIX (RINSED)	M07B-HORSETAIL (RINSED)	M07B-LEDUM (RINSED)	M07B-LICHEN (RINSED)	S04-SALIX (RINSED)
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.157	0.606	0.105	0.102	0.356
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0667	0.235	0.0549	0.0835	0.155
	Nickel (Ni)-Total (mg/kg)	0.81	0.26	<0.20	0.30	0.50
	Nickel (Ni)-Total (mg/kg wwt)	0.342	0.101	0.068	0.244	0.216
	Phosphorus (P)-Total (mg/kg)	797	1330	850	380	3680
	Phosphorus (P)-Total (mg/kg wwt)	338	515	444	311	1600
	Potassium (K)-Total (mg/kg)	7070	20300	3740	1040	11500
	Potassium (K)-Total (mg/kg wwt)	3000	7880	1950	853	5010
	Rubidium (Rb)-Total (mg/kg)	3.01	77.4	2.17	1.21	2.58
	Rubidium (Rb)-Total (mg/kg wwt)	1.28	30.0	1.13	0.990	1.12
	Selenium (Se)-Total (mg/kg)	<0.050	<0.050	<0.050	0.071	<0.050
	Selenium (Se)-Total (mg/kg wwt)	<0.010	<0.010	<0.010	0.058	0.014
	Sodium (Na)-Total (mg/kg)	<20	38	<20	23	<20
	Sodium (Na)-Total (mg/kg wwt)	<4.0	14.8	<4.0	18.9	6.0
	Strontium (Sr)-Total (mg/kg)	72.0	137	19.8	8.44	175
	Strontium (Sr)-Total (mg/kg wwt)	30.6	53.2	10.3	6.90	76.3
	Tellurium (Te)-Total (mg/kg)	<0.020	<0.020	<0.020	<0.020	<0.020
	Tellurium (Te)-Total (mg/kg wwt)	<0.0040	<0.0040	<0.0040	0.0051	<0.0040
	Thallium (Tl)-Total (mg/kg)	<0.0020	0.0085	0.0021	0.0031	<0.0020
	Thallium (Tl)-Total (mg/kg wwt)	<0.00040	0.00330	0.00107	0.00256	<0.00040
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020	<0.020	<0.020	<0.020
	Uranium (U)-Total (mg/kg)	<0.0020	<0.0020	<0.0020	0.0097	<0.0020
	Uranium (U)-Total (mg/kg wwt)	<0.00040	<0.00040	0.00097	0.00789	0.00056
	Vanadium (V)-Total (mg/kg)	<0.10	<0.10	0.18	0.90	0.26
	Vanadium (V)-Total (mg/kg wwt)	0.024	<0.020	0.093	0.734	0.114
	Zinc (Zn)-Total (mg/kg)	168	31.7	24.7	12.2	27.3
	Zinc (Zn)-Total (mg/kg wwt)	71.1	12.3	12.9	9.98	11.9
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040	<0.040	0.072	<0.040

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813330-132	L1813330-133			
	Description	Tissue	Tissue			
	Sampled Date	12-AUG-16	12-AUG-16			
	Sampled Time					
	Client ID	S19-SALIX (RINSED)	S19-LEDUM (RINSED)			
Grouping	**Analyte**					
TISSUE						
Metals	Molybdenum (Mo)-Total (mg/kg)	0.257	0.265			
	Molybdenum (Mo)-Total (mg/kg wwt)	0.0948	0.132			
	Nickel (Ni)-Total (mg/kg)	1.81	0.78			
	Nickel (Ni)-Total (mg/kg wwt)	0.669	0.388			
	Phosphorus (P)-Total (mg/kg)	5820	1440			
	Phosphorus (P)-Total (mg/kg wwt)	2150	720			
	Potassium (K)-Total (mg/kg)	15400	4470			
	Potassium (K)-Total (mg/kg wwt)	5670	2230			
	Rubidium (Rb)-Total (mg/kg)	9.95	5.42			
	Rubidium (Rb)-Total (mg/kg wwt)	3.67	2.70			
	Selenium (Se)-Total (mg/kg)	0.089	0.059			
	Selenium (Se)-Total (mg/kg wwt)	0.033	0.030			
	Sodium (Na)-Total (mg/kg)	26	<20			
	Sodium (Na)-Total (mg/kg wwt)	9.7	5.9			
	Strontium (Sr)-Total (mg/kg)	203	14.6			
	Strontium (Sr)-Total (mg/kg wwt)	74.9	7.28			
	Tellurium (Te)-Total (mg/kg)	0.021	<0.020			
	Tellurium (Te)-Total (mg/kg wwt)	0.0076	<0.0040			
	Thallium (Tl)-Total (mg/kg)	<0.0020	0.0880			
	Thallium (Tl)-Total (mg/kg wwt)	0.00058	0.0439			
	Tin (Sn)-Total (mg/kg)	<0.10	<0.10			
	Tin (Sn)-Total (mg/kg wwt)	<0.020	<0.020			
	Uranium (U)-Total (mg/kg)	0.0044	0.0064			
	Uranium (U)-Total (mg/kg wwt)	0.00162	0.00318			
	Vanadium (V)-Total (mg/kg)	0.83	1.05			
	Vanadium (V)-Total (mg/kg wwt)	0.305	0.522			
	Zinc (Zn)-Total (mg/kg)	91.5	28.8			
	Zinc (Zn)-Total (mg/kg wwt)	33.8	14.3			
	Zirconium (Zr)-Total (mg/kg)	<0.20	<0.20			
	Zirconium (Zr)-Total (mg/kg wwt)	<0.040	<0.040			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Bismuth (Bi)-Total	DUP-H	L1813330-109
Duplicate	Copper (Cu)-Total	DUP-H	L1813330-106, -11, -124, -126, -20, -21, -24, -39, -58, -59, -6, -70, -73, -74, -8, -80, -85, -86, -87, -88, -91
Duplicate	Thallium (Tl)-Total	DUP-H	L1813330-109
Duplicate	Tin (Sn)-Total	DUP-H	L1813330-106, -11, -124, -126, -20, -21, -24, -39, -58, -59, -6, -70, -73, -74, -8, -80, -85, -86, -87, -88, -91
Duplicate	Bismuth (Bi)-Total	DUP-H	L1813330-109
Duplicate	Copper (Cu)-Total	DUP-H	L1813330-106, -11, -124, -126, -20, -21, -24, -39, -58, -59, -6, -70, -73, -74, -8, -80, -85, -86, -87, -88, -91
Duplicate	Thallium (Tl)-Total	DUP-H	L1813330-109
Duplicate	Tin (Sn)-Total	DUP-H	L1813330-106, -11, -124, -126, -20, -21, -24, -39, -58, -59, -6, -70, -73, -74, -8, -80, -85, -86, -87, -88, -91
Duplicate	Uranium (U)-Total	DUP-H	L1813330-113, -131, -25, -26, -27, -28, -33, -38, -41, -42, -48, -63, -64, -65, -66, -67, -93
Method Blank	Strontium (Sr)-Total	MB-LOR	L1813330-109
Method Blank	Strontium (Sr)-Total	MB-LOR	L1813330-109

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
DUP-H	Duplicate results outside ALS DQO, due to sample heterogeneity.
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-DRY-CCMS-N-VA	Tissue	Metals in Tissue by CRC ICPMS (DRY)	EPA 200.3/6020A

This method is conducted following British Columbia Lab Manual method "Metals in Animal Tissue and Vegetation (Biota) - Prescriptive". Tissue samples are homogenized and sub-sampled prior to hotblock digestion with nitric and hydrochloric acids, in combination with addition of hydrogen peroxide. Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

Method Limitation: This method employs a strong acid/peroxide digestion, and is intended to provide a conservative estimate of bio-available metals. Near complete recoveries are achieved for most toxicologically important metals, but elements associated with recalcitrant minerals may be only partially recovered.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-WET-CCMS-N-VA	Tissue	Metals in Tissue by CRC ICPMS (WET)	EPA 200.3/6020A

This method is conducted following British Columbia Lab Manual method "Metals in Animal Tissue and Vegetation (Biota) - Prescriptive". Tissue samples are homogenized and sub-sampled prior to hotblock digestion with nitric and hydrochloric acids, in combination with addition of hydrogen peroxide. Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

Method Limitation: This method employs a strong acid/peroxide digestion, and is intended to provide a conservative estimate of bio-available metals. Near complete recoveries are achieved for most toxicologically important metals, but elements associated with recalcitrant minerals may be only partially recovered.

ALS Test Code	Matrix	Test Description	Method Reference**
MOISTURE-TISS-VA	Tissue	% Moisture in Tissues	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1813330-COFC

COC Number: 14 -

Report To	
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Address:	2100-510 West Georgia St. Vancouver, BC
Phone:	604-759-4659

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ Yes ☐ No

☐ Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: minto_environment@mintomine.com

Email 2: mheynen@accessconsulting.ca,muducharme@accessconsulting.ca

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To

Same as Report To ☑ Yes ☐ No

Copy of Invoice with Report ☑ Yes ☐ No

Company:

Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: ap@mintomine.com

Email 2:

Project Information

ALS Quote #:	
Job #:	MIN 16-07 (2016 Minto VMU)
PO / AFE:	222458
LSD:	

Oil and Gas Required Fields (client use)

Approver ID:	Cost Center:
GL Account:	Routing Code:
Activity Code:	
Location:	

ALS Lab Work Order # (lab use only):

ALS Contact: Ariel McDonnell

Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-WET/DRY-CCMS-N-VA	MOISTURE-TISS-VA	PREP-TISS-DIGEST-VA	Number of Containers
	C01-Salix	09-Aug-16	-	Tissue	R	R	R	
	C01-Lichen	09-Aug-16	-	Tissue	R	R	R	
	C01-Horsetail	09-Aug-16	-	Tissue	R	R	R	
	C01-Ledum	09-Aug-16	-	Tissue	R	R	R	
	S03-Salix	09-Aug-16	-	Tissue	R	R	R	
	S03-Lichen	09-Aug-16	-	Tissue	R	R	R	
	S11-Lichen	09-Aug-16	-	Tissue	R	R	R	
	S11-Salix	09-Aug-16	-	Tissue	R	R	R	
	S02-Salix	09-Aug-16	-	Tissue	R	R	R	
	S02-Lichen	09-Aug-16	-	Tissue	R	R	R	
	S01-Ledum	09-Aug-16	-	Tissue	R	R	R	
	S01-Salix	09-Aug-16	-	Tissue	R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples: Will require subsample & rinsing for some samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☑ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 5.0

FINAL COOLER TEMPERATURES °C: 5.1, 3.3, 4.9, 3.6, 6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: [signature]	Date: Aug 12/16	Time: 15:15	Received by: [signature]	Date: Aug-12-16	Time: 3:21	Received by: SHAYAN	Date: AUG 13	Time: 1300

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

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ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1813330-COFC

COC Number: 14 -

Report To	
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Address:	2100-510 West Georgia St. Vancouver, BC
Phone:	604-759-4659

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ Yes ☐ No

☐ Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: minto_environment@mintomine.com

Email 2: mheynen@accessconsulting.ca,muducharme@accessconsulting.ca

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To: Same as Report To ☑ Yes ☐ No

Copy of Invoice with Report ☑ Yes ☐ No

Company:

Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: ap@mintomine.com

Email 2:

Project Information

ALS Quote #:	
Job #:	MIN 16-07 (2016 Minto VMU)
PO / AFE:	222458
LSD:	

Oil and Gas Required Fields (client use)

Approver ID: Cost Center:

GL Account: Routing Code:

Activity Code:

Location:

ALS Lab Work Order # (lab use only)

ALS Contact: Ariel McDonnell

Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-WET/DRY-CCMS-N-VA	MOISTURE-TISS-VA	PREP-TISS-DIGEST-VA	Number of Containers
	S01-Lichen	09-Aug-16	-	Tissue	R	R	R	
	S18-Salix	09-Aug-16	-	Tissue	R	R	R	
	S18-Lichen	09-Aug-16	-	Tissue	R	R	R	
	S18-Ledum	09-Aug-16	-	Tissue	R	R	R	
	S18-Horsetail	09-Aug-16	-	Tissue	R	R	R	
	S15-Salix	09-Aug-16	-	Tissue	R	R	R	
	S15-Ledum	09-Aug-16	-	Tissue	R	R	R	
	S15-Horsetail	09-Aug-16	-	Tissue	R	R	R	
	S08-Salix	10-Aug-16	-	Tissue	R	R	R	
	S08-Ledum	10-Aug-16	-	Tissue	R	R	R	
	S08-Lichen	10-Aug-16	-	Tissue	R	R	R	
	S08-Blue berries	10-Aug-16	-	Tissue	R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples: Will require subsample & rinsing for some samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 6.5°

FINAL COOLER TEMPERATURES °C: 5.1, 8.3, 4.9, 3.6, 6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: Jeremy McKay	Date: 3:30AM	Time: Aug-12-16	Received by: SHAYAN	Date: AUG.13	Time: 1300

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(ALS) Environmental
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Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1813330-COFC

COC Number: 14 -

Report To	
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Address:	2100-510 West Georgia St. Vancouver, BC
Phone:	604-759-4659

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ Yes ☐ No
☐ Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: minto_environment@mintomine.com
Email 2: mheynen@accessconsulting.ca,muducharme@accessconsulting.ca

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To		
Same as Report To	☑ Yes	☐ No
Copy of Invoice with Report	☑ Yes	☐ No
Company:		
Contact:		

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: ap@mintomine.com
Email 2:

Project Information

ALS Quote #:	
Job #:	MIN 16-07 (2016 Minto VMU)
PO / AFE:	222458
LSD:	
ALS Lab Work Order # (lab use only)	

Oil and Gas Required Fields (client use)

Approver ID:	Cost Center:
GL Account:	Routing Code:
Activity Code:	
Location:	
ALS Contact: Ariel McDonnell	Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-WET/DRY-CCMS-N-VA	MOISTURE-TISS-VA	PREP-TISS-DIGEST-VA	Number of Containers
	M29-Salix	10-Aug-16	-	Tissue	R	R	R	
	M29-Horsetail	10-Aug-16	-	Tissue	R	R	R	
	M29-Ledum	10-Aug-16	-	Tissue	R	R	R	
	M29-Lichen	10-Aug-16	-	Tissue	R	R	R	
	S16-Horsetail	10-Aug-16	-	Tissue	R	R	R	
	S16-Ledum	10-Aug-16	-	Tissue	R	R	R	
	S16-Salix	10-Aug-16	-	Tissue	R	R	R	
	S05-ledum	10-Aug-16	-	Tissue	R	R	R	
	S05-Lichen	10-Aug-16	-	Tissue	R	R	R	
	S05-Horsetail	10-Aug-16	-	Tissue	R	R	R	
	S05-Salix	10-Aug-16	-	Tissue	R	R	R	
	S06-Ledum	10-Aug-16	-	Tissue	R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No
Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples: Will require subsample & rinsing for some samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice packs Yes ☑ No ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 5.0°
FINAL COOLER TEMPERATURES °C: 5.1, 3.3, 4.9, 3.6, 6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: Jeremy Mary	Date: Aug-12-16	Time: 3:30pm	Received by: SHAYAN	Date: AUG. 13	Time: 1300

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

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Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1813330-COFC

COC Number: 14 -

Report To	
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Address:	2100-510 West Georgia St. Vancouver, BC
Phone:	604-759-4659

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ Yes ☐ No
☐ Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: minto_environment@mintomine.com
Email 2: mheynen@accessconsulting.ca,muducharme@accessconsulting.ca

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To: Same as Report To ☑ Yes ☐ No
Copy of Invoice with Report ☑ Yes ☐ No
Company:
Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: ap@mintomine.com
Email 2

Project Information

ALS Quote #:
Job #: MIN 16-07 (2016 Minto VMU)
PO / AFE: 222458
LSD:

Oil and Gas Required Fields (client use)

Approver ID: Cost Center:
GL Account: Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only)

ALS Contact: Ariel McDonnell Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-WET/DRY-CCMS-N-VA	MOISTURE-TISS-VA	PREP-TISS-DIGEST-VA	Number of Containers
	S06-Salix	10-Aug-16	-	Tissue	R	R	R	
	S07-Salix	10-Aug-16	-	Tissue	R	R	R	
	S07-Blue berries	10-Aug-16	-	Tissue	R	R	R	
	S07-Horsetail	10-Aug-16	-	Tissue	R	R	R	
	S07-Ledum	10-Aug-16	-	Tissue	R	R	R	
	S17-Salix	10-Aug-16	-	Tissue	R	R	R	
	S31-Salix	10-Aug-16	-	Tissue	R	R	R	
	S32-Ledum	10-Aug-16	-	Tissue	R	R	R	
	S33-Horsetail	10-Aug-16	-	Tissue	R	R	R	
	S34-Lichen	10-Aug-16	-	Tissue	R	R	R	
	S35-Salix	10-Aug-16	-	Tissue	R	R	R	
	S36-Ledum	10-Aug-16	-	Tissue	R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No
Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples; Will require subsample & rinsing for some samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice packs Yes ☑ No ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 10c
FINAL COOLER TEMPERATURES °C: 5.1, 3.3, 4.9, 3.6, 6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: Jonny Mcus	Date: Aug-12-16	Time: 3:20pm	Received by: SHAYAN	Date: AUG.15	Time: 1300

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION   WHITE - LABORATORY COPY   YELLOW - CLIENT COPY

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ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1813330-COFC

COC Number: 14 -

Report To	
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Address:	2100-510 West Georgia St. Vancouver, BC
Phone:	604-759-4659

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ Yes ☐ No
☐ Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: minto_environment@mintomine.com
Email 2: mheynen@accessconsulting.ca,muducharme@accessconsulting.ca

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To: Same as Report To ☑ Yes ☐ No
Copy of Invoice with Report ☑ Yes ☐ No
Company:
Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: ap@mintomine.com
Email 2

Project Information

ALS Quote #:
Job #: MIN 16-07 (2016 Minto VMU)
PO / AFE: 222458
LSD:

Oil and Gas Required Fields (client use)

Approver ID: | Cost Center:
GL Account: | Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only)

ALS Contact: Ariel McDonnell | Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-WET/DRY-CCMS-N-VA	MOISTURE-TISS-VA	PREP-TISS-DIGEST-VA	Number of Containers
	C02-Horsetail	11-Aug-16	-	Tissue	R	R	R	
	C02-Ledum	11-Aug-16	-	Tissue	R	R	R	
	C02-Lichen	11-Aug-16	-	Tissue	R	R	R	
	C02-Salix	11-Aug-16	-	Tissue	R	R	R	
	S09-Salix	11-Aug-16	-	Tissue	R	R	R	
	M80-Salix	11-Aug-16	-	Tissue	R	R	R	
	M80-Ledum	11-Aug-16	-	Tissue	R	R	R	
	M26-Ledum	11-Aug-16	-	Tissue	R	R	R	
	M26-Salix	11-Aug-16	-	Tissue	R	R	R	
	M26-Lichen	11-Aug-16	-	Tissue	R	R	R	
	M26-Blueberries	11-Aug-16	-	Tissue	R	R	R	
	M07b-Blueberries	11-Aug-16	-	Tissue	R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No
Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples; Will require subsample & rinsing for some samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ | SIF Observations Yes ☐ No ☐
Ice packs Yes ☑ No ☐ | Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 5.0°
FINAL COOLER TEMPERATURES °C: 5.1, 3.3, 4.7, 3.6, 6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: Jenny McGuy	Date: Aug-12-16	Time: 3:20pm	Received by: SHAYAN	Date: AUG.13	Time: 1300

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ALS Environmental

www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1813330-COFC

COC Number: 14 -

Report To		Report Format / Distribution	
Company:	Minto Explorations Ltd.	Select Report Format:	☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report	☑ Yes ☐ No
Address:	2100-510 West Georgia St. Vancouver, BC	☐ Criteria on Report - provide details below if box checked	
		Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Phone:	604-759-4659	Email 1 or Fax	minto_environment@mintomine.com
		Email 2	mheynen@accessconsulting.ca,muducharme@accessconsulting.ca

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To		Invoice Distribution	
Same as Report To	☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Copy of Invoice with Report	☑ Yes ☐ No	Email 1 or Fax	ap@mintomine.com
Company:		Email 2	
Contact:			

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:		Approver ID:	Cost Center:
Job #:	MIN 16-07 (2016 Minto VMU)	GL Account:	Routing Code:
PO / AFE:	222458	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact: Ariel McDonnell	Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-WET/DRY-CCMS-N-VA	MOISTURE-TISS-VA	PREP-TISS-DIGEST-VA	Number of Containers
	M07b-Salix	11-Aug-16	-	Tissue	R	R	R	
	M07b-Horsetail	11-Aug-16	-	Tissue	R	R	R	
	M07b-Ledum	11-Aug-16	-	Tissue	R	R	R	
	M07b-Lichen	11-Aug-16	-	Tissue	R	R	R	
	S04-Salix	12-Aug-16	-	Tissue	R	R	R	
	S19-Salix	12-Aug-16	-	Tissue	R	R	R	
	S19-Ledum	12-Aug-16	-	Tissue	R	R	R	
			-					
			-					
			-					
			-					
			-					

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples: Will require subsample with half being rinsed and half not rinsed for all samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐		SIF Observations	Yes ☐ No ☐
Ice packs	Yes ☑ No ☐	Custody seal intact	Yes ☐ No ☐
Cooling Initiated ☐			

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
10°C			5 1, 3	.3, 4.9	, 3.6, 6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: [signature]	Date: Aug 12-16	Time: 3:30pm	Received by: SHAYAN	Date: AUG.13	Time: 1300

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NA-FM-0326e v09 Front 04 January 2014

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Minto Explorations Ltd.
ATTN: Minto Environment
Suite 2100- 510 West Georgia St
Vancouver BC V6B 0M3

Date Received: 13-AUG-16
Report Date: 24-AUG-16 18:03 (MT)
Version: FINAL

Client Phone: 604-759-0860

Certificate of Analysis

Lab Work Order #: L1813304

Project P.O. #: 222458
Job Reference: MIN 16-07 (2016 MINTO VMU)
C of C Numbers:
Legal Site Desc:

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-1	L1813304-2	L1813304-3	L1813304-4	L1813304-5
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	C01-BM1	C01-BM2	S03-BM1	S03-BM2	S11-BM1
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	11.0	13.2	6.75	5.94	15.2
	pH (1:2 soil:water) (pH)	5.57	6.24	6.46	7.02	5.99
Particle Size	% Sand (2.0mm - 0.05mm) (%)	43.1	34.4	45.9	69.7	24.5
	% Silt (0.05mm - 2um) (%)	46.7	53.1	45.7	22.4	60.6
	% Clay (<2um) (%)	10.2	12.5	8.39	7.83	14.9
	Texture	Loam	Silt loam	Loam	Sandy loam	Silt loam
Plant Available Nutrients	Cation Exchange Capacity (meq/100g)	11.1	15.6	15.8	8.53	18.8
Metals	Aluminum (Al) (mg/kg)	12700	18200	15800	13000	18800
	Antimony (Sb) (mg/kg)	0.32	0.41	0.51	0.56	0.37
	Arsenic (As) (mg/kg)	5.08	5.69	5.04	7.81	6.82
	Barium (Ba) (mg/kg)	113	146	242	124	252
	Beryllium (Be) (mg/kg)	0.53	0.62	0.37	0.40	0.38
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)	0.055	0.088	0.082	0.045	0.049
	Calcium (Ca) (mg/kg)	4030	5110	4900	3920	3780
	Chromium (Cr) (mg/kg)	24.2	34.6	30.2	27.5	34.0
	Cobalt (Co) (mg/kg)	9.14	10.7	8.03	8.68	7.35
	Copper (Cu) (mg/kg)	14.1	20.0	17.0	27.0	12.7
	Iron (Fe) (mg/kg)	22200	26200	23800	25000	25000
	Lead (Pb) (mg/kg)	5.52	7.08	6.15	5.52	7.23
	Lithium (Li) (mg/kg)	11.6	14.8	9.4	8.3	10.9
	Magnesium (Mg) (mg/kg)	4190	5300	4860	5550	4690
	Manganese (Mn) (mg/kg)	396	426	335	311	190
	Mercury (Hg) (mg/kg)	0.0163	0.0280	0.0104	0.0122	0.0141
	Molybdenum (Mo) (mg/kg)	0.34	0.40	0.66	0.55	0.62
	Nickel (Ni) (mg/kg)	13.8	21.0	21.7	23.8	18.6
	Phosphorus (P) (mg/kg)	676	721	770	683	300
	Potassium (K) (mg/kg)	670	990	760	1520	620
	Selenium (Se) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Silver (Ag) (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Sodium (Na) (mg/kg)	140	173	113	101	91
	Strontium (Sr) (mg/kg)	31.9	35.7	26.7	19.9	28.2
	Thallium (Tl) (mg/kg)	0.070	0.106	0.086	0.104	0.094
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	613	829	528	588	534

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1813304-6 SOIL 09-AUG-16 S11-BM2	L1813304-7 SOIL 09-AUG-16 S02-B	L1813304-8 SOIL 09-AUG-16 S02-BM1	L1813304-9 SOIL 09-AUG-16 S02-BM2	L1813304-10 SOIL 09-AUG-16 S01-BM1
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	6.74	13.6	8.17	6.31	14.3
	pH (1:2 soil:water) (pH)	5.22	6.00	6.36	6.50	5.14
Particle Size	% Sand (2.0mm - 0.05mm) (%)	46.3	28.7	19.0	40.1	34.2
	% Silt (0.05mm - 2um) (%)	38.8	64.4	73.8	44.7	47.5
	% Clay (<2um) (%)	14.9	6.91	7.19	15.2	18.2
	Texture	Loam	Silt loam	Silt loam	Loam	Loam
Plant Available Nutrients	Cation Exchange Capacity (meq/100g)	19.9	7.05	10.4	6.61	22.8
Metals	Aluminum (Al) (mg/kg)	19100	12300	14300	22100	25900
	Antimony (Sb) (mg/kg)	0.68	0.31	0.58	0.67	0.59
	Arsenic (As) (mg/kg)	7.41	3.36	8.43	13.3	10.6
	Barium (Ba) (mg/kg)	193	179	140	190	292
	Beryllium (Be) (mg/kg)	0.56	0.29	0.37	0.58	0.59
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)	0.035	0.112	0.051	0.052	0.054
	Calcium (Ca) (mg/kg)	3850	3300	3080	4050	5090
	Chromium (Cr) (mg/kg)	40.1	27.3	33.9	44.4	49.1
	Cobalt (Co) (mg/kg)	9.33	7.31	7.21	9.94	11.8
	Copper (Cu) (mg/kg)	33.4	7.33	12.7	25.9	21.4
	Iron (Fe) (mg/kg)	27600	21700	25100	31500	32000
	Lead (Pb) (mg/kg)	5.31	6.42	6.91	7.30	7.84
	Lithium (Li) (mg/kg)	10.2	8.1	11.4	10.4	13.1
	Magnesium (Mg) (mg/kg)	5180	3680	5300	6360	6590
	Manganese (Mn) (mg/kg)	167	279	197	254	388
	Mercury (Hg) (mg/kg)	0.0234	0.0080	0.0119	0.0160	0.0255
	Molybdenum (Mo) (mg/kg)	0.42	0.74	0.99	0.80	0.71
	Nickel (Ni) (mg/kg)	25.4	14.0	19.4	28.7	25.7
	Phosphorus (P) (mg/kg)	233	589	320	344	290
	Potassium (K) (mg/kg)	570	1320	1750	2020	790
	Selenium (Se) (mg/kg)	<0.20	<0.20	0.20	0.35	<0.20
	Silver (Ag) (mg/kg)	<0.10	0.14	0.10	<0.10	<0.10
	Sodium (Na) (mg/kg)	126	104	104	151	196
	Strontium (Sr) (mg/kg)	29.7	20.9	22.4	27.0	37.0
	Thallium (Tl) (mg/kg)	0.070	0.078	0.090	0.110	0.135
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	793	630	802	997	1150

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813304-11	L1813304-12	L1813304-13	L1813304-14	L1813304-15
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S01-BM2	S01-BC	S18-BM1	S18-BM2	S15-BM1
SOIL						
Physical Tests	Moisture (%)	14.5	7.08	13.3	7.74	11.8
	pH (1:2 soil:water) (pH)	5.85	8.18	7.11	7.57	7.10
Particle Size	% Sand (2.0mm - 0.05mm) (%)	45.1	40.5	56.7	61.7	58.0
	% Silt (0.05mm - 2um) (%)	41.2	53.4	30.8	28.6	30.3
	% Clay (<2um) (%)	13.7	6.16	12.6	9.63	11.6
	Texture	Loam	Silt loam	Sandy loam	Sandy loam	Sandy loam
Plant Available Nutrients	Cation Exchange Capacity (meq/100g)	17.5	13.4	20.2	8.43	10.6
Metals	Aluminum (Al) (mg/kg)	18700	15500	14300	10500	12300
	Antimony (Sb) (mg/kg)	0.61	0.66	0.47	0.67	0.59
	Arsenic (As) (mg/kg)	9.75	7.49	7.00	7.27	5.82
	Barium (Ba) (mg/kg)	231	213	393	199	197
	Beryllium (Be) (mg/kg)	0.54	0.43	0.48	0.40	0.39
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)	0.054	0.097	0.261	0.135	0.102
	Calcium (Ca) (mg/kg)	5190	16300	5250	5000	4870
	Chromium (Cr) (mg/kg)	37.8	31.9	28.1	25.1	27.7
	Cobalt (Co) (mg/kg)	11.5	10.6	16.5	7.99	7.93
	Copper (Cu) (mg/kg)	29.4	29.8	22.9	23.8	48.3
	Iron (Fe) (mg/kg)	29400	24600	23700	21500	21000
	Lead (Pb) (mg/kg)	6.60	5.52	5.68	5.46	5.20
	Lithium (Li) (mg/kg)	10.5	10.0	10.4	6.8	6.6
	Magnesium (Mg) (mg/kg)	5970	6310	3910	4110	3820
	Manganese (Mn) (mg/kg)	468	506	1440	396	372
	Mercury (Hg) (mg/kg)	0.0308	0.0383	0.0266	0.0340	0.0271
	Molybdenum (Mo) (mg/kg)	0.60	0.51	0.56	0.69	0.54
	Nickel (Ni) (mg/kg)	28.9	26.2	25.8	20.4	18.5
	Phosphorus (P) (mg/kg)	379	614	466	779	698
	Potassium (K) (mg/kg)	730	720	490	830	1000
	Selenium (Se) (mg/kg)	0.23	<0.20	0.28	<0.20	<0.20
	Silver (Ag) (mg/kg)	<0.10	<0.10	0.11	<0.10	<0.10
	Sodium (Na) (mg/kg)	220	298	151	240	274
	Strontium (Sr) (mg/kg)	37.5	54.9	29.0	29.4	34.5
	Thallium (Tl) (mg/kg)	0.073	0.068	0.057	0.078	0.077
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	955	863	453	536	723

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-16	L1813304-17	L1813304-18	L1813304-19	L1813304-20
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	09-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S15-BM2	M29-BM1	M29-BM2	S08-BM1	S08-BM2
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	10.6	19.6	21.8	14.6	13.7
	pH (1:2 soil:water) (pH)	7.54	7.01	7.13	6.34	6.66
Particle Size	% Sand (2.0mm - 0.05mm) (%)	65.3	22.3	22.8	53.9	47.8
	% Silt (0.05mm - 2um) (%)	26.7	55.1	57.4	36.4	41.4
	% Clay (<2um) (%)	8.07	22.6	19.7	9.66	10.8
	Texture	Sandy loam	Silt loam	Silt loam	Sandy loam	Loam
Plant Available Nutrients	Cation Exchange Capacity (meq/100g)	6.83	25.2	26.8	17.2	18.1
Metals	Aluminum (Al) (mg/kg)	10300	19700	19800	12200	13600
	Antimony (Sb) (mg/kg)	0.72	0.92	0.93	0.42	0.54
	Arsenic (As) (mg/kg)	10.0	9.94	10.1	5.78	7.10
	Barium (Ba) (mg/kg)	188	305	346	215	251
	Beryllium (Be) (mg/kg)	0.39	0.73	0.74	0.35	0.41
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)	0.139	0.255	0.282	0.084	0.099
	Calcium (Ca) (mg/kg)	4930	7060	8560	5380	5890
	Chromium (Cr) (mg/kg)	26.7	39.1	40.1	23.7	28.5
	Cobalt (Co) (mg/kg)	7.56	15.3	14.5	8.65	9.83
	Copper (Cu) (mg/kg)	35.9	39.0	41.6	40.2	42.8
	Iron (Fe) (mg/kg)	20900	33400	34600	21500	23200
	Lead (Pb) (mg/kg)	4.94	9.48	9.24	5.16	5.90
	Lithium (Li) (mg/kg)	5.9	11.2	11.4	6.9	7.7
	Magnesium (Mg) (mg/kg)	3540	7960	7910	4070	4700
	Manganese (Mn) (mg/kg)	388	762	696	451	559
	Mercury (Hg) (mg/kg)	0.0354	0.0468	0.0495	0.0286	0.0386
	Molybdenum (Mo) (mg/kg)	0.64	0.97	0.91	0.50	0.49
	Nickel (Ni) (mg/kg)	19.1	38.9	39.3	17.1	22.6
	Phosphorus (P) (mg/kg)	766	899	935	563	647
	Potassium (K) (mg/kg)	1010	2210	2020	520	530
	Selenium (Se) (mg/kg)	0.21	0.22	0.29	0.22	0.34
	Silver (Ag) (mg/kg)	<0.10	0.10	0.13	<0.10	<0.10
	Sodium (Na) (mg/kg)	322	586	605	187	189
	Strontium (Sr) (mg/kg)	34.8	54.5	62.1	35.3	37.7
	Thallium (Tl) (mg/kg)	0.080	0.169	0.148	0.057	0.054
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	665	993	1020	636	650

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1813304-21	L1813304-22	L1813304-23	L1813304-24	L1813304-25
	Sample ID	L1813304-21	L1813304-22	L1813304-23	L1813304-24	L1813304-25
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S16-BM1	S16-BM2	S17-AH	S17-BM1	S17-BM2
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	28.4	13.3	14.8	6.98	3.40
	pH (1:2 soil:water) (pH)	6.24	6.53	5.24	4.99	5.06
Particle Size	% Sand (2.0mm - 0.05mm) (%)	38.8	60.0	55.9	42.8	72.1
	% Silt (0.05mm - 2um) (%)	48.0	29.1	37.2	45.4	21.4
	% Clay (<2um) (%)	13.2	10.9	6.81	11.8	6.52
	Texture	Loam	Sandy loam	Sandy loam	Loam	Sandy loam
Plant Available Nutrients	Cation Exchange Capacity (meq/100g)	29.4 DLHC	13.9	16.4	17.7	9.60
Metals	Aluminum (Al) (mg/kg)	17700	13400	16300	24200	22900
	Antimony (Sb) (mg/kg)	0.57	0.64	0.24	0.52	0.23
	Arsenic (As) (mg/kg)	5.86	6.95	5.59	11.0	10.8
	Barium (Ba) (mg/kg)	234	192	191	149	156
	Beryllium (Be) (mg/kg)	0.49	0.46	0.32	0.48	0.51
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	0.21	<0.20	0.34
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)	0.126	0.182	0.074	0.064	0.046
	Calcium (Ca) (mg/kg)	7380	5040	2720	1650	2310
	Chromium (Cr) (mg/kg)	29.0	26.0	17.4	34.9	15.7
	Cobalt (Co) (mg/kg)	9.32	9.46	10.1	8.17	11.0
	Copper (Cu) (mg/kg)	132	98.9	221	274	930
	Iron (Fe) (mg/kg)	26200	25700	26200	31600	42500
	Lead (Pb) (mg/kg)	6.49	5.83	5.57	7.08	4.26
	Lithium (Li) (mg/kg)	10.4	8.4	8.9	10.9	9.7
	Magnesium (Mg) (mg/kg)	6920	5700	4790	6300	9650
	Manganese (Mn) (mg/kg)	419	526	359	310	605
	Mercury (Hg) (mg/kg)	0.0414	0.0302	0.0168	0.0202	0.0106
	Molybdenum (Mo) (mg/kg)	0.60	0.91	0.55	0.81	0.44
	Nickel (Ni) (mg/kg)	20.9	22.9	13.6	22.3	13.1
	Phosphorus (P) (mg/kg)	713	758	1190	390	621
	Potassium (K) (mg/kg)	3160	2080	990	2120	7550
	Selenium (Se) (mg/kg)	0.27	<0.20	<0.20	<0.20	<0.20
	Silver (Ag) (mg/kg)	0.12	<0.10	0.45	0.35	0.13
	Sodium (Na) (mg/kg)	160	136	77	87	82
	Strontium (Sr) (mg/kg)	43.5	29.3	27.5	22.7	56.6
	Thallium (Tl) (mg/kg)	0.185	0.136	0.174	0.188	0.465
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	895	764	1120	1200	2000

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1813304-26	L1813304-27	L1813304-28	L1813304-29	L1813304-30
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S07-B	S06-B	S05-BM1	S05-BM2	S21-BM2
SOIL						
Physical Tests	Moisture (%)	20.8	18.6	22.5	20.8	10.2
	pH (1:2 soil:water) (pH)	5.94	5.20	5.75	5.99	5.77
Particle Size	% Sand (2.0mm - 0.05mm) (%)	46.6	58.5	55.5	50.2	42.9
	% Silt (0.05mm - 2um) (%)	42.4	35.1	37.2	41.5	42.7
	% Clay (<2um) (%)	11.0	6.40	7.29	8.21	14.4
	Texture	Loam	Sandy loam	Sandy loam	Loam	Loam
Plant Available Nutrients	Cation Exchange Capacity (meq/100g)	4.62	19.7	21.5	19.0	17.6
Metals	Aluminum (Al) (mg/kg)	17300	23800	13200	14200	15400
	Antimony (Sb) (mg/kg)	0.45	0.38	0.37	0.48	0.56
	Arsenic (As) (mg/kg)	9.74	9.62	7.61	9.19	8.74
	Barium (Ba) (mg/kg)	379	222	273	315	225
	Beryllium (Be) (mg/kg)	0.53	0.43	0.36	0.49	0.51
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)	0.075	0.067	0.058	0.108	0.050
	Calcium (Ca) (mg/kg)	5130	1520	5100	6450	4870
	Chromium (Cr) (mg/kg)	30.1	23.3	24.7	28.3	33.1
	Cobalt (Co) (mg/kg)	10.2	8.89	9.82	11.9	10.7
	Copper (Cu) (mg/kg)	694	761	122	117	26.8
	Iron (Fe) (mg/kg)	29400	38700	25000	27700	25400
	Lead (Pb) (mg/kg)	7.49	7.25	6.12	7.13	6.36
	Lithium (Li) (mg/kg)	8.7	12.2	6.9	9.0	10.3
	Magnesium (Mg) (mg/kg)	4810	7080	5060	5930	5330
	Manganese (Mn) (mg/kg)	424	353	386	503	420
	Mercury (Hg) (mg/kg)	0.0297	0.0192	0.0265	0.0283	0.0230
	Molybdenum (Mo) (mg/kg)	2.54	4.95	2.02	1.92	0.57
	Nickel (Ni) (mg/kg)	19.3	17.7	20.6	25.8	23.7
	Phosphorus (P) (mg/kg)	712	676	796	777	395
	Potassium (K) (mg/kg)	860	3450	620	730	620
	Selenium (Se) (mg/kg)	0.58	0.32	0.51	0.56	<0.20
	Silver (Ag) (mg/kg)	0.15	0.34	<0.10	<0.10	<0.10
	Sodium (Na) (mg/kg)	169	73	212	223	203
	Strontium (Sr) (mg/kg)	40.4	16.8	40.2	47.7	31.6
	Thallium (Tl) (mg/kg)	0.092	0.205	0.074	0.100	0.074
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	783	1320	788	879	752

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1813304-31 SOIL 09-AUG-16 S22-BM1	L1813304-32 SOIL 10-AUG-16 S23-B	L1813304-33 SOIL 09-AUG-16 S24-BM1	L1813304-34 SOIL 11-AUG-16 M80-BM1	L1813304-35 SOIL 11-AUG-16 M80-BM2
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	8.44	17.3	14.4	8.75	3.37
	pH (1:2 soil:water) (pH)	6.34	5.94	6.10	4.64	5.27
Particle Size	% Sand (2.0mm - 0.05mm) (%)	19.4	44.2	23.4	56.0	93.7
	% Silt (0.05mm - 2um) (%)	72.7	43.5	60.1	30.8	2.89
	% Clay (<2um) (%)	7.88	12.3	16.5	13.2	3.41
	Texture	Silt loam	Loam	Silt loam	Sandy loam	Sand
Plant Available Nutrients	Cation Exchange Capacity (meq/100g)	11.3	8.73	20.0	16.5	6.73
Metals	Aluminum (Al) (mg/kg)	12200	12500	18800	19500	9160
	Antimony (Sb) (mg/kg)	0.60	0.46	0.41	0.63	0.75
	Arsenic (As) (mg/kg)	9.70	8.92	7.57	8.80	5.89
	Barium (Ba) (mg/kg)	130	306	264	129	70.5
	Beryllium (Be) (mg/kg)	0.34	0.48	0.41	0.28	0.21
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)	0.055	0.078	0.055	0.099	0.089
	Calcium (Ca) (mg/kg)	2710	4760	4130	2090	2170
	Chromium (Cr) (mg/kg)	31.2	27.6	37.1	35.6	25.1
	Cobalt (Co) (mg/kg)	6.81	9.61	7.97	7.75	6.02
	Copper (Cu) (mg/kg)	12.2	634	13.5	24.6	17.0
	Iron (Fe) (mg/kg)	22900	23700	25600	28600	19900
	Lead (Pb) (mg/kg)	6.34	7.22	7.73	5.91	3.66
	Lithium (Li) (mg/kg)	9.9	7.2	11.8	8.8	4.0
	Magnesium (Mg) (mg/kg)	4760	3940	4830	4170	2340
	Manganese (Mn) (mg/kg)	218	360	219	209	202
	Mercury (Hg) (mg/kg)	0.0107	0.0237	0.0125	0.0128	0.0054
	Molybdenum (Mo) (mg/kg)	0.97	2.10	0.66	0.92	0.58
	Nickel (Ni) (mg/kg)	18.4	16.3	19.9	19.4	18.1
	Phosphorus (P) (mg/kg)	332	719	317	432	381
	Potassium (K) (mg/kg)	1630	650	710	750	490
	Selenium (Se) (mg/kg)	0.23	0.56	<0.20	<0.20	<0.20
	Silver (Ag) (mg/kg)	0.11	0.15	<0.10	<0.10	<0.10
	Sodium (Na) (mg/kg)	97	135	93	85	59
	Strontium (Sr) (mg/kg)	19.3	32.4	29.2	19.2	19.4
	Thallium (Tl) (mg/kg)	0.084	0.067	0.103	0.075	<0.050
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	694	552	640	830	551

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-36	L1813304-37	L1813304-38	L1813304-39	L1813304-40
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	M26-BM1	M26-BM2	C02-B1	S09-B1	M07B-B1
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	16.8	17.0	15.7	10.5	34.1
	pH (1:2 soil:water) (pH)	6.59	6.95	6.90	5.64	5.91
Particle Size	% Sand (2.0mm - 0.05mm) (%)	29.7	26.6	60.7	64.9	64.2
	% Silt (0.05mm - 2um) (%)	41.6	43.6	30.6	29.1	27.3
	% Clay (<2um) (%)	28.7	29.8	8.67	6.04	8.43
	Texture	Clay loam	Clay loam	Sandy loam	Sandy loam	Sandy loam
Plant Available Nutrients	Cation Exchange Capacity (meq/100g)	29.8 DLHC	29.6 DLHC	13.6	15.8	25.6
Metals	Aluminum (Al) (mg/kg)	25800	26200	16100	25300	12700
	Antimony (Sb) (mg/kg)	0.54	0.61	0.45	0.21	0.34
	Arsenic (As) (mg/kg)	8.96	8.58	8.12	5.87	3.08
	Barium (Ba) (mg/kg)	259	299	199	298	310
	Beryllium (Be) (mg/kg)	0.91	1.03	0.30	0.50	0.45
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Cadmium (Cd) (mg/kg)	0.034	0.029	0.054	0.089	0.085
	Calcium (Ca) (mg/kg)	5520	6060	4080	5720	7830
	Chromium (Cr) (mg/kg)	50.4	52.4	27.9	16.2	22.0
	Cobalt (Co) (mg/kg)	15.5	12.6	8.42	10.4	7.93
	Copper (Cu) (mg/kg)	34.6	41.3	25.5	11.6	48.4
	Iron (Fe) (mg/kg)	33900	33500	24700	37600	20000
	Lead (Pb) (mg/kg)	9.67	10.2	5.50	6.81	4.65
	Lithium (Li) (mg/kg)	12.2	14.1	9.5	9.3	6.8
	Magnesium (Mg) (mg/kg)	7260	7350	4680	8910	4020
	Manganese (Mn) (mg/kg)	737	452	200	384	308
	Mercury (Hg) (mg/kg)	0.0264	0.0320	0.0156	0.0072	0.0335
	Molybdenum (Mo) (mg/kg)	0.46	0.40	0.66	0.38	0.25
	Nickel (Ni) (mg/kg)	21.7	21.3	19.1	10.6	17.0
	Phosphorus (P) (mg/kg)	250	230	243	1190	411
	Potassium (K) (mg/kg)	1210	1200	590	1080	830
	Selenium (Se) (mg/kg)	<0.20	0.23	<0.20	<0.20	0.33
	Silver (Ag) (mg/kg)	<0.10	0.10	<0.10	<0.10	<0.10
	Sodium (Na) (mg/kg)	237	240	126	275	116
	Strontium (Sr) (mg/kg)	51.4	54.5	23.8	60.7	53.6
	Thallium (Tl) (mg/kg)	0.097	0.106	0.060	0.081	0.064
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	1200	1160	838	1540	768

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-41	L1813304-42	L1813304-43	L1813304-44	
	Description	SOIL	SOIL	SOIL	SOIL	
	Sampled Date	11-AUG-16	12-AUG-16	12-AUG-16	12-AUG-16	
	Sampled Time					
	Client ID	M07B-B2	S04-BM1	S19-BM1	S19-BM2	
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	40.4	7.65	12.4	3.48	
	pH (1:2 soil:water) (pH)	5.65	5.08	5.25	5.18	
Particle Size	% Sand (2.0mm - 0.05mm) (%)	49.4	50.7	20.5	79.1	
	% Silt (0.05mm - 2um) (%)	43.6	36.1	65.6	16.2	
	% Clay (<2um) (%)	7.04	13.2	14.0	4.62	
	Texture	Loam / Sandy loam	Loam	Silt loam	Loamy sand	
Plant Available Nutrients	Cation Exchange Capacity (meq/100g)	63.0 DLHC	17.8	19.8	11.5	
Metals	Aluminum (Al) (mg/kg)	9320	25100	26400	20100	
	Antimony (Sb) (mg/kg)	0.27	0.52	0.69	0.15	
	Arsenic (As) (mg/kg)	2.91	11.4	14.0	4.32	
	Barium (Ba) (mg/kg)	271	164	266	141	
	Beryllium (Be) (mg/kg)	0.32	0.52	0.49	0.31	
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	0.22	<0.20	
	Boron (B) (mg/kg)	<5.0	<5.0	<5.0	<5.0	
	Cadmium (Cd) (mg/kg)	0.085	0.035	0.063	0.022	
	Calcium (Ca) (mg/kg)	6420	1810	2080	3020	
	Chromium (Cr) (mg/kg)	16.6	31.2	41.3	13.4	
	Cobalt (Co) (mg/kg)	6.58	8.63	11.3	10.8	
	Copper (Cu) (mg/kg)	31.3	15.2	41.8	11.3	
	Iron (Fe) (mg/kg)	15600	33300	39800	34800	
	Lead (Pb) (mg/kg)	3.40	7.92	11.0	3.55	
	Lithium (Li) (mg/kg)	4.6	12.8	18.0	8.2	
	Magnesium (Mg) (mg/kg)	2830	6900	6510	9290	
	Manganese (Mn) (mg/kg)	253	315	424	530	
	Mercury (Hg) (mg/kg)	0.0266	0.0131	0.0134	<0.0050	
	Molybdenum (Mo) (mg/kg)	0.28	0.80	1.84	0.45	
	Nickel (Ni) (mg/kg)	13.4	19.3	18.7	7.26	
	Phosphorus (P) (mg/kg)	485	368	855	1140	
	Potassium (K) (mg/kg)	710	1670	1240	5870	
	Selenium (Se) (mg/kg)	0.29	<0.20	<0.20	<0.20	
	Silver (Ag) (mg/kg)	<0.10	<0.10	<0.10	<0.10	
	Sodium (Na) (mg/kg)	104	94	104	97	
	Strontium (Sr) (mg/kg)	46.5	31.1	25.5	17.8	
	Thallium (Tl) (mg/kg)	<0.050	0.121	0.138	0.204	
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	
	Titanium (Ti) (mg/kg)	553	912	880	1420	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-1	L1813304-2	L1813304-3	L1813304-4	L1813304-5
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	C01-BM1	C01-BM2	S03-BM1	S03-BM2	S11-BM1
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	1.12	1.14	0.377	0.449	0.379
	Vanadium (V) (mg/kg)	54.2	62.8	58.2	53.3	62.6
	Zinc (Zn) (mg/kg)	37.7	56.8	39.6	43.3	39.8
	Zirconium (Zr) (mg/kg)	5.2	8.6	2.5	3.6	1.3

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-6	L1813304-7	L1813304-8	L1813304-9	L1813304-10
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S11-BM2	S02-B	S02-BM1	S02-BM2	S01-BM1
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	0.923	0.344	0.540	0.625	0.982
	Vanadium (V) (mg/kg)	70.7	55.6	59.2	77.7	88.4
	Zinc (Zn) (mg/kg)	44.9	34.8	45.3	48.4	50.1
	Zirconium (Zr) (mg/kg)	12.2	2.6	3.7	8.4	5.2

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-11	L1813304-12	L1813304-13	L1813304-14	L1813304-15
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S01-BM2	S01-BC	S18-BM1	S18-BM2	S15-BM1
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	0.720	0.410	0.880	0.513	0.565
	Vanadium (V) (mg/kg)	71.3	60.4	55.2	47.9	50.1
	Zinc (Zn) (mg/kg)	50.8	48.9	38.3	49.3	43.5
	Zirconium (Zr) (mg/kg)	7.8	3.4	<1.0	4.8	5.1

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-16	L1813304-17	L1813304-18	L1813304-19	L1813304-20
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	09-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S15-BM2	M29-BM1	M29-BM2	S08-BM1	S08-BM2
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	0.514	0.933	1.24	1.15	1.40
	Vanadium (V) (mg/kg)	48.8	68.6	71.7	51.6	56.2
	Zinc (Zn) (mg/kg)	46.3	81.3	81.6	37.7	42.1
	Zirconium (Zr) (mg/kg)	4.8	9.6	8.0	2.0	3.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-21	L1813304-22	L1813304-23	L1813304-24	L1813304-25
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16
	Sampled Time					
	Client ID	S16-BM1	S16-BM2	S17-AH	S17-BM1	S17-BM2
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	1.30	0.943	0.371	0.529	0.557
	Vanadium (V) (mg/kg)	64.8	59.0	61.8	77.7	93.9
	Zinc (Zn) (mg/kg)	76.9	64.5	67.9	66.0	110
	Zirconium (Zr) (mg/kg)	4.2	3.4	1.0	4.9	4.9

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-26	L1813304-27	L1813304-28	L1813304-29	L1813304-30
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	10-AUG-16	10-AUG-16	10-AUG-16	10-AUG-16	09-AUG-16
	Sampled Time					
	Client ID	S07-B	S06-B	S05-BM1	S05-BM2	S21-BM2
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	0.976	0.391	0.953	1.17	0.661
	Vanadium (V) (mg/kg)	67.8	96.5	62.3	66.3	62.4
	Zinc (Zn) (mg/kg)	53.9	82.5	41.8	49.1	42.6
	Zirconium (Zr) (mg/kg)	3.0	1.3	3.2	4.9	6.7

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-31	L1813304-32	L1813304-33	L1813304-34	L1813304-35
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	09-AUG-16	10-AUG-16	09-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	S22-BM1	S23-B	S24-BM1	M80-BM1	M80-BM2
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	0.500	0.887	0.414	0.388	0.367
	Vanadium (V) (mg/kg)	56.3	55.0	66.0	73.3	50.0
	Zinc (Zn) (mg/kg)	42.2	45.3	42.6	41.6	31.5
	Zirconium (Zr) (mg/kg)	3.0	3.0	1.5	1.7	4.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-36	L1813304-37	L1813304-38	L1813304-39	L1813304-40
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16	11-AUG-16
	Sampled Time					
	Client ID	M26-BM1	M26-BM2	C02-B1	S09-B1	M07B-B1
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	1.62	2.09	0.405	0.244	1.00
	Vanadium (V) (mg/kg)	95.8	98.6	65.8	102	61.1
	Zinc (Zn) (mg/kg)	43.5	40.6	36.1	114	42.7
	Zirconium (Zr) (mg/kg)	15.5	17.8	4.4	2.2	6.5

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1813304-41	L1813304-42	L1813304-43	L1813304-44	
	Description	SOIL	SOIL	SOIL	SOIL	
	Sampled Date	11-AUG-16	12-AUG-16	12-AUG-16	12-AUG-16	
	Sampled Time					
	Client ID	M07B-B2	S04-BM1	S19-BM1	S19-BM2	
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	0.816	0.380	0.541	0.269	
	Vanadium (V) (mg/kg)	43.1	77.8	93.6	87.4	
	Zinc (Zn) (mg/kg)	33.3	60.6	67.7	84.8	
	Zirconium (Zr) (mg/kg)	3.8	3.5	3.9	1.7	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Strontium (Sr)	DUP-H	L1813304-1, -2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
DUP-H	Duplicate results outside ALS DQO, due to sample heterogeneity.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CEC-SK	Soil	Cation Exchange Capacity (NH4OAC Extn)	CSSS(1978) 3.321/Comm Soil Sci 17(7)

Soil exchange sites are saturated with ammonium, then displaced with sodium. Ammonium in the extract is determined colorimetrically.

ALS Test Code	Matrix	Test Description	Method Reference**
HG-200.2-CVAF-VA	Soil	Mercury in Soil by CVAFS	EPA 200.2/1631E (mod)

Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CVAFS.

ALS Test Code	Matrix	Test Description	Method Reference**
MET-200.2-CCMS-VA	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A (mod)

Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CRC ICPMS.

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. This method does not dissolve all silicate materials and may result in a partial extraction. depending on the sample matrix, for some metals, including, but not limited to Al, Ba, Be, Cr, Sr, Ti, Tl, and V.

ALS Test Code	Matrix	Test Description	Method Reference**
MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-1:2-VA	Soil	pH in Soil (1:2 Soil:Water Extraction)	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

ALS Test Code	Matrix	Test Description	Method Reference**
PSA-1-SK	Soil	Particle Size Analysis:Mini-Pipet Method	SSIR-51 Method 3.2.1

Dry, < 2 mm soil is treated with sodium hexametaphosphate to ensure complete dispersion of primary soil particles. The homogenized suspension is allowed to settle in accordance with Stoke's Law so that only clay particles remain in suspension.To determine the clay fraction, an aliquot of the clay suspension is removed, then dried and weighed. The sand fraction is determined by wet sieving the remaining suspension, then drying and weighing the sand retained on the sieve. The silt fraction is determined by calculation where % Silt = 100 - (%Sand+%Clay)

Reference:
Burt, R. (2009). Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 5. Method 3.2.1.2.2. United States Department of Agriculture Natural Resources Conservation Service.

Kalra, Y.P., Maynard, D.G. 1991. Methods manual for forest soil and plant analysis. Forestry Canada. p. 42-45.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1813304-COFC

COC Number: 14 -

Report To	
Company:	Minto Explorations Ltd.
Contact:	Minto Environment - Coordinator
Address:	2100-510 West Georgia St. Vancouver, BC
Phone:	604-759-4659

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ Yes ☐ No

☐ Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: minto_environment@mintomine.com

Email 2: mheynen@accessconsulting.ca,muducharme@accessconsulting.ca

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

R ☑ Regular (Standard TAT if received by 3 pm - business days)

P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT

E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT

E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To — Same as Report To ☑ Yes ☐ No

Copy of Invoice with Report ☑ Yes ☐ No

Company:

Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: ap@mintomine.com

Email 2:

Project Information

ALS Quote #:	
Job #:	MIN 16-07 (2016 Minto VMU)
PO / AFE:	222458
LSD:	

Oil and Gas Required Fields (client use)

Approver ID:	Cost Center:
GL Account:	Routing Code:
Activity Code:	
Location:	

ALS Lab Work Order # (lab use only):

ALS Contact: Ariel McDonnell

Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-CCME+FULL-VA	MOISTURE-VA	PSA-1-SK	CEC-SK	PREP-DRY/GRIND-SK	Number of Containers
	C01-Bm1	09-Aug-16	-	Soil	R	R	R	R	R	
	C01-Bm2	09-Aug-16	-	Soil	R	R	R	R	R	
	S03-Bm1	09-Aug-16	-	Soil	R	R	R	R	R	
	S03-Bm2	09-Aug-16	-	Soil	R	R	R	R	R	
	S11-Bm1	09-Aug-16	-	Soil	R	R	R	R	R	
	S11-Bm2	09-Aug-16	-	Soil	R	R	R	R	R	
	S02-B	09-Aug-16	-	Soil	R	R	R	R	R	
	S02-Bm1	09-Aug-16	-	Soil	R	R	R	R	R	
	S02-Bm2	09-Aug-16	-	Soil	R	R	R	R	R	
	S01-Bm1	09-Aug-16	-	Soil	R	R	R	R	R	
	S01-Bm2	09-Aug-16	-	Soil	R	R	R	R	R	
	S01-BC	09-Aug-16	-	Soil	R	R	R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples: Will require subsample & rinsing for some samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☑ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 5

FINAL COOLER TEMPERATURES °C: 5.1, 3.3, 4.9, 3.6, 6

SHIPMENT RELEASE (client use)	INITIAL SHIPMENT RECEPTION (lab use only)	FINAL SHIPMENT RECEPTION (lab use only)
Released by: [signature] Date: Aug 12/16 Time: 15:15	Received by: [signature] Date: Aug-12-16 Time: 3:30pm	Received by: SHAYAN Date: AUG.13 Time: 1300

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY

NA-FM-0326e v09 Front/04 January 2014

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ALS Environmental

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Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1813304-COFC

COC Number: 14 -

Report To

Company: Minto Explorations Ltd.
Contact: Minto Environment - Coordinator
Address: 2100-510 West Georgia St. Vancouver, BC
Phone: 604-759-4659

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ Yes ☐ No
☐ Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: minto_environment@mintomine.com
Email 2: mheynen@accessconsulting.ca,muducharme@accessconsulting.ca

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

R ☑ Regular (Standard TAT if received by 3 pm - business days)
P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Specify Date Required for E2,E or P:

Invoice To

Same as Report To ☑ Yes ☐ No
Copy of Invoice with Report ☑ Yes ☐ No
Company:
Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: ap@mintomine.com
Email 2

Project Information

ALS Quote #:
Job #: MIN 16-07 (2016 Minto VMU)
PO / AFE: 222458
LSD:

Oil and Gas Required Fields (client use)

Approver ID: | Cost Center:
GL Account: | Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only)

ALS Contact: Ariel McDonnell | Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-CCME-FULL-VA	MOISTURE-VA	PSA-1-SK	CEC-SK	PREP-DRY/GRIND-SK	Number of Containers
	S18-Bm1	09-Aug-16	-	Soil	R	R	R	R	R	
	S18-Bm2	09-Aug-16	-	Soil	R	R	R	R	R	
	S15-Bm1	09-Aug-16	-	Soil	R	R	R	R	R	
	S15-Bm2	09-Aug-16	-	Soil	R	R	R	R	R	
	M29-Bm1	10-Aug-16	-	Soil	R	R	R	R	R	
	M29-Bm2	10-Aug-16	-	Soil	R	R	R	R	R	
	S08-Bm1	10-Aug-16	-	Soil	R	R	R	R	R	
	S08-Bm2	10-Aug-16	-	Soil	R	R	R	R	R	
	S16-Bm1	10-Aug-16	-	Soil	R	R	R	R	R	
	S16-Bm2	10-Aug-16	-	Soil	R	R	R	R	R	
	S17-Ah	10-Aug-16	-	Soil	R	R	R	R	R	
	S17-Bm1	10-Aug-16	-	Soil	R	R	R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No
Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples: Will require subsample & rinsing for some samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ | SIF Observations Yes ☐ No ☐
Ice packs Yes ☑ No ☐ | Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 5.0
FINAL COOLER TEMPERATURES °C: 5.1, 3.3, 4.9, 3.6, 6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: [signature]	Date: Aug-12-16	Time: 3:30pm	Received by: SHAYAN	Date: AUG 13	Time: 1300

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION   WHITE - LABORATORY COPY   YELLOW - CLIENT COPY

NA-FM-0326e v09 Front/04 January 2014

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Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1813304-COFC

COC Number: 14 -

Report To		Report Format / Distribution	Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Minto Explorations Ltd.	Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report ☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	2100-510 West Georgia St. Vancouver, BC	☐ Criteria on Report - provide details below if box checked Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	604-759-4659	Email 1 or Fax minto_environment@mintomine.com Email 2 mheynen@accessconsulting.ca,muducharme@accessconsulting.ca	Specify Date Required for E2,E or P:

Invoice To		Invoice Distribution
Same as Report To	☑ Yes ☐ No	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Copy of Invoice with Report	☑ Yes ☐ No	Email 1 or Fax ap@mintomine.com
Company:		Email 2
Contact:		

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:		Approver ID:	Cost Center:
Job #:	MIN 16-07 (2016 Minto VMU)	GL Account:	Routing Code:
PO / AFE:	222458	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact: Ariel McDonnell	Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-CCME+FULL-VA	MOISTURE-VA	PSA-1-SK	CEC-SK	PREP-DRY/GRIND-SK	Number of Containers
	S17-Bm2	10-Aug-16	-	Soil	R	R	R	R	R	
	S07-B	10-Aug-16	-	Soil	R	R	R	R	R	
	S06-B	10-Aug-16	-	Soil	R	R	R	R	R	
	S05-Bm1	10-Aug-16	-	Soil	R	R	R	R	R	
	S05-Bm2	10-Aug-16	-	Soil	R	R	R	R	R	
	S21-Bm2	09-Aug-16	-	Soil	R	R	R	R	R	
	S22-Bm1	09-Aug-16	-	Soil	R	R	R	R	R	
	S23-B	10-Aug-16	-	Soil	R	R	R	R	R	
	S24-Bm1	09-Aug-16	-	Soil	R	R	R	R	R	
	M80-Bm1	11-Aug-16	-	Soil	R	R	R	R	R	
	M80-Bm2	11-Aug-16	-	Soil	R	R	R	R	R	
	M26-Bm1	11-Aug-16	-	Soil	R	R	R	R	R	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples: Will require subsample & rinsing for some samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C	FINAL COOLER TEMPERATURES °C
5.0	5.1, 3.3, 4.9, 3.6, 6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: [signature]	Date: Aug-12-16	Time: 3:30PM	Received by: SHAYAN	Date: AUG.13	Time: 1300

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION   WHITE - LABORATORY COPY   YELLOW - CLIENT COPY

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ALS Environmental
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Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1813304-COFC

COC Number: 14 -

Report To		Report Format / Distribution	
Company:	Minto Explorations Ltd.	Select Report Format:	☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Contact:	Minto Environment - Coordinator	Quality Control (QC) Report with Report	☑ Yes ☐ No
Address:	2100-510 West Georgia St. Vancouver, BC	☐ Criteria on Report - provide details below if box checked; Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Phone:	604-759-4659	Email 1 or Fax	minto_environment@mintomine.com
		Email 2	mheynen@accessconsulting.ca,muducharme@accessconsulting.ca

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☑ Regular (Standard TAT if received by 3 pm - business days)
- P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
- E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
- E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge

Specify Date Required for E2,E or P:

Invoice To		Invoice Distribution	
Same as Report To	☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Copy of Invoice with Report	☑ Yes ☐ No	Email 1 or Fax	ap@mintomine.com
Company:		Email 2	
Contact:			

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:		Approver ID:	Cost Center:
Job #:	MIN 16-07 (2016 Minto VMU)	GL Account:	Routing Code:
PO / AFE:	222458	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact: Ariel McDonnell	Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	MET-CCME+FULL-VA	MOISTURE-VA	PSA-1-SK	CEC-SK	PREP-DRY/GRIND-SK	Number of Containers
	M26-Bm2	11-Aug-16	-	Soil	R	R	R	R	R	
	C02-B1	11-Aug-16	-	Soil	R	R	R	R	R	
	S09-B1	11-Aug-16	-	Soil	R	R	R	R	R	
	M07b-B1	11-Aug-16	-	Soil	R	R	R	R	R	
	M07b-B2	11-Aug-16	-	Soil	R	R	R	R	R	
	S04-Bm1	12-Aug-16	-	Soil	R	R	R	R	R	
	S19-Bm1	12-Aug-16	-	Soil	R	R	R	R	R	
	S19-Bm2	12-Aug-16	-	Soil	R	R	R	R	R	
			-							
			-							
			-							
			-							

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

Vegetation tissue samples: Will require subsample & rinsing for some samples.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C: 5°C
FINAL COOLER TEMPERATURES °C: 5.1, 3.3, 4.9, 3.6, 6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by: [signature]	Date: Aug-12-16	Time: 3:30pm	Received by: SHAYAN	Date: AUG.13	Time: 1300

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY

NA-FM-0326e v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

APPENDIX C

2009-2010 SOIL LAB ANALYSIS RESULTS

Driven by service and Science
www.maxxamanalytics.com

Your Project #: MIN-09-05 REVEGETATION MONITOR
Your C.O.C. #: 08304612, F143924, F143925

Attention: Colleen Roche
MINTO EXPLORATIONS LTD.
#900 - 999 WEST HASTINGS ST.
VANCOUVER, BC
CANADA V6C2W2

Report Date: 2009/10/06

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A953654
Received: 2009/09/25, 01:05

Sample Matrix: Soil
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Cation Exchange Capacity (1)	3	2009/10/02	2009/10/06	EENVSOP-00034	EPA SW846 6010C
Conductivity (Soluble)	3	2009/09/30	2009/10/01	BRN SOP-00267 R3.0	Based Carter 18.3.1
Elements by ICPMS (total)	3	2009/10/01	2009/10/01	BRN SOP-00203 R5.0	Based on EPA 200.8
pH (2:1 DI Water Extract) (4)	3	2009/10/01	2009/10/01	BRN SOP-00266 R6.0	Carter, SSMA 16.2
Saturated Paste	3	2009/09/30	2009/10/01	BRN SOP-00268 R5.0	Carter SSMA 18.2.2
Sublet (ORGANICS) (2)	3	N/A	2009/10/05		
Total Kjeldahl Nitrogen - Soil (14)	3	2009/10/02	2009/10/02	CAL SOP-00072	SM - 4500N
TOC Soil Subcontract (3)	3	2009/10/02	2009/10/02		

Sample Matrix: VEGETABLES
Samples Received: 24

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by CRC ICPMS (total) - Plant	24	2009/10/02	2009/10/02	BRN SOP-00206 R7.0	Based on EPA 200.8

* Results relate only to the items tested.

(1) This test was performed by Maxxam Calgary
(2) This test was performed by Ext. Sublet from Vancouver
(3) This test was performed by Maxxam Bedford(From Burnaby)
(4) SCC/CAEAL

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

VIREN THAKER, BBY Customer Service
Email: VIREN.THAKER@MaxxamAnalytics.com
Phone# (604) 444-4808 Ext:232

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

Total cover pages: 1

MINTO EXPLORATIONS LTD.
Client Project #: MIN-09-05 REVEGETATION MONITOR

Maxxam Job #: A953654
Report Date: 2009/10/06

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		Q95936		Q95937	Q95938		
Sampling Date		2009/09/21		2009/09/21	2009/09/21		
	Units	**TOE OF TAILINGS SOIL**	**QC Batch**	**SOIL SAMPLE LOWER IROD**	**SOIL SAMPLE UPPER IROD**	**RDL**	**QC Batch**
Misc. Inorganics							
Total Kjeldahl Nitrogen	mg/kg	3500(1)	3461533	1500(1)	570(1)	100	3461533
Parameter							
Subcontract Parameter	N/A	ATTACHED	3463366	ATTACHED	ATTACHED	N/A	3465804
Elements							
Cation exchange capacity	cmol+/Kg	35	3461568	24	16	10	3461568
Soluble Parameters							
Soluble Conductivity	uS/cm	2580	3456164	402	284	1	3456164
Saturation %	%	160	3455655	57	47	1	3455655

N/A = Not Applicable
RDL = Reportable Detection Limit
(1) - Detection limits raised due to dilution to bring analyte within the calibrated range.

MINTO EXPLORATIONS LTD.
Client Project #: MIN-09-05 REVEGETATION MONITOR

Maxxam Job #: A953654
Report Date: 2009/10/06

ELEMENTS BY ATOMIC SPECTROSCOPY (VEGETABLES)

Maxxam ID		Q95926	Q95927	Q95928	Q95929	Q95930	Q95931	Q95932	Q95933	Q95934		
Sampling Date		2009/09/22	2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21		
	Units	**YUKON RIVER PLANE-LEAF WILLOW LEAVES**	**COPPER KEEL BIRCH TWIGS**	**COPPER KEEL BIRCH LEAVES**	**WASTE ROCK DUMP 1ST LEVEL LEAF WILLLOW TWIGS**	**TOE OF WASTE ROCK 1ST LIFT WILLOW TWIGS (LITTLE TREE)**	**PLANE-LEAF WILLOW TOE OF WASTE ROCK DUMP 1ST LEVEL**	**TOE OF WASTE ROCK DUMP-WILLOW LEAVES (LITTLE)**	**YUKON RIVER LITTLE TREE**	**YUKON RIVER LITTLE TREE WILLOW TWIGS**	**RDL**	**QC Batch**
Total Metals by ICPMS												
Total Aluminum (Al)	mg/kg	46	27	34	149	158	1740	1120	40	17	1	3461873
Total Antimony (Sb)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461873
Total Arsenic (As)	mg/kg	0.10	<0.01	0.01	0.07	0.07	0.66	0.40	0.04	0.02	0.01	3461873
Total Barium (Ba)	mg/kg	14.8	58.9	143	3.9	4.7	20.3	13.9	109	8.9	0.1	3461873
Total Beryllium (Be)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461873
Total Bismuth (Bi)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461873
Total Boron (B)	mg/kg	50	8	47	12	8	25	26	73	9	5	3461873
Total Cadmium (Cd)	mg/kg	0.51	0.06	0.03	1.15	1.68	2.92	4.78	6.77	0.20	0.01	3461873
Total Calcium (Ca)	mg/kg	28200	6330	20200	6780	3570	41100	19200	31700	6410	10	3461873
Total Chromium (Cr)	mg/kg	1.4	<0.5	<0.5	<0.5	<0.5	1.5	<0.5	<0.5	<0.5	0.5	3461873
Total Cobalt (Co)	mg/kg	0.4	<0.1	<0.1	0.1	0.2	1.0	1.3	0.2	<0.1	0.1	3461873
Total Copper (Cu)	mg/kg	7.7	7.2	6.6	20.4	18.8	145	96.5	3.5	7.5	0.5	3461873
Total Iron (Fe)	mg/kg	97	71	71	199	216	2280	1540	73	33	10	3461873
Total Lead (Pb)	mg/kg	0.19	0.07	0.06	0.08	0.07	0.65	0.48	0.14	0.09	0.01	3461873
Total Magnesium (Mg)	mg/kg	5210	606	1840	1020	692	8880	6400	4180	743	10	3461873
Total Manganese (Mn)	mg/kg	37.9	22.2	107	55.1	83.5	447	954	136	5.8	0.1	3461873
Total Mercury (Hg)	mg/kg	0.02	<0.01	0.01	<0.01	<0.01	0.02	0.02	0.02	<0.01	0.01	3461873
Total Molybdenum (Mo)	mg/kg	1.1	<0.1	0.4	<0.1	0.1	1.3	2.1	1.8	<0.1	0.1	3461873
Total Nickel (Ni)	mg/kg	3.0	0.3	0.2	0.6	0.6	1.7	1.6	0.7	0.8	0.1	3461873
Total Phosphorus (P)	mg/kg	4270	1350	1420	920	890	856	1100	6820	1330	10	3461873
Total Potassium (K)	mg/kg	8270	2410	6090	2710	2330	9460	8170	3700	2560	10	3461873
Total Selenium (Se)	mg/kg	0.89	0.02	0.01	0.99	0.27	3.77	1.00	0.29	0.30	0.01	3461873
Total Silver (Ag)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	3461873
Total Sodium (Na)	mg/kg	10	<10	13	12	11	92	27	<10	<10	10	3461873
Total Strontium (Sr)	mg/kg	113	13.1	31.1	52.8	27.2	293	123	184	29.0	0.1	3461873
Total Thallium (Tl)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	3461873
Total Tin (Sn)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461873
Total Titanium (Ti)	mg/kg	2	1	2	5	6	65	44	2	<1	1	3461873
Total Uranium (U)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	<0.05	0.05	3461873
Total Vanadium (V)	mg/kg	<2	<2	<2	<2	<2	5	3	<2	<2	2	3461873
Total Zinc (Zn)	mg/kg	60.5	97.6	127	70.3	44.9	101	41.4	142	56.5	0.1	3461873

RDL = Reportable Detection Limit

MINTO EXPLORATIONS LTD.
Client Project #: MIN-09-05 REVEGETATION MONITOR

Maxxam Job #: A953654
Report Date: 2009/10/06

ELEMENTS BY ATOMIC SPECTROSCOPY (VEGETABLES)

Maxxam ID		Q95935	Q95939	Q95940	Q95941	Q95942	Q95943	Q95944	Q95945		
Sampling Date		2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21		
	Units	**YUKON RIVER PLANE-LEAF WILLOW TWIGS**	**TUFTED HAIRGRASS LOWER IROD**	**SHEEP FESCUE LOWER IROD**	**VIOLET WHEATGRASS LOWER IROD**	**R.M. FESCUE LOWER IROD**	**TUFTED HAIRGRASS TOE OF TAILINGS**	**VIOLET WHEATGRASS TOE OF TAILINGS**	**GLAUCOUS BLUEGRASS TOE OF TAILINGS**	**RDL**	**QC Batch**
Total Metals by ICPMS											
Total Aluminum (Al)	mg/kg	33	1060	978	702	559	1160	795	637	1	3461873
Total Antimony (Sb)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461873
Total Arsenic (As)	mg/kg	0.03	0.39	0.31	0.17	0.19	0.21	0.16	0.22	0.01	3461873
Total Barium (Ba)	mg/kg	61.4	76.0	47.6	20.4	25.6	25.0	21.8	73.1	0.1	3461873
Total Beryllium (Be)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461873
Total Bismuth (Bi)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461873
Total Boron (B)	mg/kg	16	<5	<5	<5	<5	<5	<5	6	5	3461873
Total Cadmium (Cd)	mg/kg	3.81	0.22	0.17	0.09	0.06	0.08	0.09	0.35	0.01	3461873
Total Calcium (Ca)	mg/kg	12400	4480	3630	4000	1880	2810	3500	8690	10	3461873
Total Chromium (Cr)	mg/kg	<0.5	1.0	0.9	0.6	2.1	1.5	1.6	0.7	0.5	3461873
Total Cobalt (Co)	mg/kg	<0.1	0.7	0.6	0.3	0.4	0.7	0.5	0.8	0.1	3461873
Total Copper (Cu)	mg/kg	5.3	100	81.3	58.5	49.9	213	133	113	0.5	3461873
Total Iron (Fe)	mg/kg	54	1750	1570	1000	882	2610	1800	1460	10	3461873
Total Lead (Pb)	mg/kg	0.15	0.49	0.49	0.32	0.33	0.52	0.44	0.47	0.01	3461873
Total Magnesium (Mg)	mg/kg	830	1550	1430	1310	666	1180	1210	3930	10	3461873
Total Manganese (Mn)	mg/kg	35.6	354	366	173	205	150	212	593	0.1	3461873
Total Mercury (Hg)	mg/kg	0.01	0.01	0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	3461873
Total Molybdenum (Mo)	mg/kg	1.0	2.6	1.4	1.0	1.1	1.2	1.1	2.3	0.1	3461873
Total Nickel (Ni)	mg/kg	0.4	2.5	0.9	0.5	1.8	1.2	1.1	1.4	0.1	3461873
Total Phosphorus (P)	mg/kg	1250	830	666	178	604	309	608	1090	10	3461873
Total Potassium (K)	mg/kg	3110	5880	4650	2500	2870	1770	6240	9710	10	3461873
Total Selenium (Se)	mg/kg	0.26	0.24	0.13	0.24	0.12	0.24	0.19	0.21	0.01	3461873
Total Silver (Ag)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	0.09	0.06	0.06	0.05	3461873
Total Sodium (Na)	mg/kg	<10	23	23	17	14	33	29	31	10	3461873
Total Strontium (Sr)	mg/kg	58.7	24.5	17.5	18.3	10.1	15.6	17.6	42.3	0.1	3461873
Total Thallium (Tl)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	3461873
Total Tin (Sn)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461873
Total Titanium (Ti)	mg/kg	1	50	47	29	26	80	56	43	1	3461873
Total Uranium (U)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	3461873
Total Vanadium (V)	mg/kg	<2	4	3	<2	<2	5	3	3	2	3461873
Total Zinc (Zn)	mg/kg	128	55.1	28.0	19.8	24.0	25.3	18.5	123	0.1	3461873

RDL = Reportable Detection Limit

MINTO EXPLORATIONS LTD.
Client Project #: MIN-09-05 REVEGETATION MONITOR

Maxxam Job #: A953654
Report Date: 2009/10/06

ELEMENTS BY ATOMIC SPECTROSCOPY (VEGETABLES)

Maxxam ID		Q95946		Q95947	Q95948	Q95949	Q95950	Q95951	Q95952		
Sampling Date		2009/09/21		2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21	2009/09/21		
	Units	**R.M. FESCUE TOE OF TAILINGS**	**QC Batch**	**SHEEP FESCUE TOE OF TAILINGS**	**VIOLET WHEATGRASS UPPER IROD**	**TUFTED HAIRGRASS UPPER IROD**	**SHEEP FESCUE UPPER IROD**	**GLAUCOUS BLUEGRASS UPPER IROD**	**R.M. FESCUE UPPER IROD**	**RDL**	**QC Batch**
Total Metals by ICPMS											
Total Aluminum (Al)	mg/kg	1320	3461873	601	855	1150	320	363	340	1	3461891
Total Antimony (Sb)	mg/kg	<0.1	3461873	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461891
Total Arsenic (As)	mg/kg	0.35	3461873	0.13	0.32	0.48	0.16	0.27	0.16	0.01	3461891
Total Barium (Ba)	mg/kg	90.4	3461873	31.6	71.0	63.6	25.8	151	28.6	0.1	3461891
Total Beryllium (Be)	mg/kg	<0.1	3461873	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461891
Total Bismuth (Bi)	mg/kg	<0.1	3461873	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461891
Total Boron (B)	mg/kg	<5	3461873	<5	<5	7	<5	6	<5	5	3461891
Total Cadmium (Cd)	mg/kg	0.19	3461873	0.19	0.17	0.26	0.10	0.11	0.03	0.01	3461891
Total Calcium (Ca)	mg/kg	5380	3461873	3630	4010	4260	2690	5410	1700	10	3461891
Total Chromium (Cr)	mg/kg	3.1	3461873	0.9	0.9	1.3	<0.5	<0.5	<0.5	0.5	3461891
Total Cobalt (Co)	mg/kg	1.1	3461873	0.5	0.5	0.8	0.2	0.5	0.2	0.1	3461891
Total Copper (Cu)	mg/kg	233	3461873	108	65.0	114	26.2	39.1	25.0	0.5	3461891
Total Iron (Fe)	mg/kg	2880	3461873	1360	1380	1960	525	729	559	10	3461891
Total Lead (Pb)	mg/kg	0.88	3461873	0.70	0.52	0.65	0.69	0.43	0.20	0.01	3461891
Total Magnesium (Mg)	mg/kg	2600	3461873	1890	1380	1410	1020	2090	634	10	3461891
Total Manganese (Mn)	mg/kg	498	3461873	325	174	136	123	462	121	0.1	3461891
Total Mercury (Hg)	mg/kg	<0.01	3461873	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	3461891
Total Molybdenum (Mo)	mg/kg	1.5	3461873	2.7	1.4	4.8	1.7	1.9	0.9	0.1	3461891
Total Nickel (Ni)	mg/kg	2.7	3461873	0.9	1.0	2.2	1.1	2.5	1.0	0.1	3461891
Total Phosphorus (P)	mg/kg	852	3461873	1080	439	1060	807	1030	585	10	3461891
Total Potassium (K)	mg/kg	4720	3461873	13300	5090	5690	5960	5180	3240	10	3461891
Total Selenium (Se)	mg/kg	0.30	3461873	0.15	0.15	0.21	0.07	0.20	0.07	0.01	3461891
Total Silver (Ag)	mg/kg	0.12	3461873	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	0.05	3461891
Total Sodium (Na)	mg/kg	40	3461873	28	20	29	16	15	19	10	3461891
Total Strontium (Sr)	mg/kg	30.1	3461873	20.9	21.5	21.1	12.5	29.3	9.0	0.1	3461891
Total Thallium (Tl)	mg/kg	<0.05	3461873	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	3461891
Total Tin (Sn)	mg/kg	0.1	3461873	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3461891
Total Titanium (Ti)	mg/kg	91	3461873	45	48	57	16	17	18	1	3461891
Total Uranium (U)	mg/kg	<0.05	3461873	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	3461891
Total Vanadium (V)	mg/kg	6	3461873	3	3	4	<2	<2	<2	2	3461891
Total Zinc (Zn)	mg/kg	89.3	3461873	44.0	13.6	34.7	21.0	98.3	18.8	0.1	3461891

RDL = Reportable Detection Limit

Maxxam Job #: A953654
Report Date: 2009/10/06

MINTO EXPLORATIONS LTD.
Client Project #: MIN-09-05 REVEGETATION MONITOR

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		Q95936	Q95937	Q95938		
Sampling Date		2009/09/21	2009/09/21	2009/09/21		
	Units	**TOE OF TAILINGS SOIL**	**SOIL SAMPLE LOWER IROD**	**SOIL SAMPLE UPPER IROD**	**RDL**	**QC Batch**
Misc. Inorganics						
Soluble (2:1) pH	pH Units	5.23	7.04	8.45	0.01	3458063
Total Metals by ICPMS						
Total Aluminum (Al)	mg/kg	15300	14200	12800	100	3459879
Total Antimony (Sb)	mg/kg	0.5	0.5	0.3	0.1	3459879
Total Arsenic (As)	mg/kg	6.5	5.3	6.5	0.2	3459879
Total Barium (Ba)	mg/kg	279	215	183	0.1	3459879
Total Beryllium (Be)	mg/kg	0.5	0.3	0.5	0.1	3459879
Total Bismuth (Bi)	mg/kg	0.1	0.1	<0.1	0.1	3459879
Total Cadmium (Cd)	mg/kg	0.29	0.25	0.15	0.05	3459879
Total Calcium (Ca)	mg/kg	8960	9890	11800	100	3459879
Total Chromium (Cr)	mg/kg	28	29	29	1	3459879
Total Cobalt (Co)	mg/kg	8.3	10.0	11.6	0.3	3459879
Total Copper (Cu)	mg/kg	163	123	59.6	0.5	3459879
Total Iron (Fe)	mg/kg	20900	24900	26100	100	3459879
Total Lead (Pb)	mg/kg	6.3	6.4	5.6	0.1	3459879
Total Magnesium (Mg)	mg/kg	6420	8330	11200	100	3459879
Total Manganese (Mn)	mg/kg	178	460	467	0.2	3459879
Total Mercury (Hg)	mg/kg	<0.05	<0.05	<0.05	0.05	3459879
Total Molybdenum (Mo)	mg/kg	2.1	1.3	0.6	0.1	3459879
Total Nickel (Ni)	mg/kg	23.6	32.1	53.7	0.8	3459879
Total Phosphorus (P)	mg/kg	586	742	858	10	3459879
Total Potassium (K)	mg/kg	787	1130	1470	100	3459879
Total Selenium (Se)	mg/kg	1.0	0.6	0.6	0.5	3459879
Total Silver (Ag)	mg/kg	0.14	0.12	0.09	0.05	3459879
Total Sodium (Na)	mg/kg	217	275	278	100	3459879
Total Strontium (Sr)	mg/kg	59.0	60.3	60.1	0.1	3459879
Total Thallium (Tl)	mg/kg	0.09	0.10	0.11	0.05	3459879
Total Tin (Sn)	mg/kg	0.5	0.5	0.4	0.1	3459879
Total Titanium (Ti)	mg/kg	805	928	682	1	3459879
Total Vanadium (V)	mg/kg	62	64	59	2	3459879
Total Zinc (Zn)	mg/kg	69	71	58	1	3459879
Total Zirconium (Zr)	mg/kg	2.9	3.5	3.0	0.5	3459879

RDL = Reportable Detection Limit

MINTO EXPLORATIONS LTD.
Client Project #: MIN-09-05 REVEGETATION MONITOR

Maxxam Job #: A953654
Report Date: 2009/10/06

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
3455655	Saturation %	2009/10/01					<1	%	9.1	25		
3456164	Soluble Conductivity	2009/10/01			98	80 - 120	<1	uS/cm	21.2	N/A		
3458063	Soluble (2:1) pH	2009/10/01			100	96 - 104			0.1	20		
3459879	Total Arsenic (As)	2009/10/01	99	75 - 125	98	75 - 125	<0.2	mg/kg			84	70 - 130
3459879	Total Beryllium (Be)	2009/10/01	113	75 - 125	105	75 - 125	<0.1	mg/kg				
3459879	Total Cadmium (Cd)	2009/10/01	108	75 - 125	100	75 - 125	<0.05	mg/kg			83	70 - 130
3459879	Total Chromium (Cr)	2009/10/01	105	75 - 125	98	75 - 125	<1	mg/kg			93	70 - 130
3459879	Total Cobalt (Co)	2009/10/01	105	75 - 125	101	75 - 125	<0.3	mg/kg			87	70 - 130
3459879	Total Copper (Cu)	2009/10/01	105	75 - 125	102	75 - 125	<0.5	mg/kg			89	70 - 130
3459879	Total Lead (Pb)	2009/10/01	108	75 - 125	95	75 - 125	<0.1	mg/kg	2.0	35	92	70 - 130
3459879	Total Mercury (Hg)	2009/10/01	109	75 - 125	97	75 - 125	<0.05	mg/kg				
3459879	Total Nickel (Ni)	2009/10/01	104	75 - 125	98	75 - 125	<0.8	mg/kg			89	70 - 130
3459879	Total Selenium (Se)	2009/10/01	109	75 - 125	107	75 - 125	<0.5	mg/kg				
3459879	Total Vanadium (V)	2009/10/01	119	75 - 125	113	75 - 125	<2	mg/kg			111	70 - 130
3459879	Total Zinc (Zn)	2009/10/01	NC	75 - 125	105	75 - 125	<1	mg/kg			90	70 - 130
3459879	Total Aluminum (Al)	2009/10/01					<100	mg/kg			105	70 - 130
3459879	Total Antimony (Sb)	2009/10/01					<0.1	mg/kg			93	70 - 130
3459879	Total Barium (Ba)	2009/10/01					<0.1	mg/kg			112	70 - 130
3459879	Total Calcium (Ca)	2009/10/01					<100	mg/kg			91	70 - 130
3459879	Total Iron (Fe)	2009/10/01					<100	mg/kg			98	70 - 130
3459879	Total Magnesium (Mg)	2009/10/01					<100	mg/kg			102	70 - 130
3459879	Total Manganese (Mn)	2009/10/01					<0.2	mg/kg			124	70 - 130
3459879	Total Molybdenum (Mo)	2009/10/01					<0.1	mg/kg			86	70 - 130
3459879	Total Phosphorus (P)	2009/10/01					<10	mg/kg			77	70 - 130
3459879	Total Silver (Ag)	2009/10/01					<0.05	mg/kg			83	70 - 130
3459879	Total Strontium (Sr)	2009/10/01					0.1, RDL=0.1	mg/kg			128	70 - 130
3459879	Total Thallium (Tl)	2009/10/01					<0.05	mg/kg			76	70 - 130
3459879	Total Titanium (Ti)	2009/10/01					<1	mg/kg			111	70 - 130
3459879	Total Bismuth (Bi)	2009/10/01					<0.1	mg/kg				
3459879	Total Potassium (K)	2009/10/01					<100	mg/kg				
3459879	Total Sodium (Na)	2009/10/01					<100	mg/kg				
3459879	Total Tin (Sn)	2009/10/01					<0.1	mg/kg				
3459879	Total Zirconium (Zr)	2009/10/01					<0.5	mg/kg				
3461533	Total Kjeldahl Nitrogen	2009/10/02	NC	75 - 125	104	80 - 120	<10	mg/kg	18.2	35	84	60 - 121
3461568	Cation exchange capacity	2009/10/06							NC	35		
3461873	Total Arsenic (As)	2009/10/02	108	75 - 125	105	75 - 125	<0.01	mg/kg	12.0	35		
3461873	Total Beryllium (Be)	2009/10/02	110	75 - 125	110	75 - 125	<0.1	mg/kg	NC	35		
3461873	Total Cadmium (Cd)	2009/10/02	111	75 - 125	112	75 - 125	<0.01	mg/kg	2.4	35		
3461873	Total Chromium (Cr)	2009/10/02	107	75 - 125	108	75 - 125	<0.5	mg/kg	NC	35		
3461873	Total Cobalt (Co)	2009/10/02	107	75 - 125	108	75 - 125	<0.1	mg/kg	NC	35		

Maxxam Job #: A953654
Report Date: 2009/10/06

MINTO EXPLORATIONS LTD.
Client Project #: MIN-09-05 REVEGETATION MONITOR

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
3461873	Total Copper (Cu)	2009/10/02	106	75 - 125	107	75 - 125	<0.5	mg/kg	0.2	35		
3461873	Total Lead (Pb)	2009/10/02	105	75 - 125	111	75 - 125	<0.01	mg/kg	0.3	35		
3461873	Total Mercury (Hg)	2009/10/02	103	75 - 125	107	75 - 125	0.01, RDL=0.01	mg/kg	NC	35		
3461873	Total Nickel (Ni)	2009/10/02	106	75 - 125	107	75 - 125	<0.1	mg/kg	2.6	35		
3461873	Total Selenium (Se)	2009/10/02	112	75 - 125	114	75 - 125	0.01, RDL=0.01	mg/kg	9.6	35		
3461873	Total Uranium (U)	2009/10/02	110	75 - 125	113	75 - 125	<0.05	mg/kg	NC	35		
3461873	Total Vanadium (V)	2009/10/02	111	75 - 125	107	75 - 125	<2	mg/kg	NC	35		
3461873	Total Zinc (Zn)	2009/10/02	NC	75 - 125	112	75 - 125	<0.1	mg/kg	1.5	35		
3461873	Total Aluminum (Al)	2009/10/02					1, RDL=1	mg/kg	2.2	35		
3461873	Total Antimony (Sb)	2009/10/02					<0.1	mg/kg	NC	35		
3461873	Total Barium (Ba)	2009/10/02					<0.1	mg/kg	2.0	35		
3461873	Total Bismuth (Bi)	2009/10/02					<0.1	mg/kg	NC	35		
3461873	Total Boron (B)	2009/10/02					<5	mg/kg	1.1	35		
3461873	Total Calcium (Ca)	2009/10/02					<10	mg/kg	1.5	35		
3461873	Total Iron (Fe)	2009/10/02					<10	mg/kg	11.2	35		
3461873	Total Magnesium (Mg)	2009/10/02					<10	mg/kg	0.5	35		
3461873	Total Manganese (Mn)	2009/10/02					<0.1	mg/kg	1.9	35		
3461873	Total Molybdenum (Mo)	2009/10/02					<0.1	mg/kg	1.2	35		
3461873	Total Phosphorus (P)	2009/10/02					<10	mg/kg	1.5	35		
3461873	Total Potassium (K)	2009/10/02					<10	mg/kg	0.5	35		
3461873	Total Silver (Ag)	2009/10/02					<0.05	mg/kg	NC	35		
3461873	Total Sodium (Na)	2009/10/02					<10	mg/kg	NC	35		
3461873	Total Strontium (Sr)	2009/10/02					<0.1	mg/kg	1.6	35		
3461873	Total Thallium (Tl)	2009/10/02					<0.05	mg/kg	NC	35		
3461873	Total Tin (Sn)	2009/10/02					<0.1	mg/kg	NC	35		
3461873	Total Titanium (Ti)	2009/10/02					<1	mg/kg	NC	35		
3461891	Total Arsenic (As)	2009/10/02	110	75 - 125	111	75 - 125	<0.01	mg/kg	5.7	35		
3461891	Total Beryllium (Be)	2009/10/02	111	75 - 125	110	75 - 125	<0.1	mg/kg	NC	35		
3461891	Total Cadmium (Cd)	2009/10/02	115	75 - 125	115	75 - 125	<0.01	mg/kg	7.7	35		
3461891	Total Chromium (Cr)	2009/10/02	109	75 - 125	112	75 - 125	<0.5	mg/kg	NC	35		
3461891	Total Cobalt (Co)	2009/10/02	107	75 - 125	110	75 - 125	<0.1	mg/kg	NC	35		
3461891	Total Copper (Cu)	2009/10/02	NC	75 - 125	110	75 - 125	<0.5	mg/kg	0.09	35		
3461891	Total Lead (Pb)	2009/10/02	107	75 - 125	110	75 - 125	<0.01	mg/kg	1	35		
3461891	Total Mercury (Hg)	2009/10/02	104	75 - 125	104	75 - 125	<0.01	mg/kg	NC	35		
3461891	Total Nickel (Ni)	2009/10/02	107	75 - 125	110	75 - 125	<0.1	mg/kg	7.4	35		
3461891	Total Selenium (Se)	2009/10/02	110	75 - 125	114	75 - 125	0.01, RDL=0.01	mg/kg	2.9	35		
3461891	Total Uranium (U)	2009/10/02	110	75 - 125	111	75 - 125	<0.05	mg/kg	NC	35		
3461891	Total Vanadium (V)	2009/10/02	111	75 - 125	111	75 - 125	<2	mg/kg	NC	35		
3461891	Total Zinc (Zn)	2009/10/02	NC	75 - 125	115	75 - 125	<0.1	mg/kg	0.3	35		
3461891	Total Aluminum (Al)	2009/10/02					1, RDL=1	mg/kg	0.08	35		

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
3461891	Total Antimony (Sb)	2009/10/02					<0.1	mg/kg	NC	35		
3461891	Total Barium (Ba)	2009/10/02					<0.1	mg/kg	0.4	35		
3461891	Total Bismuth (Bi)	2009/10/02					<0.1	mg/kg	NC	35		
3461891	Total Boron (B)	2009/10/02					<5	mg/kg	NC	35		
3461891	Total Calcium (Ca)	2009/10/02					<10	mg/kg	1.7	35		
3461891	Total Iron (Fe)	2009/10/02					<10	mg/kg	1.6	35		
3461891	Total Magnesium (Mg)	2009/10/02					<10	mg/kg	0.9	35		
3461891	Total Manganese (Mn)	2009/10/02					<0.1	mg/kg	0.4	35		
3461891	Total Molybdenum (Mo)	2009/10/02					<0.1	mg/kg	1	35		
3461891	Total Phosphorus (P)	2009/10/02					<10	mg/kg	0.7	35		
3461891	Total Potassium (K)	2009/10/02					<10	mg/kg	1.5	35		
3461891	Total Silver (Ag)	2009/10/02					<0.05	mg/kg	NC	35		
3461891	Total Sodium (Na)	2009/10/02					<10	mg/kg	NC	35		
3461891	Total Strontium (Sr)	2009/10/02					<0.1	mg/kg	0.3	35		
3461891	Total Thallium (Tl)	2009/10/02					<0.05	mg/kg	NC	35		
3461891	Total Tin (Sn)	2009/10/02					<0.1	mg/kg	NC	35		
3461891	Total Titanium (Ti)	2009/10/02					<1	mg/kg	0.9	35		

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Maxxam Analytics Inc
8577 Commerce Court, Burnaby, BC V5A 4N5
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Phone: (604) 444-4808
Fax.: (604) 444-4511
Toll-Free: 1-800-440-4808

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

08304612

A953654

LAB USE ONLY — MAXXAM JOB #

ANALYSIS REQUEST

LAB USE ONLY — COC #

COMPANY NAME: Minto Explorations Ltd.	CLIENT PROJECT NO.: MIN-09-05 Revegetation Monitoring Sept 09
COMPANY ADDRESS:	TEL.: E-MAIL: scott@accessconsulting.ca colleenr@mintomine.com FAX:

SAMPLER NAME (PRINT):	PROJECT MANAGER:	LABORATORY CONTACT:
Stu Withers	Scott Keesey/Colleen Roche	Kimberley Webber

#	FIELD SAMPLE ID	MAXXAM LAB # (LAB USE ONLY)	GROUNDWATER	SURFACE WATER	DRINKING WATER	SOIL	OTHER	DATE DD/MM/YY	TIME	# CONTAINERS	ICP Metals
1	Yukon River Plane-leaf Willow Leaves						x	2009/09/22	16:00	1	x
2	Copper Keel Birch Twigs						x	2009/09/21	17:00	1	x
3	Copper Keel Birch Leaves						x	2009/09/21	17:00	1	x
4	Waste Rock Dump 1st level Leaf Willow Twigs									1	X
5	Toe of Waste Rock 1st lift willow twigs (little)									1	X
6	Plane-leaf willow - toe of waste rock dump 1st level									1	X
7	Toe of waste Rock Pump - willow leaves (little)									1	X
8	Yukon River little tree'									1	X
9	Yukon River little tree willow twigs									1	X
10	Yukon River plane-leaf willow twigs									1	X
11	Toe of Tailings soil									1	X
12	Soil sample lower Ind									1	X

TAT (Turnaround Time)

LESS THAN 5 DAY TAT MUST HAVE PRIOR APPROVAL

* Some exceptions apply - please contact laboratory

STANDARD	5 BUSINESS DAYS	X
RUSH	3 BUSINESS DAYS	
RUSH	2 BUSINESS DAYS	
URGENT	1 BUSINESS DAY	

OTHER BUSINESS DAYS ____

PO NUMBER OR QUOTE NUMBER: PR 7041

SPECIAL DETECTION LIMITS / CONTAMINANT TYPE:

CCME / CSR / AB TIER 1 / OTHER

LAB USE ONLY — ARRIVAL TEMPERATURE °C: — DUE DATE: — LOG IN CHECK:

ACCOUNTING CONTACT:

SPECIAL REPORTING OR BILLING INSTRUCTIONS:

JARS USED:

CUSTODY

	DATE: DD/MM/YY	TIME:	
RELINQUISHED BY SAMPLER: S. Withers	23/09/09	20:00	RECEIVED BY:
RELINQUISHED BY:			RECEIVED BY:
RELINQUISHED BY:	25/09/09	1:05	RECEIVED BY LABORATORY: [signature]

Maxxam Analytics

8577 Commerce Court
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A953654

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

PAGE 2 OF 3

MAXXAM JOB # ____ ANALYSIS REQUEST F 143924

COMPANY NAME: Minto

PH. #:
E-mail:
FAX #:

COMPANY ADDRESS:

CLIENT PROJECT ID: (#) MIN-09-05 Revegetation Monitoring Sept 09

SAMPLER NAME (PRINT): Stu Withers

PROJECT MANAGER: Scott Keesey/Colleen Roche

	FIELD SAMPLE ID	MAXXAM LAB # (Lab Use Only)	MATRIX: GROUND WATER	SURFACE WATER	SOIL	DRINKING WATER	OTHER	# CONTAINERS	SAMPLING: DATE DD/MM/YY	TIME	HEADSPACE VAPOUR
1	Soilsample Upper Irod							1			
2	Tufted hairgrass Lower Irod										
3	Sheep Fescue Lower Irod										
4	Violet Wheatgrass Lower Irod										
5	R.M. Fescue Lower IRod										
6	Tufted hairgrass Toe of Tailings										
7	Violet Wheatgrass Toe of Tailings										
8	Glaucous Bluegrass Toe of Tailings										
9	R.M. Fescue Toe of Tailings										
10	Sheep Fescue Toe of Tailings										
11											
12											

LAB USE ONLY

	BTEX / LH / BTEX / VPH / MTBE	VOC's / VPH	EPH / TEH	PAH / LEPH/HEPH	CCME-PHC (FRACTIONS 1-4 PLUS BTEX)	CCME-PHCS (FRACTIONS 2-4)	CCME BTEX (FRACTION 1 PLUS BTEX)	PHENOLS BY 4AAP / PHENOLS BY GCMS	TOTAL O&G / MINERAL O&G	Dissolved Metals Field Filtered? YES NO	Field Preserved? YES NO	Total Metals Field Preserved? YES NO	NITRATE / NITRITE / AMMONIA	CHLORIDE / FLUORIDE / SULPHATE	TOTAL SUSPENDED SOLIDS (NFR)	CYANIDE SAD / WAD	LEACHABLE LEAD (AA) (TCLP)	LEACHABLE BTEX (AA) (TCLP)	ICP Metals	HOLD
1																			X	
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				

TAT (Turnaround Time)

<5 DAY TAT MUST HAVE PRIOR APPROVAL

*some exceptions apply please contact lab

STANDARD 5 BUSINESS DAYS ☒
RUSH 3 BUSINESS DAYS ☐
RUSH 2 BUSINESS DAYS ☐
URGENT 1 BUSINESS DAY ☐
OTHER BUSINESS DAYS ____

P.O. NUMBER / QUOTE NUMBER:

SPECIAL DETECTION LIMITS / CONTAMINANT TYPE:

☐ CCME
☐ CSR
☐ ALBERTA TIER 1
☐ OTHER

LAB USE ONLY

ARRIVAL TEMPERATURE °C: | DUE DATE: | LOG IN CHECK:

ACCOUNTING CONTACT:

SPECIAL REPORTING OR BILLING INSTRUCTIONS:

SOIL JARS USED AND NOT SUBMITTED:

RELINQUISHED BY SAMPLER: | DATE: DD/MM/YY | TIME: | RECEIVED BY:

RELINQUISHED BY: | DATE: DD/MM/YY | TIME: | RECEIVED BY:

CUSTODY

Maxxam Analytics

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A953654

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

PAGE 3 OF 3

MAXXAM JOB #

ANALYSIS REQUEST

F 143925

COMPANY NAME: Minto

PH. #:
E-mail:
FAX #:

COMPANY ADDRESS:

CLIENT PROJECT ID: (#) MIN-09-05 Revegetation Monitoring Sept 09

SAMPLER NAME (PRINT): Stu Withers

PROJECT MANAGER: Scott Keesey/Colleen Roche

LAB USE ONLY

Analysis columns: BTEX / LH, BTEX / VPH, MTBE, VOC's / VPH, EPH, TEH, PAH, LEPH/HEPH, CCME-PHC (FRACTIONS 1-4 PLUS BTEX), CCME-PHCS (FRACTIONS 2-4), CCME BTEX (FRACTION 1 PLUS BTEX), PHENOLS BY 4AAP, PHENOLS BY GCMS, TOTAL O&G, MINERAL O&G, Dissolved Metals (Field Filtered? YES / NO; Field Preserved? YES / NO), Total Metals Field Preserved? YES / NO, NITRATE, NITRITE, AMMONIA, CHLORIDE, FLUORIDE, SULPHATE, TOTAL SUSPENDED SOLIDS (NFR), CYANIDE SAD, WAD, LEACHABLE LEAD (AA), (TCLP), LEACHABLE BTEX (AA), (TCLP), HOLD

	FIELD SAMPLE ID	MAXXAM LAB # (Lab Use Only)	MATRIX: GROUND WATER	SURFACE WATER	SOIL	DRINKING WATER	OTHER	# CONTAINERS	SAMPLING: DATE DD/MM/YY	TIME	HEADSPACE VAPOUR
1	Violet Wheatgrass Upper Irod										
2	Tufted Hairgrass Upper Irod										
3	Sheep fescue Upper Irod										
4	Glaucous Bluegrass Upper Irod										
5	R.M. Fescue Upper Irod										
6											
7											
8											
9											
10											
11											
12											

TAT (Turnaround Time)

<5 DAY TAT MUST HAVE PRIOR APPROVAL

some exceptions apply please contact lab

STANDARD 5 BUSINESS DAYS ☐
RUSH 3 BUSINESS DAYS ☐
RUSH 2 BUSINESS DAYS ☐
URGENT 1 BUSINESS DAY ☐

OTHER BUSINESS DAYS ____

P.O. NUMBER / QUOTE NUMBER:

SPECIAL DETECTION LIMITS / CONTAMINANT TYPE:

☐ CCME
☐ CSR
☐ ALBERTA TIER 1
☐ OTHER

LAB USE ONLY

ARRIVAL TEMPERATURE °C: | DUE DATE: | LOG IN CHECK:

ACCOUNTING CONTACT:

SPECIAL REPORTING OR BILLING INSTRUCTIONS:

SOIL JARS USED AND NOT SUBMITTED:

RELINQUISHED BY SAMPLER: | DATE: DD/MM/YY | TIME: | RECEIVED BY:

RELINQUISHED BY: | DATE: DD/MM/YY | TIME: | RECEIVED BY:

CUSTODY

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CHAIN-OF CUSTODY RECORD AND ANALYSIS REQUEST

LAB USE ONLY — MAXXAM JOB #:

ANALYSIS REQUEST

LAB USE ONLY — COC #:

COMPANY NAME: Minto Explorations Ltd.	CLIENT PROJECT NO.: MIN-09-05 Revegetation Monitoring Sept 09
COMPANY ADDRESS:	TEL.: E-MAIL: scott@accessconsulting.ca, colleenr@mintomine.com FAX:

SAMPLER NAME (PRINT):	PROJECT MANAGER:	LABORATORY CONTACT:
Stu Withers	Scott Keesey/Colleen Roche	Kimberley Webber

Handwritten analysis notes: TOC → BEDV; C:N Ratio → Pacific Soil Subcontract; CEC → CALC Sub. Calgary; Total N → Calgary; Nutrients → Basic Fertility Package #1 @ PACIFIC SOIL: pH, N, P, K, Ca, Mg, Org. matter

#	FIELD SAMPLE ID	MAXXAM LAB # (LAB USE ONLY)	GROUNDWATER	SURFACE WATER	DRINKING WATER	SOIL	OTHER	DATE DD/MM/YY	TIME	# CONTAINERS	ICP Metals	pH/EC	Texture	TOC	C:N Ratio	CEC	Total N	Nutrients
1	Upper IROD Soils					x		09/21/2009	13:00	1	x	x	x	x	x	x	x	x
2	Lower IROD Soils					x		09/21/2009	15:00	1	x	x	x	x	x	x	x	x
3	Toe of Tailings Soils					x		09/21/2009	11:00	1	x	x	x	x	x	x	x	x
4	Upper IROD Violet Wheatgrass						x	09/21/2009	13:00	1	x							
5	Upper IROD Tufted Hairgrass						x	09/21/2009	13:00	1	x							
6	Upper IROD R.M. Fescue						x	09/21/2009	13:00	1	x							
7	Upper IROD Sheep Fescue						x	09/21/2009	13:00	1	x							
8	Upper IROD Glaucous Bluegrass						x	09/21/2009	13:00	1	x							
9	Lower IROD Violet Wheatgrass						x	09/21/2009	15:00	1	x							
10	Lower IROD Tufted Hairgrass						x	09/21/2009	15:00	1	x							
11	Lower IROD R.M. Fescue						x	09/21/2009	15:00	1	x							
12	Lower IROD Sheep Fescue						x	09/21/2009	15:00	1	x							

TAT (Turnaround Time)

LESS THAN 5 DAY TAT MUST HAVE PRIOR APPROVAL

* Some exceptions apply - please contact laboratory

STANDARD	5 BUSINESS DAYS	X
RUSH	3 BUSINESS DAYS	
RUSH	2 BUSINESS DAYS	
URGENT	1 BUSINESS DAY	

OTHER BUSINESS DAYS ______

PO NUMBER OR QUOTE NUMBER: PR 7041

SPECIAL DETECTION LIMITS / CONTAMINANT TYPE:

☐ CCME ☐ CSR ☐ AB TIER 1 ☐ OTHER

LAB USE ONLY — ARRIVAL TEMPERATURE °C: | DUE DATE: | LOG IN CHECK:

ACCOUNTING CONTACT:

SPECIAL REPORTING OR BILLING INSTRUCTIONS: Bill To Minto Explorations Ltd.

JARS USED:

RELINQUISHED BY SAMPLER:	DATE: DD/MM/YY	TIME:	RECEIVED BY:
S. Withers	23/09/09	20:00	
RELINQUISHED BY:	DATE: DD/MM/YY	TIME:	RECEIVED BY:
RELINQUISHED BY:	DATE: DD/MM/YY	TIME:	RECEIVED BY LABORATORY:

CUSTODY RECORD

COCFORM - BC - 20070822

Your Project #: MIN - 110466
Your C.O.C. #: 08322883, 08322884

Attention: Scott Keesey
ACCESS CONSULTING GROUP
#3 Calcite
151 Industrial Road
WHITEHORSE, YT
CANADA Y1A 3C8

Report Date: 2010/10/07

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B092008
Received: 2010/09/27, 08:30

Sample Matrix: VEGETATION
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by CRC ICPMS (total) - Plant	10	2010/09/30	2010/10/05	BRN SOP-00206 R7.0	Based on EPA 200.8

Sample Matrix: Soil
Samples Received: 12

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Cation Exchange Capacity (1)	12	2010/10/01	2010/10/01	AB SOP-00042	EPA 200.7
Conductance - soil	12	2010/10/01	2010/10/01	BRN SOP-00269 R2.0	Based on SM - 18.2.4
Elements by ICPMS (total)	12	2010/09/30	2010/09/30	BRN SOP-00203 R5.0	Based on EPA 200.8
Potassium (Available) (1)	12	2010/10/01	2010/10/01	AB SOP-00042	EPA 200.7
Nitrate-N (Available) (1)	12	2010/10/01	2010/10/01	AB SOP-00023	SM 4110-B
Phosphorus (Available by ICP) (1)	12	2010/10/01	2010/10/01	AB SOP-00042	EPA 200.7
pH (2:1 DI Water Extract)	12	2010/09/30	2010/09/30	BRN SOP-00266 R6.0	Carter, SSMA 16.2
Sublet (Inorganics) (2)	12	N/A	2010/09/30		
Texture by Hydrometer (1)	12	N/A	2010/10/01	CAL SOP-00033	MMFSPA Ch9
Texture Class (1)	12	N/A	2010/10/01	CAL SOP-00033	MMFSPA Ch9

* Results relate only to the items tested.

(1) This test was performed by Maxxam Calgary
(2) This test was performed by Ext. Sublet from Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

KIMBERLEY WEBBER, BBY Customer Service
Email: kim.webber@maxxamanalytics.com
Phone# (604) 638-3254

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.
Total cover pages: 1

Maxxam Job #: B092008
Report Date: 2010/10/07

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Sampler Initials: LK

NPK (AVAILABLE)

Maxxam ID		X23895	X23896	X23897	X23898	X23899	X23900		
Sampling Date		2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15		
	Units	**RECLAMATION B TOE OF WASTE ROCK**	**RECLAMATION F MINTO CR FLAME**	**RECLAMATION E MINTO RD KM 2**	**RECLAMATION D TOE OF DAM S.**	**R1 (IROD) PLOT A**	**R1 (IROD) PLOT B**	**RDL**	**QC Batch**
Nutrients									
Available (NH4F) Nitrogen (N)	mg/kg	<2	<2	<2	<2	<2	<2	2	4305435
Available (NH4F) Phosphorus (P)	mg/kg	<1	<1	22	3	<1	<1	1	4305771
Available (NH4OAc) Potassium (K)	mg/kg	73	38	60	40	30	51	2	4305594

Maxxam ID		X23901	X23902	X23903	X23904	X23905	X23906		
Sampling Date		2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15		
	Units	**R3 TAILINGS DUMP PLOT A**	**R3 TAILINGS DUMP PLOT B**	**R3 TAILINGS DUMP PLOT C**	**R4 MINTO RD KM 3 PLOT A**	**R4 MINTO RD KM 3 PLOT B**	**R4 MINTO R KM 3 PLOT C**	**RDL**	**QC Batch**
Nutrients									
Available (NH4F) Nitrogen (N)	mg/kg	<2	<2	<2	<2	<2	<2	2	4305435
Available (NH4F) Phosphorus (P)	mg/kg	<1	<1	<1	5	23	<1	1	4305771
Available (NH4OAc) Potassium (K)	mg/kg	57	50	47	35	64	33	2	4305594

RDL = Reportable Detection Limit

Maxxam Job #: B092008
Report Date: 2010/10/07

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Sampler Initials: LK

ELEMENTS BY ATOMIC SPECTROSCOPY (VEGETATION)

Maxxam ID		X23975	X23976	X23977	X23978	X23979		
Sampling Date		2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15		
	Units	**RECLAMATION (B) TOE OF WASTE ROCK - GRASS FESTUCA OVINA**	**RECLAMATION (B) TOE OF WASTE ROCK - GRASS AGROPYRON VIOLA**	**PLOT R1 (IROD) TREMBLING ASPEN**	**PLOT R1 (IROD) LITTLE TREE WILLOW**	**PLOT R1 (IROD) GREY LEAF WILLOW**	**RDL**	**QC Batch**
Total Metals by ICPMS								
Total Aluminum (Al)	mg/kg	669	415	248	663	959	1	4303157
Total Antimony (Sb)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	4303157
Total Arsenic (As)	mg/kg	0.36	0.22	0.13	0.31	0.49	0.01	4303157
Total Barium (Ba)	mg/kg	46.6	36.5	47.7	34.6	26.8	0.1	4303157
Total Beryllium (Be)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	4303157
Total Bismuth (Bi)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	4303157
Total Boron (B)	mg/kg	<5	5	18	37	59	5	4303157
Total Cadmium (Cd)	mg/kg	0.14	0.16	2.80	6.02	2.44	0.01	4303157
Total Calcium (Ca)	mg/kg	4110	4580	23300	25000	16900	10	4303157
Total Chromium (Cr)	mg/kg	4.4	2.1	1.9	0.8	1.8	0.5	4303157
Total Cobalt (Co)	mg/kg	0.5	0.3	1.5	1.9	1.8	0.1	4303157
Total Copper (Cu)	mg/kg	56.7	34.9	20.7	48.0	77.1	0.5	4303157
Total Iron (Fe)	mg/kg	1170	726	477	1140	1620	10	4303157
Total Lead (Pb)	mg/kg	0.36	0.24	0.18	0.46	0.53	0.01	4303157
Total Magnesium (Mg)	mg/kg	1410	1030	2740	8000	4540	10	4303157
Total Manganese (Mn)	mg/kg	406	199	149	787	245	0.1	4303157
Total Mercury (Hg)	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	4303157
Total Molybdenum (Mo)	mg/kg	3.7	1.8	1.2	2.4	1.3	0.1	4303157
Total Nickel (Ni)	mg/kg	2.8	2.0	2.8	10.9	5.6	0.1	4303157
Total Phosphorus (P)	mg/kg	1300	621	3200	8630	4430	10	4303157
Total Potassium (K)	mg/kg	11300	6070	8530	11100	13400	10	4303157
Total Selenium (Se)	mg/kg	0.44	0.27	0.09	0.35	0.12	0.01	4303157
Total Silver (Ag)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4303157
Total Sodium (Na)	mg/kg	24	21	17	39	35	10	4303157
Total Strontium (Sr)	mg/kg	29.9	34.4	98.9	97.3	76.9	0.1	4303157
Total Thallium (Tl)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4303157
Total Tin (Sn)	mg/kg	<0.1	<0.1	<0.1	<0.1	0.2	0.1	4303157
Total Titanium (Ti)	mg/kg	41	25	10	26	31	1	4303157
Total Uranium (U)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4303157
Total Vanadium (V)	mg/kg	2	<2	<2	2	3	2	4303157
Total Zinc (Zn)	mg/kg	23.6	9.8	321	452	248	0.1	4303157

RDL = Reportable Detection Limit

Maxxam Job #: B092008
Report Date: 2010/10/07

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Sampler Initials: LK

ELEMENTS BY ATOMIC SPECTROSCOPY (VEGETATION)

Maxxam ID		X23980	X23981	X23982	X23983	X23984		
Sampling Date		2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15		
	Units	**PLOT R3 TAILINGS TOE GREY LEAF WILLOW**	**PLOT R3 TAILINGS TOE LITTLE TREE WILLOW**	**PLOT R3 TAILINGS TOE GRASS CALAMAGROSH'S**	**RECLAMATION F MINTO CR GREY LEAF WILLOW**	**R4 KM 3 MINTO RD GREY LEAF WILLOW**	**RDL**	**QC Batch**
Total Metals by ICPMS								
Total Aluminum (Al)	mg/kg	660	314	935	194	197	1	4303157
Total Antimony (Sb)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	4303157
Total Arsenic (As)	mg/kg	0.17	0.09	0.24	0.06	0.06	0.01	4303157
Total Barium (Ba)	mg/kg	19.2	10.2	62.4	22.3	85.5	0.1	4303157
Total Beryllium (Be)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	4303157
Total Bismuth (Bi)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	4303157
Total Boron (B)	mg/kg	36	37	9	56	80	5	4303157
Total Cadmium (Cd)	mg/kg	1.65	1.30	0.11	0.65	1.01	0.01	4303157
Total Calcium (Ca)	mg/kg	18400	15000	5510	20300	14900	10	4303157
Total Chromium (Cr)	mg/kg	1.1	0.7	4.5	0.7	1.0	0.5	4303157
Total Cobalt (Co)	mg/kg	1.2	1.2	0.7	0.9	2.3	0.1	4303157
Total Copper (Cu)	mg/kg	187	86.0	209	39.4	11.0	0.5	4303157
Total Iron (Fe)	mg/kg	1610	744	2230	406	361	10	4303157
Total Lead (Pb)	mg/kg	0.39	0.28	0.48	0.13	0.14	0.01	4303157
Total Magnesium (Mg)	mg/kg	3880	4620	2040	4940	2520	10	4303157
Total Manganese (Mn)	mg/kg	219	395	854	159	553	0.1	4303157
Total Mercury (Hg)	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	4303157
Total Molybdenum (Mo)	mg/kg	2.1	1.8	3.1	0.3	1.9	0.1	4303157
Total Nickel (Ni)	mg/kg	3.3	3.3	2.7	6.6	2.6	0.1	4303157
Total Phosphorus (P)	mg/kg	2130	1840	701	4770	2900	10	4303157
Total Potassium (K)	mg/kg	14700	13500	4940	13100	9620	10	4303157
Total Selenium (Se)	mg/kg	0.24	0.13	0.28	0.06	0.01	0.01	4303157
Total Silver (Ag)	mg/kg	0.07	<0.05	0.14	<0.05	<0.05	0.05	4303157
Total Sodium (Na)	mg/kg	59	88	36	16	24	10	4303157
Total Strontium (Sr)	mg/kg	69.5	51.0	31.1	163	128	0.1	4303157
Total Thallium (Tl)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4303157
Total Tin (Sn)	mg/kg	<0.1	<0.1	0.1	0.1	<0.1	0.1	4303157
Total Titanium (Ti)	mg/kg	35	20	59	11	13	1	4303157
Total Uranium (U)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4303157
Total Vanadium (V)	mg/kg	3	<2	4	<2	<2	2	4303157
Total Zinc (Zn)	mg/kg	168	104	28.2	101	102	0.1	4303157

RDL = Reportable Detection Limit

Maxxam Job #: B092008
Report Date: 2010/10/07

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Sampler Initials: LK

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		X23895	X23896	X23897	X23898	X23899		X23900		
Sampling Date		2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15		2010/09/15		
	Units	**RECLAMATION B TOE OF WASTE ROCK**	**RECLAMATION F MINTO CR FLAME**	**RECLAMATION E MINTO RD KM 2**	**RECLAMATION D TOE OF DAM S.**	**R1 (IROD) PLOT A**	**QC Batch**	**R1 (IROD) PLOT B**	**RDL**	**QC Batch**
CONVENTIONALS										
Soluble (5:1) Conductivity	uS/cm	105	154	33	70	149	4306513	135	1	4306513
Parameter										
Subcontract Parameter	N/A	ATTACHED	ATTACHED	ATTACHED	ATTACHED	ATTACHED	4311892	ATTACHED	N/A	4311892
Elements										
Cation exchange capacity	cmol+/Kg	14	25	<10	<10	24	4304356	22	10	4304359
Physical Properties										
% sand by hydrometer	%	59	75	76	81	57	4304707	63	2	4304707
% silt by hydrometer	%	22	17	17	11	34	4304707	29	2	4304707
Clay Content	%	19	8	7	8	9	4304707	8	2	4304707
Texture	N/A	SANDY LOAM	SANDY LOAM	SANDY LOAM	LOAMY SAND	SANDY LOAM	4294603	SANDY LOAM	N/A	4294603

Maxxam ID		X23901	X23902	X23903	X23904	X23905	X23906		
Sampling Date		2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15		
	Units	**R3 TAILINGS DUMP PLOT A**	**R3 TAILINGS DUMP PLOT B**	**R3 TAILINGS DUMP PLOT C**	**R4 MINTO RD KM 3 PLOT A**	**R4 MINTO RD KM 3 PLOT B**	**R4 MINTO R KM 3 PLOT C**	**RDL**	**QC Batch**
CONVENTIONALS									
Soluble (5:1) Conductivity	uS/cm	102	136	105	16	33	17	1	4306513
Parameter									
Subcontract Parameter	N/A	ATTACHED	ATTACHED	ATTACHED	ATTACHED	ATTACHED	ATTACHED	N/A	4311892
Elements									
Cation exchange capacity	cmol+/Kg	23	25	24	<10	19	11	10	4304359
Physical Properties									
% sand by hydrometer	%	52	43	58	69	71	89	2	4304707
% silt by hydrometer	%	39	48	34	22	20	8	2	4304707
Clay Content	%	9	9	8	9	9	3	2	4304707
Texture	N/A	LOAM	LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SAND	N/A	4294603

N/A = Not Applicable
RDL = Reportable Detection Limit

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Maxxam Job #: B092008
Report Date: 2010/10/07

Sampler Initials: LK

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		X23895	X23896	X23897	X23898	X23899	X23900		
Sampling Date		2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15		
	Units	**RECLAMATION B TOE OF WASTE ROCK**	**RECLAMATION F MINTO CR FLAME**	**RECLAMATION E MINTO RD KM 2**	**RECLAMATION D TOE OF DAM S.**	**R1 (IROD) PLOT A**	**R1 (IROD) PLOT B**	**RDL**	**QC Batch**
Physical Properties									
Soluble (2:1) pH	pH Units	8.16	8.29	6.00	7.79	7.36	8.13	0.01	4302430
Total Metals by ICPMS									
Total Aluminum (Al)	mg/kg	13000	9880	11900	10200	12700	13300	100	4302308
Total Antimony (Sb)	mg/kg	0.8	0.3	0.2	0.2	0.4	0.4	0.1	4302308
Total Arsenic (As)	mg/kg	5.7	3.7	2.6	3.3	6.2	7.0	0.2	4302308
Total Barium (Ba)	mg/kg	207	151	181	121	215	254	0.1	4302308
Total Beryllium (Be)	mg/kg	0.5	0.3	0.4	0.4	0.4	0.3	0.1	4302308
Total Bismuth (Bi)	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	4302308
Total Cadmium (Cd)	mg/kg	0.46	0.09	0.10	0.09	0.13	0.20	0.05	4302308
Total Calcium (Ca)	mg/kg	7740	8550	2680	5340	9930	13600	100	4302308
Total Chromium (Cr)	mg/kg	21	16	14	12	27	25	1	4302308
Total Cobalt (Co)	mg/kg	10.8	7.1	6.2	7.9	10.3	11.1	0.3	4302308
Total Copper (Cu)	mg/kg	687	23.6	6.7	79.4	79.2	179	0.5	4302308
Total Iron (Fe)	mg/kg	25400	19800	18100	23100	23600	26200	100	4302308
Total Lead (Pb)	mg/kg	7.5	4.2	3.8	3.0	6.1	6.0	0.1	4302308
Total Magnesium (Mg)	mg/kg	7610	6210	4510	6710	8160	9120	100	4302308
Total Manganese (Mn)	mg/kg	488	439	395	586	382	574	0.2	4302308
Total Mercury (Hg)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4302308
Total Molybdenum (Mo)	mg/kg	1.9	0.5	0.4	0.6	0.7	0.8	0.1	4302308
Total Nickel (Ni)	mg/kg	24.0	15.1	9.2	11.4	37.7	31.8	0.8	4302308
Total Phosphorus (P)	mg/kg	793	718	527	845	910	957	10	4302308
Total Potassium (K)	mg/kg	2220	1330	1740	2200	1170	2660	100	4302308
Total Selenium (Se)	mg/kg	1.0	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	4302308
Total Silver (Ag)	mg/kg	0.10	0.05	<0.05	<0.05	0.06	0.06	0.05	4302308
Total Sodium (Na)	mg/kg	127	198	<100	103	258	297	100	4302308
Total Strontium (Sr)	mg/kg	50.4	60.7	23.3	24.9	53.3	57.8	0.1	4302308
Total Thallium (Tl)	mg/kg	0.14	0.06	0.07	0.09	0.08	0.12	0.05	4302308
Total Tin (Sn)	mg/kg	0.4	0.3	0.3	0.3	0.4	0.4	0.1	4302308
Total Titanium (Ti)	mg/kg	538	467	484	580	655	832	1	4302308
Total Vanadium (V)	mg/kg	50	41	41	52	55	60	2	4302308
Total Zinc (Zn)	mg/kg	89	54	54	61	54	72	1	4302308
Total Zirconium (Zr)	mg/kg	4.0	1.5	<0.5	1.6	2.6	2.3	0.5	4302308

RDL = Reportable Detection Limit

Maxxam Job #: B092008
Report Date: 2010/10/07

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Sampler Initials: LK

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		X23901	X23902	X23903	X23904	X23905	X23906		
Sampling Date		2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15	2010/09/15		
	Units	**R3 TAILINGS DUMP PLOT A**	**R3 TAILINGS DUMP PLOT B**	**R3 TAILINGS DUMP PLOT C**	**R4 MINTO RD KM 3 PLOT A**	**R4 MINTO RD KM 3 PLOT B**	**R4 MINTO R KM 3 PLOT C**	**RDL**	**QC Batch**
Physical Properties									
Soluble (2:1) pH	pH Units	7.79	8.04	7.76	6.75	6.13	6.88	0.01	4302430
Total Metals by ICPMS									
Total Aluminum (Al)	mg/kg	11600	11400	10600	7430	9940	10900	100	4302308
Total Antimony (Sb)	mg/kg	0.5	0.5	0.4	0.5	0.3	0.1	0.1	4302308
Total Arsenic (As)	mg/kg	6.0	9.0	6.5	5.2	2.9	1.1	0.2	4302308
Total Barium (Ba)	mg/kg	187	187	185	143	174	131	0.1	4302308
Total Beryllium (Be)	mg/kg	0.4	0.3	0.4	0.3	0.3	0.4	0.1	4302308
Total Bismuth (Bi)	mg/kg	<0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	4302308
Total Cadmium (Cd)	mg/kg	0.22	0.27	0.25	0.21	0.10	<0.05	0.05	4302308
Total Calcium (Ca)	mg/kg	8780	11400	9280	3550	3250	4570	100	4302308
Total Chromium (Cr)	mg/kg	25	25	23	20	13	8	1	4302308
Total Cobalt (Co)	mg/kg	9.9	10.4	9.7	7.4	5.3	6.5	0.3	4302308
Total Copper (Cu)	mg/kg	96.4	114	422	19.9	9.8	7.5	0.5	4302308
Total Iron (Fe)	mg/kg	22800	23600	22900	17000	17400	19500	100	4302308
Total Lead (Pb)	mg/kg	6.1	6.0	5.9	4.5	3.5	2.4	0.1	4302308
Total Magnesium (Mg)	mg/kg	6910	7130	6320	3240	3670	6060	100	4302308
Total Manganese (Mn)	mg/kg	366	392	493	325	307	519	0.2	4302308
Total Mercury (Hg)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4302308
Total Molybdenum (Mo)	mg/kg	0.8	2.0	1.0	0.7	0.4	0.2	0.1	4302308
Total Nickel (Ni)	mg/kg	26.4	27.6	25.6	17.3	9.5	6.2	0.8	4302308
Total Phosphorus (P)	mg/kg	935	964	975	819	489	672	10	4302308
Total Potassium (K)	mg/kg	1140	934	1010	634	1220	1870	100	4302308
Total Selenium (Se)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	4302308
Total Silver (Ag)	mg/kg	0.06	0.07	0.17	0.05	<0.05	<0.05	0.05	4302308
Total Sodium (Na)	mg/kg	256	267	237	<100	<100	<100	100	4302308
Total Strontium (Sr)	mg/kg	48.9	53.4	46.3	23.5	24.8	29.2	0.1	4302308
Total Thallium (Tl)	mg/kg	0.08	0.08	0.07	0.06	0.05	0.06	0.05	4302308
Total Tin (Sn)	mg/kg	0.4	0.3	0.3	0.2	0.3	0.2	0.1	4302308
Total Titanium (Ti)	mg/kg	668	628	580	394	427	562	1	4302308
Total Vanadium (V)	mg/kg	55	55	52	36	38	38	2	4302308
Total Zinc (Zn)	mg/kg	61	59	60	45	40	67	1	4302308
Total Zirconium (Zr)	mg/kg	2.5	3.2	2.4	2.2	0.5	1.7	0.5	4302308

RDL = Reportable Detection Limit

Maxxam Job #: B092008
Report Date: 2010/10/07

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Sampler Initials: LK

Package 1	9.0°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Maxxam Job #: B092008
Report Date: 2010/10/07

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Sampler Initials: LK

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4302308	Total Arsenic (As)	2010/10/01	103	75 - 125	104	75 - 125	<0.2	mg/kg	1.2	30	91	70 - 130
4302308	Total Beryllium (Be)	2010/10/01	103	75 - 125	107	75 - 125	<0.1	mg/kg	NC	30		
4302308	Total Cadmium (Cd)	2010/10/01	108	75 - 125	110	75 - 125	<0.05	mg/kg	1.5	30	95	70 - 130
4302308	Total Chromium (Cr)	2010/10/01	NC	75 - 125	99	75 - 125	<1	mg/kg	0.3	30	98	70 - 130
4302308	Total Cobalt (Co)	2010/10/01	101	75 - 125	101	75 - 125	<0.3	mg/kg	2.8	30	96	70 - 130
4302308	Total Copper (Cu)	2010/10/01	NC	75 - 125	105	75 - 125	<0.5	mg/kg	0.1	30	91	70 - 130
4302308	Total Lead (Pb)	2010/10/01	NC	75 - 125	106	75 - 125	<0.1	mg/kg	0.1	35	98	70 - 130
4302308	Total Mercury (Hg)	2010/10/01	92	75 - 125	96	75 - 125	<0.05	mg/kg	3.4	35		
4302308	Total Nickel (Ni)	2010/10/01	NC	75 - 125	102	75 - 125	<0.8	mg/kg	1.2	30	98	70 - 130
4302308	Total Selenium (Se)	2010/10/01	105	75 - 125	107	75 - 125	<0.5	mg/kg	NC	30		
4302308	Total Vanadium (V)	2010/10/01	NC	75 - 125	103	75 - 125	<2	mg/kg	0.9	30	100	70 - 130
4302308	Total Zinc (Zn)	2010/10/01	NC	75 - 125	108	75 - 125	<1	mg/kg	1.2	30	91	70 - 130
4302308	Total Aluminum (Al)	2010/10/01					<100	mg/kg	1.9	35	99	70 - 130
4302308	Total Antimony (Sb)	2010/10/01					<0.1	mg/kg	1.0	30	89	70 - 130
4302308	Total Barium (Ba)	2010/10/01					<0.1	mg/kg	2.0	35	106	70 - 130
4302308	Total Calcium (Ca)	2010/10/01					<100	mg/kg	2.3	30	94	70 - 130
4302308	Total Iron (Fe)	2010/10/01					<100	mg/kg	0.09	30	96	70 - 130
4302308	Total Magnesium (Mg)	2010/10/01					<100	mg/kg	1.5	30	96	70 - 130
4302308	Total Manganese (Mn)	2010/10/01					<0.2	mg/kg	0.2	30	97	70 - 130
4302308	Total Molybdenum (Mo)	2010/10/01					<0.1	mg/kg	1.5	35	102	70 - 130
4302308	Total Phosphorus (P)	2010/10/01					<10	mg/kg	2.5	30	98	70 - 130
4302308	Total Silver (Ag)	2010/10/01					<0.05	mg/kg	22.7	35	63 (1)	70 - 130
4302308	Total Strontium (Sr)	2010/10/01					<0.1	mg/kg	0.09	35	91	70 - 130
4302308	Total Thallium (Tl)	2010/10/01					<0.05	mg/kg	NC	30	84	70 - 130
4302308	Total Titanium (Ti)	2010/10/01					<1	mg/kg	1.4	35	100	70 - 130
4302308	Total Bismuth (Bi)	2010/10/01					<0.1	mg/kg	NC	30		
4302308	Total Potassium (K)	2010/10/01					<100	mg/kg	3.2	35		
4302308	Total Sodium (Na)	2010/10/01					<100	mg/kg	NC	35		
4302308	Total Tin (Sn)	2010/10/01					<0.1	mg/kg	2.8	35		
4302308	Total Zirconium (Zr)	2010/10/01					<0.5	mg/kg	NC	30		
4302430	Soluble (2:1) pH	2010/09/30			102	96 - 104			2.1	20		
4303157	Total Aluminum (Al)	2010/10/05					11, RDL=1 (2)	mg/kg	7.9	35		
4303157	Total Antimony (Sb)	2010/10/05					<0.1	mg/kg	NC	35		
4303157	Total Arsenic (As)	2010/10/05					<0.01	mg/kg	13.3	35		
4303157	Total Barium (Ba)	2010/10/05					<0.1	mg/kg	4.9	35		
4303157	Total Beryllium (Be)	2010/10/05					<0.1	mg/kg	NC	35		
4303157	Total Bismuth (Bi)	2010/10/05					<0.1	mg/kg	NC	35		
4303157	Total Boron (B)	2010/10/05					<5	mg/kg	NC	35		
4303157	Total Cadmium (Cd)	2010/10/05					<0.01	mg/kg	7.0	35		
4303157	Total Calcium (Ca)	2010/10/05					25, RDL=10 (3)	mg/kg	5.3	35		

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Maxxam Job #: B092008
Report Date: 2010/10/07

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Sampler Initials: LK

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4303157	Total Chromium (Cr)	2010/10/05					<0.5	mg/kg	37.1(1, 4)	35		
4303157	Total Cobalt (Co)	2010/10/05					<0.1	mg/kg	NC	35		
4303157	Total Copper (Cu)	2010/10/05					<0.5	mg/kg	11.5	35		
4303157	Total Iron (Fe)	2010/10/05					<10	mg/kg	6.6	35		
4303157	Total Lead (Pb)	2010/10/05					<0.01	mg/kg	9.5	35		
4303157	Total Magnesium (Mg)	2010/10/05					<10	mg/kg	8.0	35		
4303157	Total Manganese (Mn)	2010/10/05					<0.1	mg/kg	3.2	35		
4303157	Total Mercury (Hg)	2010/10/05					<0.01	mg/kg	NC	35		
4303157	Total Molybdenum (Mo)	2010/10/05					<0.1	mg/kg	8.5	35		
4303157	Total Nickel (Ni)	2010/10/05					<0.1	mg/kg	25.2	35		
4303157	Total Phosphorus (P)	2010/10/05					<10	mg/kg	5.0	35		
4303157	Total Potassium (K)	2010/10/05					<10	mg/kg	6.0	35		
4303157	Total Selenium (Se)	2010/10/05					<0.01	mg/kg	1.3	35		
4303157	Total Silver (Ag)	2010/10/05					<0.05	mg/kg	NC	35		
4303157	Total Sodium (Na)	2010/10/05					<10	mg/kg	NC	35		
4303157	Total Strontium (Sr)	2010/10/05					<0.1	mg/kg	6.0	35		
4303157	Total Thallium (Tl)	2010/10/05					<0.05	mg/kg	NC	35		
4303157	Total Tin (Sn)	2010/10/05					<0.1	mg/kg	NC	35		
4303157	Total Titanium (Ti)	2010/10/05					<1	mg/kg	4.6	35		
4303157	Total Uranium (U)	2010/10/05					<0.05	mg/kg	NC	35		
4303157	Total Vanadium (V)	2010/10/05					<2	mg/kg	NC	35		
4303157	Total Zinc (Zn)	2010/10/05					<0.1	mg/kg	2.7	35		
4304356	Cation exchange capacity	2010/10/01							NC	35		
4304359	Cation exchange capacity	2010/10/01							NC	35		
4304707	% sand by hydrometer	2010/10/01							1.9	35	110	89 - 111
4304707	% silt by hydrometer	2010/10/01							2.3	35	93	78 - 122
4304707	Clay Content	2010/10/01							NC	35	93	86 - 114
4305435	Available (NH4F) Nitrogen (N)	2010/10/01	100	80 - 120	109	90 - 111	<2	mg/kg	NC	35		
4305594	Available (NH4OAc) Potassium (K)	2010/10/01			95	80 - 120	<2	mg/kg	3.4	35	111	75 - 125

Maxxam Job #: B092008
Report Date: 2010/10/07

ACCESS CONSULTING GROUP
Client Project #: MIN - 110466

Sampler Initials: LK

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4305771	Available (NH4F) Phosphorus (P)	2010/10/01			99	80 - 120	<1	mg/kg	NC	35		
4306513	Soluble (5:1) Conductivity	2010/10/01			100	80 - 120	1, RDL=1	uS/cm	2.3	35		

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.
(2) - Blank outside acceptance criteria . All results higher than 10x Blank concentration.
(3) - Blank outside acceptance criteria. All results higher than 20x Blank concentration.
(4) - Duplicate RPD above control limit - Non-homogenous sample - Increased variability of results

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Toll-Free: 1-800-440-4808

CHAIN-O ANALYSIS REQUEST

08322883

PAGE 1 OF 2

MAXXAM JOB #: B092008

ANALYSIS REQUEST

COC #:

COMPANY NAME: Access Consulting Group	CLIENT PROJECT NO.: MIN-10466
COMPANY ADDRESS: #3 Calcite Business Center, 151 Industrial Rd., Whitehorse, YT, Y1A 2V3	TEL.: E-MAIL: FAX: 867-667-6680

SAMPLER NAME (PRINT):	PROJECT MANAGER:	LABORATORY CONTACT:
Lisa Knight	Scott Keesey	Kim Webber

#	FIELD SAMPLE ID	GROUNDWATER	SURFACE WATER	DRINKING WATER	SOIL	OTHER	DATE DD/MM/YY	TIME	# CONTAINERS	ICP Metals	pH/EC	Texture	TOC	C:N ratio	CEC	Total N	Nutrients
1	Reclamation B Toe of Wast Rock				X		15/09/10		1	X	X	X	X	X	X	X	X
2	Reclamation E Minto Cr Flume				X				1	X	X	X	X	X	X	X	X
3	" " " E Minto Rd Km 2				X				1	X	X	X	X	X	X	X	X
4	Reclamation D Toe of Dam S.				X				1	X	X	X	X	X	X	X	X
5	R1 (IROD) Plot A				X				1	X	X	X	X	X	X	X	X
6	R1 (IROD) Plot B				X				1	X	X	X	X	X	X	X	X
7	R3 Tailings Dump Plot A				X				1	X	X	X	X	X	X	X	X
8	R3 Tailings Dump Plot B				X				1	X	X	X	X	X	X	X	X
9	R3 Tailings Dump Plot C				X				1	X	X	X	X	X	X	X	X
10	R4 Minto Rd Km 3 Plot A				X				1	X	X	X	X	X	X	X	X
11	R4 Minto Rd Km 3 Plot B				X				1	X	X	X	X	X	X	X	X
12	R4 Minto R Km 3 Plot C				X				1	X	X	X	X	X	X	X	X

TAT (Turnaround Time)

LESS THAN 5 DAY TAT MUST HAVE PRIOR APPROVAL

* Some exceptions apply - please contact laboratory

STANDARD 5 BUSINESS DAYS
RUSH 3 BUSINESS DAYS
RUSH 2 BUSINESS DAYS
URGENT 1 BUSINESS DAY

OTHER BUSINESS DAYS

PO NUMBER OR QUOTE NUMBER:

SPECIAL DETECTION LIMITS / CONTAMINANT TYPE:

CCME
CSR
AB TIER 1
OTHER

ARRIVAL TEMPERATURE °C: 9 9 9

DUE DATE:

LOG IN CHECK:

ACCOUNTING CONTACT:

SPECIAL REPORTING OR BILLING INSTRUCTIONS:

JARS USED:

RELINQUISHED BY	DATE DD/MM/YY	TIME	RECEIVED BY
RELINQUISHED BY SAMPLER: Lisa Knight	24/09/10	13:30	RECEIVED BY:
RELINQUISHED BY: Paul [illegible]	24/09/10	15:00	RECEIVED BY: 09 27 10
RELINQUISHED BY:		0830	RECEIVED BY LABORATORY: C. ROSEN

CUSTODY RECORD

COCFORM - BC - 20070822

Maxxam Analytics Inc

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Burnaby, BC V5A 4N5
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CHAIN-OF C 08322884 **NALYSIS REQUEST**

PAGE 2 OF 2

MAXXAM JOB #	ANALYSIS REQUEST	COC #

COMPANY NAME: Access Consulting Group	CLIENT PROJECT NO.: MIN-110466
COMPANY ADDRESS: #3 Calcite Business Center, 151 Industrial Rd., Whitehorse, YT, Y1A 2V3	TEL.: E-MAIL: FAX: 867-667-6680
SAMPLER NAME (PRINT): Lisa Knight	PROJECT MANAGER: Scott Keesey
LABORATORY CONTACT:	

	FIELD SAMPLE ID		MATRIX: GROUNDWATER	SURFACE WATER	DRINKING WATER	SOIL	OTHER	SAMPLING: DATE DD/MM/YY	TIME	# CONTAINERS	ICP Metals
1	Reclamation (B) Toe of Waste Rock	[redacted]					X	15/09/10		1	X
2	- Grass Festuca ovina	[redacted]					X			1	X
3	- Grass Agropyron viola	[redacted]					X			1	X
4	Plot R1 (IROD) Trembling Aspen	[redacted]					X			1	X
5	Plot R1 (IROD) Little tree willow	[redacted]					X			1	X
6	Plot R1 " Grey leaf willow	[redacted]					X			1	X
7	Plot R3 Tailings Toe Greyleaf wi	[redacted]					X			1	X
8	Plot R3 " " Little Tree Wi	[redacted]					X			1	X
9	Plot R3 " " Grass Calamagros	[redacted]					X			1	X
10	Reclamation F Minto Cr Gr	[redacted]					X			1	X
11	R4 Km 3 Minto Rd Greyleaf	[redacted]					X			1	X
12		[redacted]									

TAT (Turnaround Time)

LESS THAN 5 DAY TAT MUST HAVE PRIOR APPROVAL

* Some exceptions apply - please contact laboratory

STANDARD	5 BUSINESS DAYS	
RUSH	3 BUSINESS DAYS	
RUSH	2 BUSINESS DAYS	
URGENT	1 BUSINESS DAY	

OTHER BUSINESS DAYS ______

PO NUMBER OR QUOTE NUMBER:

SPECIAL DETECTION LIMITS / CONTAMINANT TYPE:

CCME / CSR / AB TIER 1 / OTHER

ARRIVAL TEMPERATURE °C: 9 9 9

DUE DATE:

LOG IN CHECK:

ACCOUNTING CONTACT:

SPECIAL REPORTING OR BILLING INSTRUCTIONS:

JARS USED:

RELINQUISHED BY	DATE: DD/MM/YY	TIME:	RECEIVED BY
RELINQUINSHED BY SAMPLER: Lisa Knight	24/09/10	13:30	RECEIVED BY:
RELINQUINSHED BY: Paul Inglis	24/09/10	15:00	RECEIVED BY: 092710
RELINQUINSHED BY:		0830	RECEIVED BY LABORATORY: C. Rosen

CUSTODY RECORD

COCFORM - BC - 20070822

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W: www.exova.com

Exova

Analytical Report

Bill To:	Maxxam Analytics	Project:		Lot ID:	**765203**
Report To:	Maxxam Analytics	ID:	Job #B092008	Control Number:	
	4606 Canada Way	Name:		Date Received:	Sep 29, 2010
	Burnaby, BC, Canada	Location:		Date Reported:	Oct 4, 2010
	V5G 1K5	LSD:		Report Number:	1361913
Attn:	Kimberley Webber	P.O.:			
Sampled By:		Acct code:			
Company:					

		Reference Number	765203-1	765203-2	765203-3	
		Sample Date	Sep 15, 2010	Sep 15, 2010	Sep 15, 2010	
		Sample Time	NA	NA	NA	
		Sample Location				
		Sample Description	X23895-01R \ Reclamation	X23896-01R \ Reclamation	X23897-01R \ Reclamation	
		Matrix	Soil	Soil	Soil	
Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
Classification						
C:N Ratio			29	25	26	0.1
Nitrogen	Total	%	0.03	0.10	0.07	0.01
Organic Matter	Total	%	1.66	4.97	3.52	
Carbon	Total Organic	%	0.83	2.49	1.76	0.02

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Analytical Report

Bill To:	Maxxam Analytics	Project:	
Report To:	Maxxam Analytics	ID:	Job #B092008
	4606 Canada Way	Name:	
	Burnaby, BC, Canada	Location:	
	V5G 1K5	LSD:	
Attn:	Kimberley Webber	P.O.:	
Sampled By:		Acct code:	
Company:			

Lot ID:	**765203**
Control Number:	
Date Received:	Sep 29, 2010
Date Reported:	Oct 4, 2010
Report Number:	1361913

		Reference Number	765203-4	765203-5	765203-6	
		Sample Date	Sep 15, 2010	Sep 15, 2010	Sep 15, 2010	
		Sample Time	NA	NA	NA	
		Sample Location				
		Sample Description	X23898-01R \ Reclamation	X23899-01R \ R1 (IROD) Plot	X23900-01R \ R1 (IROD) Plot	
		Matrix	Soil	Soil	Soil	
Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
Classification						
C:N Ratio			>50	23.0	17.9	0.1
Nitrogen	Total	%	<0.01	0.14	0.12	0.01
Organic Matter	Total	%	0.95	6.50	4.38	
Carbon	Total Organic	%	0.48	3.25	2.19	0.02

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Analytical Report

Bill To:	Maxxam Analytics	Project:		Lot ID:	**765203**
Report To:	Maxxam Analytics	ID:	Job #B092008	Control Number:	
	4606 Canada Way	Name:		Date Received:	Sep 29, 2010
	Burnaby, BC, Canada	Location:		Date Reported:	Oct 4, 2010
	V5G 1K5	LSD:		Report Number:	1361913
Attn:	Kimberley Webber	P.O.:			
Sampled By:		Acct code:			
Company:					

		Reference Number	765203-7	765203-8	765203-9	
		Sample Date	Sep 15, 2010	Sep 15, 2010	Sep 15, 2010	
		Sample Time	NA	NA	NA	
		Sample Location				
		Sample Description	X23901-01R \ R3 Tailings D	X23902-01R \ R3 Tailings D	X23903-01R \ R3 Tailings D	
		Matrix	Soil	Soil	Soil	
Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
Classification						
C:N Ratio			17.3	13.7	16.4	0.1
Nitrogen	Total	%	0.22	0.18	0.17	0.01
Organic Matter	Total	%	7.63	4.87	5.59	
Carbon	Total Organic	%	3.82	2.44	2.79	0.02

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Analytical Report

Bill To:	Maxxam Analytics	Project:		Lot ID:	**765203**
Report To:	Maxxam Analytics	ID:	Job #B092008	Control Number:	
	4606 Canada Way	Name:		Date Received:	Sep 29, 2010
	Burnaby, BC, Canada	Location:		Date Reported:	Oct 4, 2010
	V5G 1K5	LSD:		Report Number:	1361913
Attn:	Kimberley Webber	P.O.:			
Sampled By:		Acct code:			
Company:					

		Reference Number	765203-10	765203-11	765203-12	
		Sample Date	Sep 15, 2010	Sep 15, 2010	Sep 15, 2010	
		Sample Time	NA	NA	NA	
		Sample Location				
		Sample Description	X23904-01R \ R4 Minto Rd K	X23905-01R \ R4 Minto Rd K	X23906-01R \ R4 Minto R KM	
		Matrix	Soil	Soil	Soil	
Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
Classification						
C:N Ratio			>20	16.6	>10	0.1
Nitrogen	Total	%	<0.01	0.24	<0.01	0.01
Organic Matter	Total	%	0.49	7.84	0.22	
Carbon	Total Organic	%	0.24	3.92	0.11	0.02

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Methodology and Notes

Bill To:	Maxxam Analytics	Project:		Lot ID:	**765203**
Report To:	Maxxam Analytics	ID:	Job #B092008	Control Number:	
	4606 Canada Way	Name:		Date Received:	Sep 29, 2010
	Burnaby, BC, Canada	Location:		Date Reported:	Oct 4, 2010
	V5G 1K5	LSD:		Report Number:	1361913
Attn:	Kimberley Webber	P.O.:			
Sampled By:		Acct code:			
Company:					

Method of Analysis

Method Name	Reference	Method	Date Analysis Started	Location
Total Carbon, Nitrogen & Sulfur by Leco Combustion	SSSA Book Series 5	* Nitrogen-Total, Ch 37	01-Oct-10	Exova Surrey
Total Carbon, Nitrogen & Sulfur by Leco Combustion	SSSA Book Series 5	* Total Carbon, Organic Carbon, and Organic Matter, Ch 34	01-Oct-10	Exova Surrey

** Reference Method Modified*

Comments:

APPENDIX D

2016 PHOTO LOG

2016 VMU Photo log

	
Photo 1: C01 soil pit	**Photo 2: C01 vegetation**
	
Photo 3: S18 soil pit	**Photo 4: S18 vegetation**
	
Photo 5: S01 soil pit	**Photo 6: S01 vegetation**

2016 VMU Photo log

Photo 7: M29 soil pit

Photo 8: M29 vegetation

Photo 9: S06 soil pit

Photo 10: S06 vegetation

Photo 11: S07 soil pit

Photo 12: S07 vegetation

2016 VMU Photo log

	
Photo 13: S16 soil pit	**Photo 14: S16 vegetation**
	
Photo 15: S17 soil pit	**Photo 16: S17 vegetation**
	
Photo 17: C02 soil pit	**Photo 18: C02 vegetation**

2016 VMU Photo log

Photo 19: M07b soil pit

Photo 20: M07b vegetation

Photo 21: M80 soil pit

Photo 22: M80 vegetation

Photo 23: Example of vegetation samples

Photo 24: Example of lichen samples

APPENDIX E

PARTICULATE MATTER DISPERSION MODELLING

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Minto Mine Phase V/VI Expansion Project

Draft Report

Particulate Matter Dispersion Modelling

RWDI # 1300542
August 9, 2013

SUBMITTED TO

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CONSULTING ENGINEERS & SCIENTISTS

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CONSULTING ENGINEERS & SCIENTISTS

1. INTRODUCTION

This report presents an assessment of the ambient impact of particulate matter emissions from the proposed Minto Mine Phase V/VI expansion operations (the Project). Specifically, dispersion modelling was performed to predict concentrations of total suspended particulates (TSP) and fine particulate matter ($PM_{2.5}$). Two emissions scenarios were considered for this assessment; current operations (Baseline scenario) and the Phase V/VI expansion operations (Future scenario). The Baseline scenario characterizes emissions based on the 2012 production rates. The Future scenario considers emissions based on 2014 production rates. This year was selected as it is the year with the highest production rates for the Phase V/VI expansion and is representative of worst-case emissions for the expansion.

Refined dispersion modelling was conducted in accordance with the BC Ministry of Environment's 2008 *Guidelines for Air Quality Dispersion Modelling in BC.* The methods and data used are described in the following section. Section 3 presents the results of dispersion modelling. Mitigation measures and best management practices are described in Section 4.

2. METHODS AND DATA

This section provides information on the contaminants considered in this assessment and the respective ambient air quality standards that were selected for comparison. Also detailed are the emission rate development and methodology adopted to complete the air quality modelling component.

2.1 Contaminants and Ambient Air Quality Standards

Particulate matter is often defined in terms of size fractions. Particles less than 40 µm in diameter typically remain suspended in the air for some time, and are referred to as TSP. Suspended particulate matter less than 10 µm in diameter is termed PM_{10}, and particulate matter less than 2.5 µm in diameter is termed $PM_{2.5}$. This report focuses on ambient concentrations of TSP and $PM_{2.5}$, the two size fractions regulated in the Yukon Ambient Air Quality Standards. Table 1 shows the maximum concentrations over the specified averaging periods that are acceptable in ambient air throughout the Yukon Territory.

Table 1: Yukon Ambient Air Quality Standards (in µg/m^3)

Contaminant	Averaging Period	Standard
Total Suspended Particulate (TSP)	24-hour	120
	Annual geometric mean	60
$PM_{2.5}$	24-hour	30

2.2 Emissions

Dust from mining activities at the Minto Mine Site are generated from: drilling, blasting, loading, and hauling activities in the open pit, and crushing and conveyer activities at remote crushing stations as well as at crushers located outside of the mill. Dust is generated from the fraction of dry aggregate that is less than 75 µm (or passes through a 200 mesh screen). These fine particles are easily disaggregated and released to the atmosphere. The moisture content also has an effect on the mobility of these fine particles. Typically, material at Minto has a moisture content of less than four percent and, without some means of dust control, particles will become airborne. Material transfer, handling, and mechanical breakdown contribute to dust mobilization and are compounded by natural forces, such as the wind.

This section of the report describes the methodology used to estimate dust emissions from mining at the Minto Mine site, based on predicted mine processing and handling rates for the year 2014. It is noted that no additional substantial particulate matter sources were found to currently exist or have been approved in the study area, and therefore, ambient background concentrations were assumed to be negligible.

Fugitive dust emissions from the following activities at the Minto Mine site were estimated and included in the dispersion model:

- Material processing and handling operations;
- Stockpiles;
- Blasting activities;
- Drilling operations, and;
- Bulldozing activities.

In order to fully capture predicted concentrations of particulate matter emissions from diesel equipment, emissions from vents from the underground mine and exhaust from the mill area of the mine were also estimated. The following subsections outline the methodology used to estimate emissions from the various sources as well as the related assumptions regarding material handling and other activity information.

2.2.1 Material Handling

Fugitive emissions of TSP and $PM_{2.5}$ were estimated for material handling activities such as loading of trucks by excavators, dumping of material from trucks at ore stockpiles or at waste rock areas, material handling by conveyors, and screening and crushing operations. The fugitive emissions were based on emission factors obtained from the US EPA's AP-42 document, Chapter 11.24 "Metallic Minerals Processing". Emission factors for $PM_{2.5}$ were obtained by applying a scaling factor of 0.15 on PM_{10} emission factors, for all material handling sources. For the Gyratory crusher, TSP emission factors were obtained by scaling the PM_{10} emission factors by 2.7.

Emission factors in US EPA's AP-42 for handling and processing activities do not account for controls that mitigate fugitive dust emissions; as a result, control efficiencies were developed to better represent emissions from mining operations. Activities associated with material handling in mining operations are recognized as the dominant emission sources due to a combination of heavy equipment being used for hauling, screening and crushing rock. As a result, mitigation is generally required to create a meaningful reduction in emissions from these dominant sources. Control efficiencies were applied as a percentage reduction from uncontrolled to the material handling sources based on published efficiencies that considered the type and scope of the controls employed at the Project and are presented in Table 2.

Table 2: Control Efficiencies Applied to Material Handling Activities

Type of Dust Control	Control Efficiency
Water Spray	60%[1]
Indoor Handling and Processing	70%[2]
Telescoping Skirt around Conveyor Discharge	70%[2]
Water and Envirobind© Mixture	70%[2]
Under-pile Conveyor	80%[2]
Baghouse	95%[2]

Notes:
[1] Cowherd, C. G. E. Muleski and J. S. Kinsey (1988). Control of Open Fugitive Dust Sources. U.S. Environmental Protection Agency, EPA-450/3-88-008.
[2] Air & Waste Management Association. 2000. Air Pollution Engineering Manual, Second Edition. 886 pp. ISBN: 0-471-33333-6.

A control efficiency of 60% was applied to underground activities where water sprays are used. A control efficiency of 70% was applied to material handling sources in the crusher circuit, which includes processing of material between the jaw crusher and gyratory crusher, to account for the application of a mixture of water and Envirobind© at the vibrating screen. A control efficiency of 70% was also applied to the telescoping skirts that will provide wind protection to material dropped from the gyratory crusher discharge. The transfer of material from the apron feeder to the SAG mill is indoors which reduces emissions; a control factor of 70% was applied. A control efficiency of 80% was applied to the under-pile conveyor from the crushed ore stockpile to the apron feeder. A control efficiency of 95% was applied to baghouse systems that collect dust at the jaw crusher and gyratory crusher. Incorporation of these control efficiencies are expected to have a positive effect on reducing particulate emissions from these dominant emission sources related to mining activities.

2.2.2 Stockpiles

The emission factor for TSP emissions from wind erosion of stockpiles was obtained from Table 11.9.4 of the US EPA's AP-42 document, Chapter 11.9 "Western Surface Coal Mining". This emission factor adopts a linear relationship between dust emissions from overburden stockpiles and wind speed. Stockpiles at Minto Mine contain material and aggregate sizes similar to overburden at coal mines; therefore, the emission factor from Chapter 11.9 "Western Surface Coal Mining" was used. Since a $PM_{2.5}$ emission factor is not provided, particle size fraction multipliers from Section 13.2.5 of US EPA AP-42 were applied to the emission rate of TSP to obtain the emission rate for $PM_{2.5}$.

Since the TSP emission factor considers maintenance of active stockpiles, it was assumed that emissions associated with pile disturbances from contouring activities are accounted for in the emission calculation. Fugitive dust controls are not used on stockpiles; therefore no control efficiencies were applied to the fugitive emissions from the stockpiles.

2.2.3 Blasting

At the Minto Mine, blasting is employed to separate overburden from the ore seam and also to break up the ore seam. Fugitive emissions from the blasting operations were estimated based on emission factors obtained from Chapter 11.9 “Western Surface Coal Mining” of US EPA AP-42. A working area of 2,596 m^2 was assumed for each blast. Since overburden is considered to be the material overlying useful geological deposits, blasting of overburden and ore seams at Minto Mine was assumed to be similar to blasting of overburden at coal mines. Although the emission factor was developed for coal mining, it is analogous to blasting at Minto. The approach is generally accepted for other applications where blasting emissions were estimated, there are no other reasonable alternatives available for estimating blasting emissions.

2.2.4 Bulldozing

Fugitive emissions generated from the bulldozing of overburden material at the Minto Mine site were estimated based on emission factors obtained from Table 11.9.2 of the US EPA’s AP-42 document, Chapter 11.9 “Western Surface Coal Mining”. Emissions from bulldozing activities are proportional to the silt content while greater moisture content decreases emissions from bulldozing. An average silt content of 6.9% was assumed as per Table 11.9.3 in Chapter 11.9 “Western Surface Coal Mining” of US EPA’s AP-42. The moisture content of the overburden material was provided by Minto Mine to be 4%. Although the emission factor was developed for coal mining, it is analogous to bulldozing at Minto and also recommended for use in Chapter 13.2 “Heavy Construction Operations” of US EPA AP-42. The approach is generally accepted for other applications where bulldozing emissions were estimated.

2.2.5 Drilling

The emission factor for fugitive TSP emissions due to the drilling operations at the Minto Mine was obtained from Table 11.9.4 of the US EPA’s AP-42 document, Chapter 11.9 “Western Surface Coal Mining”. Particle size fraction multipliers from Section 13.2.5 of US EPA AP-42 were applied to the TSP emission rate to obtain emission rates for $PM_{2.5}$. The emission rate was based on a maximum of six holes being drilled every hour. Although the emission factor was developed for coal mining, it is analogous to drilling activities at Minto and also recommended for use in Chapter 13.2 “Heavy Construction Operations” of US EPA AP-42.

2.2.6 Diesel Equipment

Exhaust emissions of TSP and $PM_{2.5}$ were calculated for diesel-fuelled non-road equipment such as bulldozers, excavators, loaders, graders, and haul trucks using the methodology in US EPA’s 2004 report number NR-009c “Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression Ignition”. The calculations are based on equipment horsepower, load factor, model year, and hours of operation. Load factors were also obtained from the US EPA’s report number NR-009c. The model years of the various diesel equipment used on site were assumed to be between 2004 and 2014.

2.2.7 Vents from Underground Mine

Emissions from underground material handling processes, blasting, drilling, and diesel equipment used underground were estimated as described in the preceding sections. Total emissions from the underground sources were apportioned to the vents based on the exit velocity of each vent.

2.2.8 Summary of Emission Estimates

Maximum hourly and annual emission rates for all sources for the Baseline and Future scenarios are summarized in Table 3 and Table 4, respectively. Compared to the Baseline scenario, Emissions in the Future scenario are expected to be higher due to increase in drilling activities and an increase use of diesel equipment.

Table 3: Summary of Maximum Hourly and Annual Emission Rates of TSP and $PM_{2.5}$ for the Baseline Scenario

Emission Source	Maximum Hourly Emission Rate (g/s)		Annual Emission Rate (Mg/year)	
	TSP	$PM_{2.5}$	TSP	$PM_{2.5}$
Material Handling Sources				
Excavator loading onto Trucks	0.007	0.000	0.047	0.003
Trucks dump at stockpiles	0.001	0.000	0.011	0.001
Trucks dump at crusher stockpile	0.001	0.000	0.007	0.001
Trucks dump at waste rock dumps	0.009	0.001	0.057	0.004
Cat 773 Trucks loaded at OP stockpiles	0.004	0.000	0.002	0.000
Cat 773 Trucks dump ore from stockpiles at crusher stockpile	0.006	0.000	0.004	0.000
UG load to (40t) trucks dump	0.000	0.000	0.002	0.000
UG (40t) trucks dump at UG stockpile on surface, near portal	0.000	0.000	0.003	0.000
Cat 773 trucks loaded at UG stockpile with Cat 990	0.002	0.000	0.002	0.000
Cat 773 trucks dump at crusher stockpile	0.002	0.000	0.003	0.000
Loading tram at crusher stockpile	0.001	0.000	0.010	0.001
Tramming ore from crusher stockpile to grizzly / jaw crusher	0.001	0.000	0.016	0.001
Grizzly Screen	0.722	0.052	8.988	0.647
Jaw Crusher	0.578	0.042	7.190	0.518
Jaw Crusher to Conveyor	1.040	0.075	12.942	0.932
Conveyor from jaw crusher discharge to vibrating screen	1.040	0.075	12.942	0.932
Vibrating Screen	1.040	0.075	12.942	0.932
Conveyor from vibratory screen oversize to	1.040	0.075	12.942	0.932

Emission Source	Maximum Hourly Emission Rate (g/s)		Annual Emission Rate (Mg/year)	
	TSP	$PM_{2.5}$	TSP	$PM_{2.5}$
gyratory				
Gyratory Crusher	1.733	0.125	21.571	1.553
Conveyor from vibratory screen undersize to live pile	1.040	0.075	12.942	0.932
Drop off end of conveyor on to live pile (crushed ore stockpile)	2.080	0.150	12.942	0.932
Live pile drop to Apron feeder	1.387	0.100	8.628	0.621
Apron feeder drop to conveyor	2.080	0.150	12.942	0.932
Conveyor drop to SAG mill	2.080	0.150	12.942	0.932
Total of Material Handling Sources	**15.9**	**1.1**	**150.1**	**10.8**
Stockpile Wind Erosion				
Crushed Ore pile (live pile)	0.01	0.00	0.29	0.02
Crusher stockpile	0.01	0.00	0.22	0.02
North stockpile	0.02	0.00	0.67	0.05
West stockpile	0.03	0.00	0.81	0.06
East stockpile	0.03	0.00	0.94	0.07
South stockpile	0.02	0.00	0.67	0.05
Total of Stockpile Wind Erosion Emissions	**0.06**	**0.00**	**1.99**	**0.15**
Blasting	**8.08**	**0.24**	**8.73**	**0.26**
Bulldozing	**12.1**	**1.27**	**60.3**	**6.33**
Drilling	**0.105**	**0.008**	**0.373**	**0.027**
Diesel Equipment [1]	**1.83**	**1.77**	**24.19**	**23.46**
Underground Vents [3]	**1.16**	**0.07**	**28.43**	**1.83**

Notes:

[1] Includes all emissions from diesel equipment with the exception of equipment used underground.

[2] Emissions from the mill exhausts are the total emissions of material handling at the apron feeder drop to conveyor and conveyor drop to SAG mill.

[3] Emissions from underground vents are total emissions from underground drilling, blasting, material handling, and diesel equipment used underground.

Table 4: Summary of Maximum Hourly and Annual Emission Rates of TSP and $PM_{2.5}$ for the Future Scenario

Emission Source	Maximum Hourly Emission Rate (g/s)		Annual Emission Rate (Mg/year)	
	TSP	$PM_{2.5}$	TSP	$PM_{2.5}$
Material Handling Sources				
Excavator loading onto Trucks	0.007	0.000	0.162	0.012
Trucks dump at stockpiles	0.001	0.000	0.020	0.001
Trucks dump at crusher stockpile	0.001	0.000	0.014	0.001
Trucks dump at waste rock dumps	0.009	0.001	0.225	0.016
Cat 773 Trucks loaded at OP stockpiles	0.004	0.000	0.005	0.000
Cat 773 Trucks dump ore from stockpiles at crusher stockpile	0.006	0.000	0.007	0.001
UG load to (40t) trucks dump	0.000	0.000	0.004	0.000
UG (40t) trucks dump at UG stockpile on surface, near portal	0.000	0.000	0.006	0.000
Cat 773 trucks loaded at UG stockpile with Cat 990	0.002	0.000	0.004	0.000
Cat 773 trucks dump at crusher stockpile	0.002	0.000	0.006	0.000
Loading tram at crusher stockpile	0.001	0.000	0.018	0.001
Tramming ore from crusher stockpile to grizzly / jaw crusher	0.001	0.000	0.030	0.002
Grizzly Screen	0.722	0.052	17.109	1.232
Jaw Crusher	0.578	0.042	13.688	0.986
Jaw Crusher to Conveyor	1.040	0.075	24.638	1.774
Conveyor from jaw crusher discharge to vibrating screen	1.040	0.075	24.638	1.774
Vibrating Screen	1.040	0.075	24.638	1.774
Conveyor from vibratory screen oversize to gyratory	1.040	0.075	24.638	1.774
Gyratory Crusher	1.733	0.125	41.063	2.957
Conveyor from vibratory screen undersize to live pile	1.040	0.075	24.638	1.774
Drop off end of conveyor on to live pile (crushed ore stockpile)	2.080	0.150	24.638	1.774
Live pile drop to Apron feeder	1.387	0.100	16.425	1.183
Apron feeder drop to conveyor	2.080	0.150	24.638	1.774
Conveyor drop to SAG mill	2.080	0.150	24.638	1.774
Total of Material Handling Sources	**15.9**	**1.1**	**285.9**	**20.6**
Stockpile Wind Erosion				

Emission Source	Maximum Hourly Emission Rate (g/s)		Annual Emission Rate (Mg/year)	
	TSP	$PM_{2.5}$	TSP	$PM_{2.5}$
Crushed Ore pile (live pile)	0.01	0.00	0.29	0.02
Crusher stockpile	0.01	0.00	0.22	0.02
North stockpile	0.02	0.00	0.67	0.05
West stockpile	0.03	0.00	0.81	0.06
East stockpile	0.03	0.00	0.94	0.07
South stockpile	0.02	0.00	0.67	0.05
Total of Stockpile Wind Erosion Emissions	**0.06**	**0.00**	**1.99**	**0.15**
Blasting	**8.08**	**0.24**	**8.73**	**0.26**
Bulldozing	**12.1**	**1.27**	**60.3**	**6.33**
Drilling	**0.105**	**0.008**	**1.294**	**0.093**
Diesel Equipment [1]	**1.54**	**1.50**	**58.37**	**56.62**
Underground Vents [3]	**1.16**	**0.07**	**28.43**	**1.83**

Notes:

[1] Includes all emissions from diesel equipment with the exception of equipment used underground.

[2] Emissions from the mill exhausts are the total emissions of material handling at the apron feeder drop to conveyor and conveyor drop to SAG mill.

[3] Emissions from underground vents are total emissions from underground drilling, blasting, material handling, and diesel equipment used underground.

2.3 Dispersion Modelling

Refined dispersion modelling was conducted in accordance with the BC Ministry of Environment's 2008 *Guidelines for Air Quality Dispersion Modelling in BC* to assess potential environmental effects of fugitive dust emissions using the US EPA approved CALPUFF model, version 5.8. CALPUFF was used to estimate hourly maximum concentrations of TSP and $PM_{2.5}$ and annual mean concentrations of TSP in the study area.

CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model. It simulates the effects of time- and space-varying meteorological conditions on pollutant transport, dispersion, transformation, and deposition. CALPUFF can use three-dimensional meteorological fields prepared with the CALMET model or simple, single-station winds in a format consistent with the meteorological files used to drive the ISCST3 steady-state Gaussian model. The CALPUFF model was applied using the ISC mode option for this assessment, because the CALMET-level of modelling sophistication was not deemed necessary.

All technical options (model switches) relating to the CALPUFF dispersion model were set according to the BC Ministry of Environment's 2008 *Guidelines for Air Quality Dispersion Modelling in BC* or to the model defaults. These include parameters and options such as the calculation of plume dispersion coefficients, the plume path coefficients used for terrain adjustments, exponents for the wind speed profile, and wind speed categories. A list of the selected model-switch settings is provided in Appendix A.

A circle of 7.5 km radius centred on the Minto Mine site was chosen as the Minto project boundary. An additional boundary that reflects the Minto Quartz Claims was also considered to provide spatial context to the predictions. The radius of the Project boundary was determined as the distance from the centre of the Project to the Yukon River. A receptor grid was generated following the BC Ministry of Environment's 2008 *Guidelines for Air Quality Dispersion Modelling in BC* with the following spacing:

- 500 m within the Project boundary;
- 20 m on the Project boundary;
- 50 m within 500 m from the Project boundary;
- 250 m within 2 km from the Project boundary;
- 500 m within 5 km from the Project boundary; and
- 1,000 m beyond 5 km from the Project boundary.

Modelling results of annual TSP concentrations are arithmetic means while the Yukon Ambient Air Quality Standard shown in Table 1 in Section 2.1 is based on a geometric mean. The distribution of hourly particulate concentrations is typically skewed with a long tail toward higher than average values. Under such a distribution, the arithmetic mean is higher than the geometric mean, and therefore, conservatively overestimates ambient concentrations.

2.4 Meteorology

A one-year meteorological data set from October 1, 2011 to September 30, 2012 was prepared for this assessment. Hourly wind speed, wind direction, and temperature were obtained from the Minto Mine HOBO station. Hourly observations of cloud cover and ceiling height were required to estimate atmospheric stability. Although the Environment Canada operated station Pelly Ranch is closer to the study area, the station does not collect hourly measurements of cloud cover and ceiling height suitable for modelling. As a result, data were obtained from the closest airport with hourly measurements in Mayo, Yukon, located about 135 km northeast of the Project. Mixing heights were calculated based on upper air data obtained from Whitehorse, Yukon. The Whitehorse station is the nearest upper air station, and is located about 240 km southeast of the Project. Due to the limited availability of upper air data in the region, the data were considered the most representative of the study area. These meteorological data were pre-processed for input to the CALPUFF model using the MPRM pre-processor.

The joint frequency distribution of wind speed and direction for the dataset is illustrated in Figure 1. The distribution is shown in a "wind rose" format, which is essentially a bar chart in polar format. The direction of the bar indicates the direction from which the wind is blowing, the colour indicates the wind speed class and the length of the bar indicates the frequency of occurrence. The wind rose for the Minto Mine meteorological station indicates that winds were predominantly from the south-southeast and southeast at this location. The highest hourly mean wind speed during the one-year period was 16.6 m/s. The frequency of calms (i.e., wind speeds less than 0.5 m/s) is 13.69% and the calculated average hourly wind speed is 3.0 m/s.

2.5 Study Limitations

A number of limitations are inherent in the air quality study. These include limitations in emissions estimation and limitations in dispersion modelling.

Emissions have been estimated based on Project-specific activity data where available, and default activity data from US EPA where Project-specific information are not available. Default activity data are based on the average of conditions observed at a limited number of project sites, mainly in the United States, which are reasonable surrogates but may not be exactly representative of the Project. The use of published emission factors is associated with inherent limitations in that such factors are based on averages of available data, which may not be sufficient to extrapolate for Project-specific activity parameters (e.g., vehicle speed, material silt content, etc.) outside the observed range of these parameters. Furthermore, these published emission factors are typically representative of long-term averages and the use of such emission factors for estimating short-term emission rates for dispersion modelling are associated with uncertainties.

By definition, air quality dispersion models can only approximate atmospheric processes. Many assumptions and simplifications are required to describe real phenomena in mathematical equations. Model uncertainties can result from:

- Simplifications and accuracy limitations related to source data;
- Extrapolation of meteorological data from selected locations to a larger region; and
- Simplifications of model physics to replicate the random nature of atmospheric dispersion processes.

Models are reasonable and reliable in estimating the maximum concentrations occurring on an average basis. That is, the maximum predicted concentration that may occur at some time somewhere within the model domain, as opposed to the exact concentration at a point at a given time, is usually within the ±10% to ±40% range of the observed maximum concentration as described in the US EPA July 2003 Edition of *Guideline on Air Quality Models* (US EPA 2003). Typically, a model is viewed as replicating dispersion processes if it can predict within a factor of two, and if it can replicate the temporal and meteorological variations associated with monitoring data. Model predictions at a specific site and for a specific hour, however, may correlate poorly with the associated observations due to the above-indicated uncertainties. For example, an uncertainty of five to ten degrees in the measured wind direction can result in concentration errors of 20% to 70% for an individual event (US EPA 2003).

3. RESULTS

3.1 Baseline Scenario

Maximum predicted ground-level concentrations of TSP and $PM_{2.5}$ in the Baseline scenario are presented in Table 5. The predicted 24-hour and annual average ground-level concentrations of TSP are presented in Figure 2 and Figure 3, respectively. The highest concentrations of TSP were predicted to occur at the centre of the Project boundary, adjacent to the emission sources of particulate matter. Outside of the Minto quartz claims boundary, exceedances of the 24-hour average TSP and $PM_{2.5}$ standards were not predicted. Exceedances of the annual average TSP standard were predicted up to one kilometre from emission sources. No exceedances of the annual TSP standard were predicted outside of the Project boundary.

Table 5: Maximum Predicted Concentrations – Baseline Scenario (in µg/m^3)

Contaminant	Averaging Period	Maximum Predicted Concentration (Inside Boundary)	Maximum Predicted Concentration (Outside Boundary)	Yukon Ambient Air Quality Standard
Total Suspended Particulate (TSP)	24-hour	**3,440**	22	120
	Annual geometric mean	**752**	2.1	60
$PM_{2.5}$	24-hour	**549**	17	30

Note: Concentrations in boldface text exceed the Yukon ambient air quality standard

Maximum predicted 24-hour average ground-level concentrations of $PM_{2.5}$ are presented in Figure 4. Exceedances of the 24-hour average $PM_{2.5}$ ambient air quality standard were not predicted outside the Project boundary. Concentrations greater than 240 µg/m^3 were predicted up to three kilometres from emission sources, while exceedances were predicted up to four kilometres from emission sources. The maximum predicted 24-hour average $PM_{2.5}$ concentration at the camp complex was 62 µg/m^3 based on the 98th percentile, and the predicted average $PM_{2.5}$ concentration was 11 µg/m^3.

3.2 Future Scenario

Maximum predicted ground-level concentrations of TSP and $PM_{2.5}$ inside and outside the Project boundary in the Future scenario are presented in Table 6. The predicted 24-hour and annual average ground-level concentrations of TSP are presented in Figure 5 and Figure 6, respectively. Outside of the area of limited public access and Minto quartz claims boundary, exceedances of the Yukon ambient air quality standards were predicted to not occur. The highest concentrations of TSP were predicted at and around where the Minto North Pit is located. Exceedances of the annual average TSP standard were predicted to occur up to one kilometre from emission sources. Exceedances of the Yukon ambient air quality standard for 24-hour average TSP were not predicted. Maximum predicted concentrations of TSP exceed the Yukon ambient air quality standards inside the Project boundary.

Table 6: Maximum Predicted Concentrations – Future Scenario (in µg/m^3)

Contaminant	Averaging Period	Maximum Predicted Concentration (Inside Boundary)	Maximum Predicted Concentration (Outside Boundary)	Yukon Ambient Air Quality Standard
Total Suspended Particulate (TSP)	24-hour	**6,270**	78	120
	Annual geometric mean	**1,050**	12	60
$PM_{2.5}$	24-hour	**703**	13	30

Note: Concentrations in boldface text exceed the Yukon ambient air quality standard

Maximum predicted 24-hour average ground-level concentrations of $PM_{2.5}$ are presented in Figure 8. Exceedances of the 24-hour average $PM_{2.5}$ ambient air quality standard were not predicted to occur outside the area of limited public access. Exceedances of the Yukon ambient air quality standard were predicted up to four kilometres from emission sources. The maximum predicted 24-hour average $PM_{2.5}$ concentration at the camp complex was 46 µg/m^3 (based on 98th percentile), and the predicted average $PM_{2.5}$ concentration was 9.0 µg/m^3.

4. DISCUSSION

4.1 Interpretation of Results

Maximum 24-hour $PM_{2.5}$ concentrations were predicted to not exceed the ambient air quality standards outside the area of limited public access in the Baseline scenario and Future scenario. Maximum 24-hour and annual average TSP concentrations were predicted to not exceed the ambient air quality standard outside the area of limited public access. Activities such blasting, bulldozing and crushing were estimated to be the largest contributors to total site emissions.

The variations in estimated concentrations between the Baseline and Future scenarios were due to an increased product throughput in the Future scenario and the location of emission sources. In the Future scenario, most of the activities were from the Minto North pit, the Minto North dump and the mill complex. Emission source locations in the Baseline scenario cover a larger area than the Future scenario, primarily at the mill complex, Area 2 Stage 1 and Area 2 Stage 2 pits, and nearby overburden and waste dumps.

Mitigation measures and best management practices could be implemented to reduce particulate emissions.

4.2 Current Mitigation Measures

Dust control at the Minto Mine site is normally managed through application of water and Envirobind© at various generating locations. Application of Envirobind© helps prevent freezing at cold temperatures and encourages binding of fine particles.

Water used for dust suppression at the crushers and drills is obtained from the water storage pond or from the main pit. In the summer months, water for the roads is obtained from other sources, including the surface water flowing into the Southwest Diversion Ditch.

4.2.1 Drilling

The four drills used at Minto use water at all times while drilling to collar the production holes and to cut down on dust generation. In the winter, due to difficulties with antifreeze products, the use of water is intermittent. The drills have dust collector systems built in on the current rigs using the air from the drill's compressor. The application of water and dust collector systems reduces estimated emissions from drilling by approximately 90%.

4.2.2 Blasting

There are currently no procedures in place aimed specifically at reducing dust generated during blasting. Minto optimizes its blasts to minimize the amount of explosive product used and to achieve the best possible confinement of explosive energy. This optimization serves to lower dust dispersion. Minto prepares screened crush for use in stemming and specifies loading instructions such that adequate confinement is available and the amount of energy lost through the top of the blast is minimized.

4.2.3 Loading and Hauling

Approximately 12 million tons of material are handled annually using a combination of D9, D-10, and D-11 bulldozers with Hitachi 1100 and 1200 excavators. This material is then trucked using 100 ton Cat 777 and 60 ton Cat 773 haul trucks, to various locations at the mine site with average distances between 0.5 km and 2 km. Material is re-handled at the ore stockpiles and crusher stockpile using Cat 992 and Cat 990 loaders. These transfer and re-handling sites are all subject to amplified dust generation.

Haul roads are watered in the summer months using a 10,000 gallon tank pulled by a Cat 631D scraper tractor with a 270 hp power rating. Triggers for application of water on haul roads are visual cues and are subjective in nature.

No dust control measures are currently in place for loading haul trucks or for loading the crusher hoppers. Occasionally, the ore stockpiles themselves are watered down at the digging face to reduce dust generation during re-handling.

4.2.4 Crushing

There are two main locations for crushing on the Minto Mine site: the mobile Nuway Crusher, which produces P100 19mm and P80 9mm run-of-mill feed; and the permanent jaw and gyratory crusher, which provides 28 mm run-of-mill feed. Dust is generated at various locations in the process, including: from loading of the jaw crusher, on the conveyors, and at the gyratory crusher and the stacker conveyor.

The Nuway crushing mobile unit has dust control measures in place at three locations of the process: at the cone-crusher feed, the lower vibrating screen, and at the stacker conveyor. A mixture of Envirobind© and water is applied through custom nozzles at these locations.

The permanent jaw and gyratory unit adjacent to the mill has dust control nozzles in place at two locations of the process: at the feed to the gyratory crusher and at the stacker conveyor. A mixture of Envirobind© and water is applied through custom nozzles at these locations.

4.3 Phase V/VI Expansion Mitigation Measures

The primary source at the Minto crusher is fugitive dust carried away by wind at the discharge of the stacker conveyor. The plan for the upgraded crusher circuit, due to be installed in summer of 2013, is to eliminate the Envirobind©/water nozzles at the stacker conveyor in favor of a telescoping wind protection 'skirt' covering the drop from the conveyor discharge to the top of the live pile. This chute is compatible with the fine crush size that is planned and will provide excellent dust control on a year-round basis.

Other leading contributors to dust generation at the Minto crusher are dust emissions at the equipment and conveyor transfer points. A baghouse dust collection system with dust hoods and ductwork is proposed to collect dust from equipment and transfer points. The dust would then be dropped by the baghouse into a screw auger system that discharges onto the feed end of the radial stacker conveyor.

Calcium chloride is to be used on the access road between kilometer 0 and 27 and applied at a rate of approximately 1 kg/m^2. Calcium chloride dust control applications not only reduce airborne particulate matter but have the added benefits of reducing sediment load on waterways and minimizing the need for additional aggregate and road maintenance.

4.4 Dust Management Plan and Future Mitigation Measures

Emissions from Minto Mine Phase V/VI expansion operations can be further mitigated though best management practices detailed in the Fugitive Dust Best Management Practices document (in Appendix B). To reduce fugitive dust emissions at the mine, a best management practices document has been prepared. This management plan is designed to assist Minto in controlling dust emissions at each of the sources. Many of the control measures described in the best management practices document are currently implemented at Minto. The practices that have yet to be implemented would provide relatively minor improvements compared to current practices. Although these have not been accounted for in the emissions estimates and dispersion modelling, following the dust management plan will reduce emissions of particulate matter from mining activities, consequently lowering the maximum predicted concentrations both onsite and offsite, and reducing the likelihood of exceeding the Yukon ambient air quality standards.

5. RECOMMENDATIONS

Based on the results of this study, it was determined that Minto has made a significant commitment to reducing fugitive dust and particulate matter emissions from mining operations. The following actions are recommended:

- Minto should continue their high level of emission reduction activities. These include the use of water and chemical dust suppressants, skirting around conveyors, and baghouse dust collection systems at the crushers.

- Monitoring of particulate matter at the camp is recommended as there were elevated concentrations of particulate matter predicted at the camp complex. Mitigation measures should be considered if these measurements indicate the potential for health concerns or elevated worker exposure. Recommendations for the siting of the monitoring stations have been provided below.

- Implementation of best management practices. Emissions from Phase V/VI expansion operations can be further mitigated through best management practices. Although the benefits of implementing the measures presented in the document that have not yet been adopted cannot be quantified through predictive modelling, it is expected that the further reduce the concentrations of TSP and $PM_{2.5}$ will be realized.

5.1 Monitoring Plan

Further monitoring of particulate matter is advised at the camp based on model predictions. Particulate monitors that measure TSP and $PM_{2.5}$ concentration should be installed near the camp location; however, the monitor should not be placed adjacent to a particulate matter emission source, or within twice the height of camp buildings or other structures as directed by the Ontario Ministry of the Environment's 2003 *Operations Manual for Point Source Air Quality Monitoring*. The sited location should be on a paved area or with good vegetative ground cover. The monitor should be placed between 0.5 m to 1.0 m above ground with the sample inlet at least one metre (vertical) and at least two metres (horizontal) from a supporting structure. Particulate monitoring should be continuous, with averaging periods of 1-hour and 24-hours.

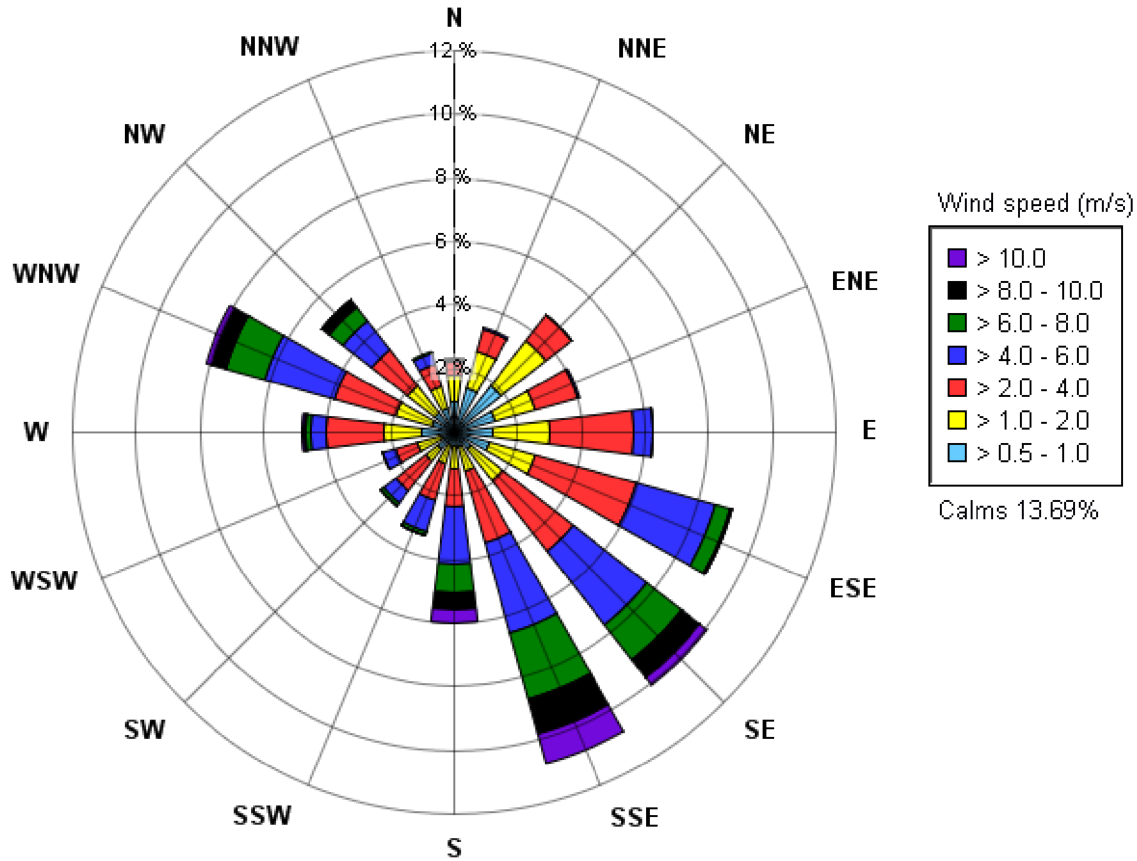
It is also recommend for Minto Mine to install a $PM_{2.5}$ monitor on the western edge inside the Minto Quartz Claims boundary as elevated 24-hour average $PM_{2.5}$ concentrations were predicted. Recommended locations of continuous particulate matter monitoring are shown in Figure 8.

.

6. CONCLUSIONS

Project emissions from current operations (Baseline scenario) and Phase V/VI expansion operations (Future scenario) were estimated to determine the ambient impact of particulate matter. For all averaging periods of TSP and $PM_{2.5}$, concentrations were predicted to not exceed the Yukon Ambient Air Quality Standards outside the Project boundary in both the Baseline and Future scenarios. Elevated levels of particulate matter were predicted at the camp site during Phase V/VI expansion operations. As a result, monitoring at the camp site is recommended and mitigation measures may be warranted if measurements indicate the potential for health concerns or elevated worker exposure. Emissions from Phase V/VI expansion operations can be further mitigated through best management practices.

FIGURES

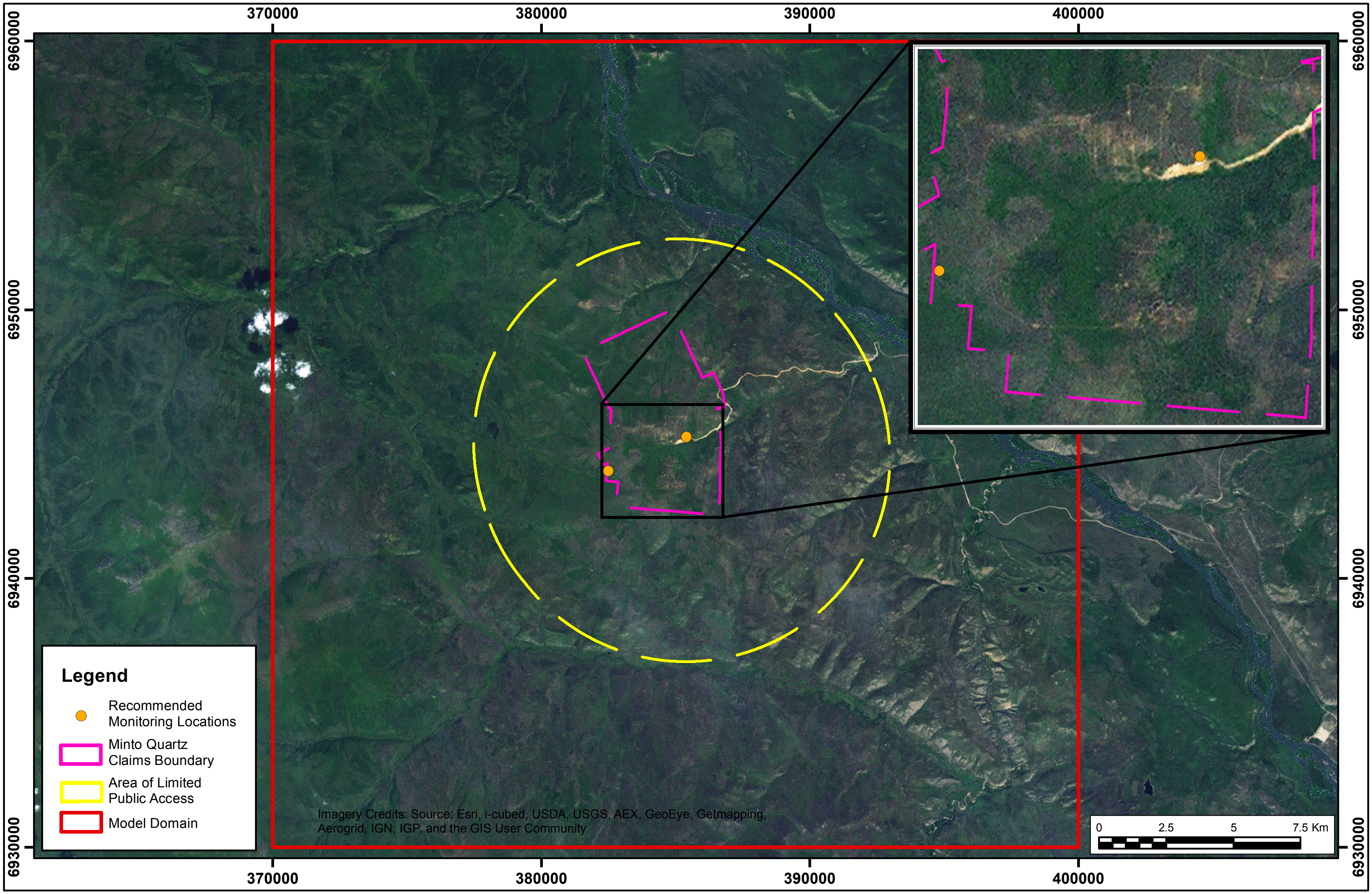


Hourly Wind Speed and Direction Frequency Distribution
Observed at Minto Mine HOBO Station (October 2011 to September 2012)

Minto Mine Expansion Phase V/VI - Minto Mine, Yukon

Project #1300542

Drawn by:	NBN	Figure:	1
Approx. Scale:	NTS		
Date Revised:	Apr. 9, 2013		



Recommended PM Monitoring Locations

True North

Drawn by: NBN | Figure: 8

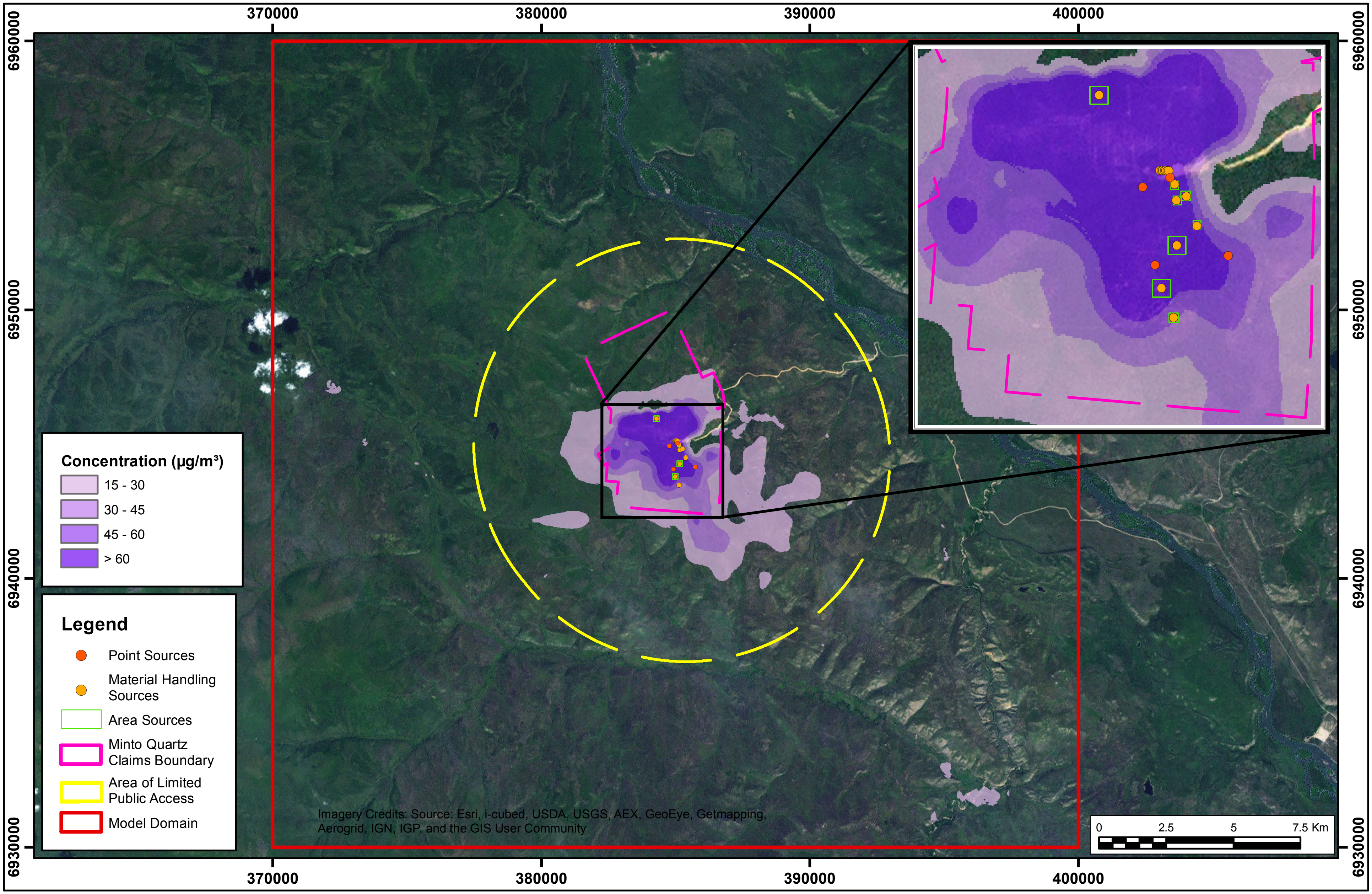
Approx. Scale: 1:200,000

Date Revised: Aug. 8, 2013

Map Projection: NAD 1983 UTM Zone 8N.

Minto Mine Expansion Phase V/VI - Minto Mine, Yukon

Project #1300542



Modelled Maximum 24-Hour $PM_{2.5}$ Concentrations (Emissions from All Sources)
Future Case (AAQO = 30 µg/m³)

Map Projection: NAD 1983 UTM Zone 8N.

Minto Mine Expansion Phase V/VI - Minto Mine, Yukon

True North

Project #1300542

Drawn by:	NBN	Figure:	7
Approx. Scale:	1:200,000		
Date Revised:	Aug. 8, 2013		

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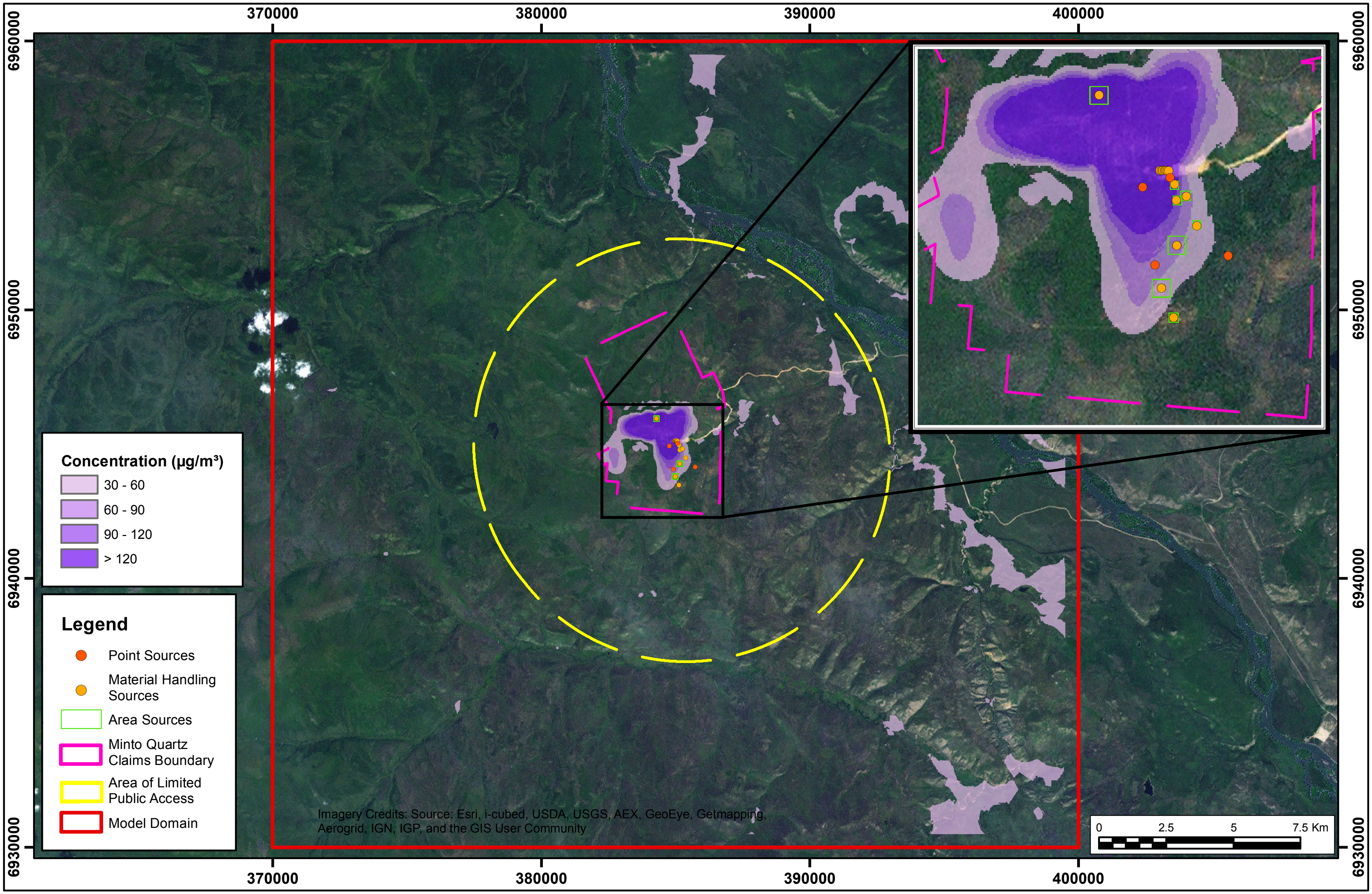

Modelled Maximum Annual TSP Concentrations (Emissions from All Sources)
Future Case (AAQO = 60 µg/m³)

Map Projection: NAD 1983 UTM Zone 8N.

Minto Mine Expansion Phase V/VI - Minto Mine, Yukon

True North

Project #1300542

Drawn by:	NBN	Figure:	6
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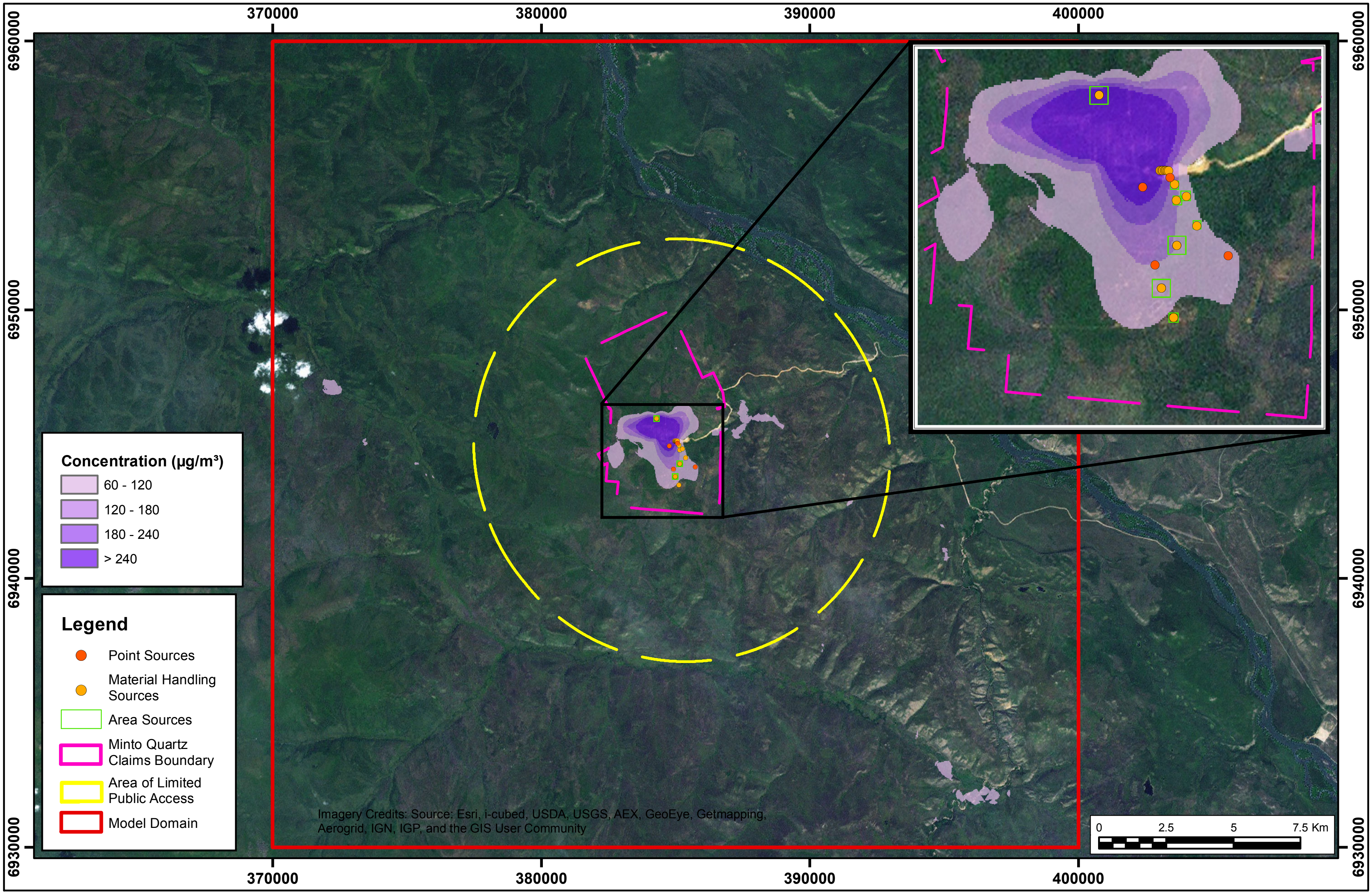
Date Revised:			Aug. 8, 2013

RWDI



Modelled Maximum 24-Hour TSP Concentrations (Emissions from All Sources)
Future Case (AAQO = 120 µg/m³)

Map Projection: NAD 1983 UTM Zone 8N.

Minto Mine Expansion Phase V/VI - Minto Mine, Yukon

True North

Project #1300542

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Approx. Scale:			1:200,000
Date Revised:			Aug. 8, 2013

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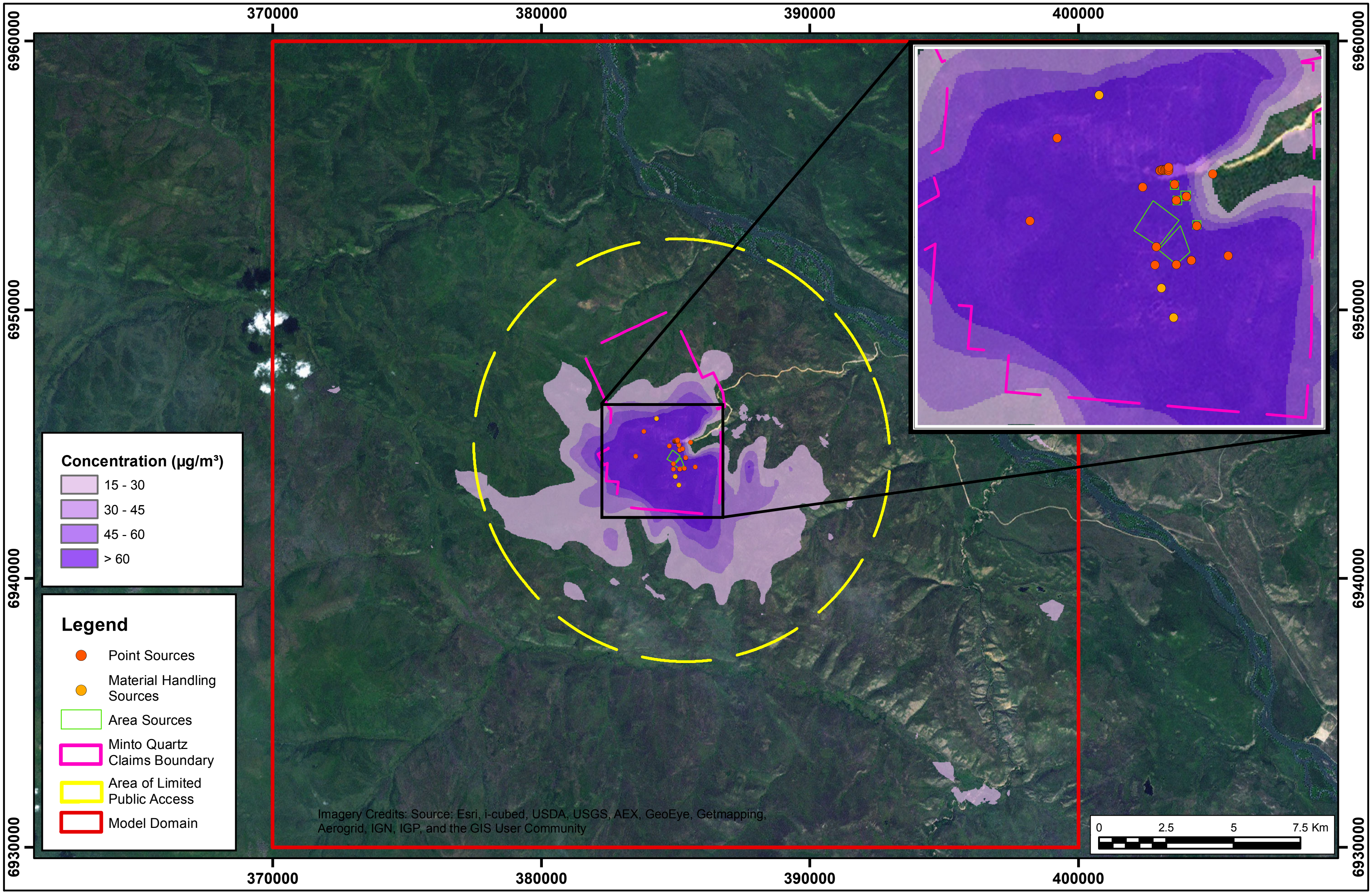


Modelled Maximum 24-Hour $PM_{2.5}$ Concentrations (Emissions from All Sources)
Baseline Case (AAQO = 30 µg/m³)

True North

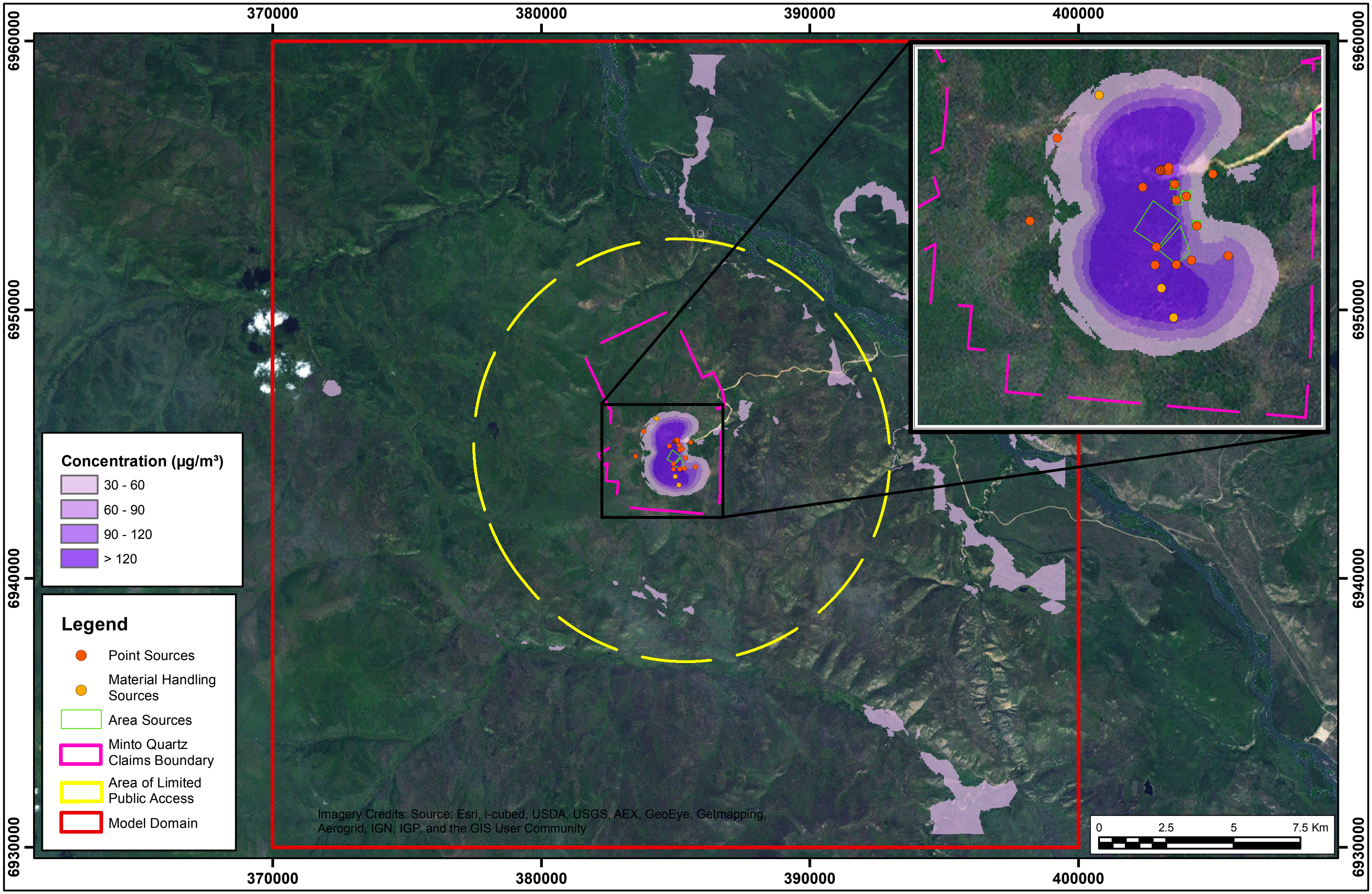
Map Projection: NAD 1983 UTM Zone 8N.

Minto Mine Expansion Phase V/VI - Minto Mine, Yukon

Project #1300542

Drawn by:	NBN	Figure:	4
Approx. Scale:	1:200,000		
Date Revised:	Aug. 8, 2013		

RWDI



Modelled Maximum Annual TSP Concentrations (Emissions from All Sources)
Baseline Case (AAQO = 60 µg/m³)

Map Projection: NAD 1983 UTM Zone 8N.

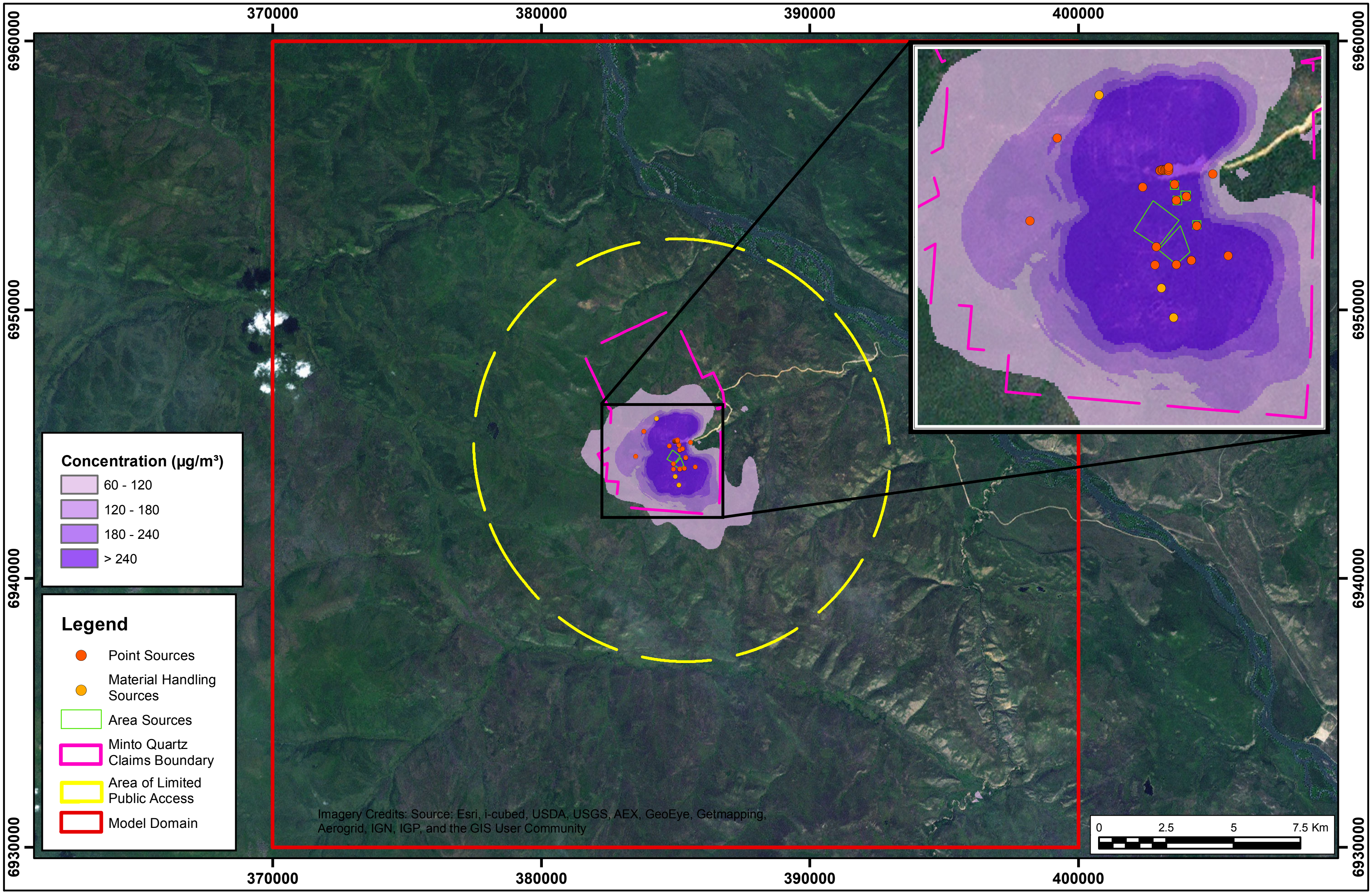
Minto Mine Expansion Phase V/VI - Minto Mine, Yukon

True North

Project #1300542

Drawn by:	NBN	Figure:	3
Approx. Scale:			1:200,000
Date Revised:			Aug. 8, 2013

RWDI



Modelled Maximum 24-Hour TSP Concentrations (Emissions from All Sources)
Baseline Case (AAQO = 120 µg/m³)

Map Projection: NAD 1983 UTM Zone 8N.

Minto Mine Expansion Phase V/VI - Minto Mine, Yukon

True North

Project #1300542

Drawn by: NBN	Figure: 2
Approx. Scale:	1:200,000
Date Revised:	Aug. 8, 2013

RWDI

APPENDIX A

Table A.1 CALPUFF Model-Switch Settings

Parameter	Default	Project	Comments
MGAUSS	1	1	Gaussian distribution used in near field
MCTADJ	3	3	Partial plume path terrain adjustment
MCTSG	0	0	Scale-scale complex terrain not modelled
MSLUG	0	0	Near-field puffs not modelled as elongated
MTRANS	1	1	Transitional plume rise modelled
MTIP	1	1	Stack tip downwash used
MSHEAR	0	0	Vertical wind shear not modelled
MSPLIT	0	0	Puffs are not split
MCHEM	1	0	Chemical transformation not modelled
MAQCHEM	0	0	Aqueous phase transformation not modelled
MWET	1	0	Wet removal not modelled
MDRY	1	1	Dry deposition was modelled
MDISP	3	2	Near-field dispersion coefficients internally calculated from sigma-v, sigma-w using micrometeorological variables
MTURBVW	3	3	Use both σ_v and σ_w from PROFILE.DAT to compute σ_y and σ_z (n/a)
MDISP2	3	2	This variable is not used for MDISP = 2
MROUGH	0	0	PG σ_y and σ_z not adjusted for roughness

APPENDIX B

CONSULTING ENGINEERS
& SCIENTISTS

Minto Mine Phase V/VI Expansion Project

Draft
Fugitive Dust Best Management Practices
Version 1

RWDI # 1300542
June 13, 2013

CONSULTING ENGINEERS
& SCIENTISTS

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Objectives of this Best Management Practices Plan

This proposed Best Management Practices (BMP) Plan is to provide an overview for fugitive dust emissions management at the Minto Mine site. It is an overview document that outlines the expected dust emissions sources at the site and describes measures used to manage emissions from these sources. Most sections of this document take the general form of standard operating procedures that are geared towards clearly defining roles, responsibilities, and courses of action.

1.2 Contents of this Best Management Practices Plan

This BMP contains:

- Descriptions of the targeted activities and emission sources;
- Measures to be applied in addressing potential emissions;
- Contingency activities to be implemented should dust become a severe issue;
- Details regarding the site monitoring practices, and;
- Details regarding record keeping practices.

1.3 Layout of this Best Management Practices Plan

This document is structured such that each activity expected to occur at the mine site that generates significant emissions is given a separate section. Each section includes a description of emission sources, complete with control measures applicable to that source.

2. SITE PREPARATION, DRILLING & BLASTING

2.1 Activities Included

- Earthworks (soil stripping and clearing, and excavation) using an excavator or loader and haul trucks, and;
- Drilling.

2.2 Earthworks

- Stabilize and re-vegetate soil stockpiles, and;
- Reclaim exposed land from soil stripping and clearing as soon as possible.

2.3 Drilling

- Equip drilling rigs with dust-collection devices, and;
- Apply water to cuttings discharged adjacent to the drilling rig.

3. STORAGE PILES & MATERIAL TRANSFER AND HANDLING

3.1 Activities Included

- Outdoor piles of materials; and,
- Material handling and transferring activities including conveyor and crushing operations.

3.2 Outdoor Stockpiles

- Maintain a suitable moisture content in surface material and as well as to depths to which handling might occur;
- Additional water application to problematic areas;
- Construction of berms upwind to reduce wind speed in the lee of the stockpiles, and;

3.3 Material Handling, Transferring & Processing

- Minimize drop heights;
- Use of enclosures or skirting at conveyor transfer points;
- Belt sweepers installed on the conveyor system, and;
- Baghouse dust collector at crusher.

3.4 Contingency Measures

- Covers on all conveyors, and;
- Additional water or chemical dust suppression for problematic areas.

4. HAUL ROADS

4.1 Activities Included

- Ore Hauling/Transfer routes

4.2 General Controls

- Restricting vehicle speed to less than 50 km/h;
- Grading snow into top surface of road;
- Water application;
- Chemical dust suppression, and;
- Minimize vehicle idling

4.3 Contingency Measures

- Increased frequency of watering problematic roadway sections;
- Increased frequency in application of chemical dust suppressants, and;
- Further reduction in speed limits.

5. COMBUSTION EMISSIONS

5.1 Activities Included

- Heavy equipment such as excavators, graders, scrapers, bulldozers, haul trucks, etc.

5.2 General Controls

- Use ultra-low sulphur diesel (<15 ppm sulphur content);
- Use equipment with exhaust gas treatment systems:
    - Particulate filters (diesel);
    - Oxidation catalysts (diesel); and,
    - Catalytic Converters (gasoline).
- Ensure combustion equipment and exhaust systems are properly maintained;
- Reduce vehicle idling;
- Minimize cold starts by using:
    - Engine block heaters, and;
    - Electrically pre-heated catalytic converters.

6. ADMINISTRATION

6.1 Implementation Schedule

- All control measures should be in place before activities commence.

6.2 Implementation Plan

- Formal training on new and existing operating procedures should be provided to relevant new and existing staff at a minimum of once every 3 years, and in the event of changes to the BMP;
- Management should communicate the BMP to responsible supervisors, who shall ensure personnel are following operating procedures defined in the BMP;
- Responsibility should be assigned for ensuring the BMP is followed;
- Management should ensure the BMP is reviewed annually; and,
- The BMP shall be kept in an easily accessible location.

7. MONITORING & RECORD KEEPING

7.1 Monitoring

During mining activities, the following parameters should be monitored and recorded as required:

General Measures

- Water trucks operating.
- Water applied to dust sources.
- Dust suppressants other than water applied to dust sources.

Access/Haul Roads

- Road visibly moist.
- Dust suppressants other than water applied to surface.

Weather Conditions

- Planning for high wind events based on observation thresholds.

7.2 Record Keeping

- A standardized site inspection form should be prepared to document each of the above listed parameters, as well as:
  - When unpaved roads and regularly travelled portions of the site are re-graded;
  - Quantity of water used on-site as a dust suppressant;
  - Type of chemical dust suppressant applied (if applicable), vendor name, and method, frequency, concentration and quantity of application; and,
  - On-site fuel usage.
- A standardized form should be prepared to document information pertaining to high dust emission events or activities, and;
- Responsibility should be assigned to ensure that record keeping is being performed at the prescribed frequency.

Appendix T – 2016 Update Minto Mine Constructed Wetland Treatment Research Program

Minto Mine Constructed Wetland Treatment Research Program – Demonstration Scale 2016 Update

Document – 011_0217_05B

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February 2017

Executive summary

The Minto Mine, operated by Capstone Mining Corp., is located 240 km northwest of Whitehorse on the west side of the Yukon River. In 2013 Contango Strategies Ltd. (Contango) was retained by Capstone Mining Corp. to conduct a phased assessment to determine the feasibility of using passive means to treat water at closure at the Minto Mine. Pilot-scale testing, completed by Contango in July 2014, determined that plants and beneficial microbes found at the Minto site could be used to remediate contaminated mine drainage in a constructed wetland treatment system (CWTS; November, 2014). In August 2014, a demonstration-scale CWTS was implemented at the Minto Mine site. The performance results from the on-site demonstration-scale CWTS confirm that a passive water treatment system can be used to successfully improve mine-impacted waters.

To date, the demonstration-scale CWTS has had 312 operational days (i.e., water flowing), consisting of 24 days in 2014, 137 days in 2015, and 152 days in 2016. Day 248 (July 28, 2016) is when organics were added to the CWTS to aid in treating the additional copper load originating from the soils used as substrate, and marked the end of what we will now be referring to as the period "commissioning-A", and the beginning of period "commissioning-B". The commissioning-B period will continue in 2017 until the demonstration-scale CWTS performance is consistently achieving performance expectations. These commissioning periods are necessary for operational adjustments to be made (e.g., raising water depth, modifying outflow patterns), and for plant and microbial populations to establish and mature to achieve full operational performance of the CWTS. Owing to the types of soils used as substrate in construction (i.e., high concentrations of oxidized copper), commissioning has taken longer than would normally be the case (or would be the case for the full-scale system).

The commissioning period is also being used to collect additional information about the on-site demonstration-scale CWTS that will aid in the final full-scale CWTS design, sizing, and construction. For example, a tracer study was carried out in June 2016 to assess the hydrology and hydraulic retention time (HRT) of the CWTS. Using the data from the tracer study, the pore space involvement of the CWTS substrate was calculated.

Performance continues to be monitored and while full treatment functionality of the demonstration-scale system is not expected during the commissioning period, the information would aid in the development of the full-scale system in the following ways:

- Evaluation of construction effectiveness and potential optimizations.
- Assessment of timelines to reach targeted operational parameters to allow for effective phasing of implementation (e.g., soil redox, percentage and abundance of sulphate reducing bacteria).
- Assessment of the effectiveness of *Carex aquatilis* and aquatic moss transplantation to assess planting density, time period to full density, and if plant propagation and/or a replanting schedule is necessary.

In July 2016 the demonstration-scale system was not achieving stable soil redox values within the targeted range (nor associated performance expectations); therefore, woodchips and straw were added to the demonstration-scale CWTS as sources or organic carbon. Because

the demonstration-scale system takes time for plants to mature (and generate organic carbon for the microbes to feed on), the addition of organics early in the operation of the system can supplement the carbon sources needed for beneficial microbes that drive treatment of selenium and other constituents. This will be included in the full-scale system design specifications. The addition of organics marked the end of the commissioning-A period.

Once the commissioning–A period was complete, the commissioning-B period began on July 29 and continued to the end of 2016 operations on September 30, 2016. During the commissioning-B period, the demonstration-scale CWTS achieved on average 64% removal of dissolved cadmium (mean influent 0.0185 µg/L, mean outflow 0.0066 µg/L), 37% removal of dissolved copper (mean influent 46.1 µg/L, mean outflow 28.8 µg/L), a 21% removal of molybdenum (mean influent 7.3 µg/L, mean outflow 5.7 µg/L), a 41% removal of dissolved selenium (mean influent 5.7 µg/L, mean outflow 3.3 µg/L) and a 69% removal of dissolved zinc (mean influent 37.6 µg/L, mean outflow 11.6 µg/L). The percent removal of molybdenum and selenium is notable, as it has increased from 0% removal during commissioning-A, to achieving 21% and 41% removal, respectively during commissioning-B. Monitoring through 2015 and 2016 has indicated that percent removal of elements of concern have been increasing over time. The results of the 2016 on-site demonstration-scale CWTS performance indicate that the CWTS is continuing to mature. Plans for 2017 will focus on testing operations and performance. Flow rates will be set at a constant flow to evaluate the stability of the CWTS performance over one year. A second HRT tracer study will be performed using an updated method based on the findings from the 2016 HRT tracer study. A second evapotranspiration study will also be performed to determine the amount of water that is being lost to evapotranspiration from the CWTS. Weekly monitoring will continue throughout 2017 to evaluate performance of the CWTS.

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Abbreviations and definitions

Acidity – A measure of the capacity of water to neutralize base. Influences pH along with alkalinity.

Alkalinity (Alk) – A measure of the capacity of water to neutralize acids. Influences pH along with acidity.

Amendment – A chemical or organic material added to encourage specific conditions (e.g., aerobic/anaerobic, pH, ORP) or as a source of something that is needed for passive treatment (e.g., nutrients, alkalinity, binding sites, etc).

ANAMMOX – Anaerobic ammonium oxidation; a microbiological process where ammonium and nitrite are converted directly to dinitrogen gas ($NH_4^+ + NO_2^- \rightarrow N_2 + 2H_20$).

Biofilm(s) – A visible and often slimy-looking film (community) of bacteria (may contain other microbes).

Carbon source – A source of carbon (energy/electrons) for microbes (see **electron donors**). Examples include ethanol, methanol, acetate, sugar (glucose), molasses, wood chips, detritus (dead plant matter).

Carex aquatilis – A plant (emergent macrophyte) commonly known as water sedge.

Carex utriculata – A plant (emergent macrophyte) commonly known as Northwest Territory sedge or beaked sedge.

Contango – Contango Strategies Ltd.

Constructed wetland treatment system (CWTS) – Wetlands that are designed and constructed to remove compounds from water, using natural processes to sequester them into the soils rendering them less bioavailable. They are different from wetlands that provide habitat for wildlife.

Denitrification – Where nitrate (NO_3^-) is reduced by microorganisms to form nitrite (NO_2^-), nitric oxide (NO), or nitrous oxide (N_2O), or nitrogen gas (N_2) (see **nitrate reduction**).

Dissolved oxygen (DO) – Diatomic oxygen (O_2) dissolved in water; oxygen can dissolve in water by diffusion from surrounding air, as a product of photosynthesis, or through forced aeration.

Electron donor(s) – A chemical compound that donates electrons to another compound (see **carbon source**). An electron donor is a reducing agent, which that by virtue of it donating electrons, is itself oxidized (see **oxidation** and **reduction**).

Explanatory parameters – Quantifiable parameters that describe how water treatment reactions take place.

Evapotranspiration – The combined effects of open water evaporation and plant transpiration (Beebe *et al*, 2014).

Genetic analysis – Analysis to assess the presence, identity, and diversity of different microbes in a sample.

ICP-MS – Inductively coupled plasma mass spectrometry.

Macrophytes – An aquatic plant, large enough to be seen by eye. Can be emergent, submergent, or floating.

Microbes – Microscopic organisms that can be uni- or multi-cellular. This includes algae, bacteria, fungi, viruses, and yeast.

Most probable number (MPN) – A statistical value representing the viable population of microbes in a sample through use of dilution and multiple inoculations.

Oxidation – The loss of electrons, or increase in valence state, by a molecule, atom, or ion. Can be driven by microbes. Process is complementary to chemical reduction.

Oxidation-reduction potential (ORP) – A measure of the tendency of a chemical species to acquire or donate electrons, thus becoming reduced or oxidized, respectively, measured in millivolts.

Passive or semi-passive treatment system(s) (PTS) – General term used to refer to both passive and semi-passive treatment systems that use processes coupling transformations (e.g., chemical and biogeochemical reactions) with physical transfers (e.g., sorption, filtration) to remove constituents from water, often operationally passive with little long-term management required.

Redox – Oxidation-reduction potential (in sediment), a measure of the tendency of a chemical species acquire or donate electrons, thus becoming reduced or oxidized, measured in millivolts. This measurement is relative to the water ORP.

Reduction – The gain of electrons, or a decrease in valence state, by a molecule, atom, or ion. Can be catalyzed by microbes. Process is complementary to chemical oxidation.

Simultaneously extracted metals (SEM) – Amounts of heavy metals such as Ni, Zn, Cd, Pb, Cu, Hg in sediment, assessed in the context of AVS for excess sulphide. (also see **acid volatile sulphide**)

Sorption – The physical and/or chemical process by which one substance becomes attached to another substance.

Specific conductivity (SPC) – A measurement of electrical conductivity in water that is typically expressed in µs/cm, which has been adjusted for temperature (25°C).

Species (sp.) – One of the basic units of biological classification and a taxonomic rank. Rank in the classification of organisms below genus and above strain. Also can be used to refer to the oxidation state of a mineral (e.g., selenate and selenite are species of selenium).

SPLP – Synthetic precipitation leachate procedure.

Sulphide – An inorganic anion of sulphur that can form stable complexes with metals and make them insoluble in water (remove them from the water).

Sulphide producing bacteria (SPB) – Microbial reduction of sulphur compounds, such as sulphate, sulphite, thiosulphate, and sulphur, which produces sulphides and alkalinity. (see also **SRB**).

Sulphate reducing bacteria (SRB) – A form of sulphide producing bacteria that specifically uses sulphate for reduction (see **sulphide producing bacteria**).

Sulphide production – Microbial reduction of sulphur compounds, such as sulphate, sulphite, thiosulphate, and sulphur, which produces sulphides and alkalinity.

Total dissolved solids (TDS) – A measure of the combined organic and inorganic salts dissolved in water.

Total organic carbon (TOC) – A measurement of the total organic carbons present in water.

Total suspended solids (TSS) – A measurement of all particles in water that are larger than 2 μm (anything smaller than 2 μm considered a dissolved solid).

Transfer – Processes that treat water by transferring a constituent to another location without changing its form. For example: absorption, adsorption, dilution, dispersion, filtration, precipitation (aqueous to solid), and volatilization.

Transform – Processes that change the chemical form or state of a constituent. For example: biodegradation, biotransformation, hydrolysis, ionization, oxidation, photolysis, and reduction.

1. Introduction and background

The Minto Mine, operated by Capstone Mining Corp., is located 240 km northwest of Whitehorse on the west side of the Yukon River. The Minto property lies within the eastern part of the Dawson Range, with elevations from 700 to 1,000 m; the landscape has rounded mountains intersected by broad valleys and drainages that are part of the Yukon River watershed.

The Minto Mine has been in commercial operation since October 2007 and the deposits being mined are copper sulphide mineralized zones. Surface and groundwater water quality is a key consideration in the evaluation of potential effects of mining and mineral development projects and changes to water quality parameters have the potential to affect aquatic and human use of water resources. A Reclamation and Closure Plan (RCP) is required under both the Water License and the Quartz Mining License. The RCP is intended to address the long-term physical and chemical stability of the site and closure of the proposed features and disturbances associated with the mine. As a part of the RCP, a Constructed Wetland Treatment System (CWTS) is being designed, evaluated, and optimized for water treatment at closure through a phased program (Minto Phase V/VI Expansion Project, YOR Project Number 2013-0100).

For CWTSs to be effective, they must be designed, piloted, optimized, implemented, and maintained in a site-specific manner. A scaled approach for CWTS implementation allows for improvement, optimization, and flexibility for modifications along each step. Phases include:

1) site assessment and information gathering,
2) technology selection and conceptual design,
3) pilot-scale testing and optimization (controlled environment),
4) on-site demonstration-scale confirmation and optimization, and
5) full-scale implementation.

Phases 1-3 have been completed (reports 2013-0100-256 and 2013-0100-257 on YESAB registry, and Contango, March 2014; Contango, November 2014) and confirmed plant amenability to transplantation and the CWTS design for further on-site testing. During pilot-scale trials, the selected CWTS design achieved on average 92% removal of cadmium (mean influent 0.336 μg/L, outflow 0.027 μg/L), 92% removal of copper (mean influent 146 μg/L, outflow 11.3 μg/L), 41% removal of selenium (mean influent 10.2 μg/L, outflow 6 μg/L), and 92% removal of zinc (mean influent 40 μg/L, outflow 3.2 μg/L), using synthetic influent designed to mimic the worst-case water chemistry of a long-term closure scenario, but tested under the controlled conditions (e.g., controlled flows, known temperature, etc) of an off-site treatability testing center (Contango, November 2014). It should be noted that lower influent concentrations will have a lower percent removal even when achieving the same final outflow concentrations.

Phase 4 of the project is underway, with the on-site demonstration scale CWTS constructed at the Minto Mine during fall 2014 (Contango, March 2015). The on-site demonstration-scale CWTS operated for 137 days in 2015 and 152 days in 2016 (Table 1). The results of the 2015 and 2016 on-site demonstration-scale CWTS performance indicate that the CWTS is maturing as expected and maturation continued to be monitored in 2016. This document reports on the on-site demonstration scale CWTS data from construction, and through two years of commissioning-A (2015/2016) and into the commissioning-B period (late 2016).

Table 1 – Days of operation of CWTS.

<table>
<tr><th rowspan="2">Scale</th><th rowspan="2">Year</th><th rowspan="2">Days Operated</th><th colspan="2">Date</th></tr>
<tr><th>Start</th><th>End</th></tr>
<tr><td>Pilot (off-site)[1]</td><td>2013 -2014</td><td>205</td><td>Nov 4</td><td>May 28</td></tr>
<tr><td rowspan="3">Demonstration (on-site) Commissioning-A</td><td>2014[2]</td><td>23</td><td>Aug 27</td><td>Sep 19</td></tr>
<tr><td>2015</td><td>137</td><td>May 16</td><td>Sep 29</td></tr>
<tr><td>2016</td><td>101</td><td>May 2</td><td>Jul 28</td></tr>
<tr><td>Demonstration (on-site) Commissioning-B</td><td>2016</td><td>51</td><td>Jul 29</td><td>Sep 30</td></tr>
<tr><td colspan="5">[1] Pilot-scale system operated from Nov 4, 2013 to July 16, 2014.
[2]The system was constructed in 2014, but no water testing occurred during this first month of commissioning-A.</td></tr>
</table>

2. Construction and operation

2.1. System layout and dimensions

The demonstration-scale CWTS includes 2 systems in parallel with 2 cells in each series and a final catchment basin that both systems flow into (Figure 1). Dimensions and construction details are available in the Minto Demonstration Scale Report Document 011_0315_01A (Contango, March 2015). The two parallel systems serve as a replicate for data analysis, and as testing has progressed, the two systems have also allowed for comparison of different management techniques. Dimensions of the systems are provided here in Table 2.

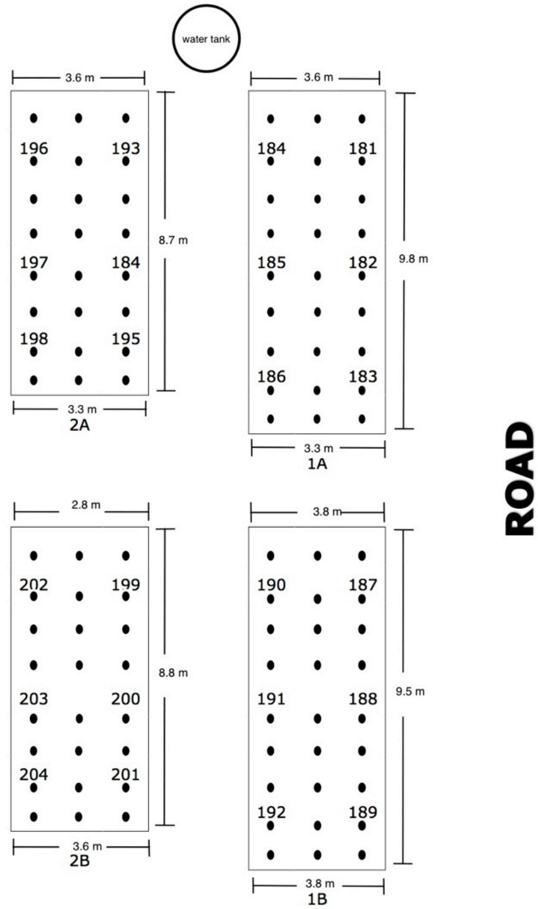


Figure 1 – Diagram of demonstration-scale CWTS.
Dimension measurements are indicated at soil surface. Black dots indicate initial construction grid marked by moss stakes, and locations of soil redox probes with identifying numbers.

Table 2 – Dimensions of demonstration-scale CWTS cells at soil surface and resultant areas of treatment systems.

Measurement		Series 1		Series 2	
		1A	1B	2A	2B
Width (m)	Inflow	3.6	3.8	3.6	2.8
	Outflow	3.3	3.8	3.3	3.6
Length (m)		9.8	9.5	8.7	8.8
Approximate surface area at soil (m^2)		33.8	36.1	30.0	28.2
Total area of system at soil (m^2)		69.9		58.2	

2.2. Substrate soils used in construction

Soils used to construct the CWTS are described in the initial report that outlines construction (Contango, March 2015). In brief, the recommended soil for the CWTS was sand, with 2-7% by volume as organic material (e.g., woodchips, peat). In the pilot-scale systems, this resulted in a total organic carbon (TOC) content by weight of 0.2-0.6% (the sand itself was at 0.1% TOC prior to adding amendment). Ideally, this percentage could be higher, approximately 2-10% by weight to stimulate the desired reducing conditions. For the demonstration-scale system, the soil added to each of the 4 cells during construction was from a local borrow site. As is expected in a mining area, the soils are likely mineralized. Although a potential borrow source was tested prior to construction ("Tested Soil"; Table 3), a different borrow source was available upon construction of the demonstration-scale wetland ("Soil used"; Table 3). The material used in the construction of the demonstration-scale wetland was an organic peat, and analyses received after construction indicated an elevated concentration of leachable copper (Table 3). It should be noted that in a full-scale system, the variability in soil substrate would be normalized by the larger volume of soil used. The substrate in the wetland (composed of the organic peat soil, wood chips, and straw) had a TOC content of 1.8-3.1%. The implications of this are discussed in section 6.1 of this report.

Table 3 – Comparison of copper concentrations in soils of pilot- and demonstration-scale CWTS.

Test method	Pilot-scale	Demonstration-scale	
	Initial soil	Tested soil (June, 2014)	Soil used (August, 2014)
SPLP Copper (mg/L)[1]	-	0.00546-0.0296[2]	0.148-0.608
Total Copper (mg/kg)	5.3-5.5	210-1400[2]	960-1400[3]

[1] SPLP - Synthetic Precipitation Leaching Procedure
[2] For the June 2014 samples, the soil with the highest total copper concentration also had the lowest leachable copper concentration, and was therefore deemed acceptable for use.
[3] Total copper value for soils used was taken in June 2015 (no data for August 2014).

2.3. Vegetation used in planting

The demonstration-scale CWTS was planted with *Carex aquatilis* (aquatic sedge) and aquatic mosses from the W10 area of the Minto Site. The plant selection and borrow source was previously determined through the site assessment (reports 2013-0100-256 and 2013-0100-257 on the YESAB registry) and pilot-scale testing (Contango, November 2014). Five *C. aquatilis* plants were planted per square meter, with moss tied to stakes that outlined the 1 m x 1 m grid for planting (details provided in Contango, March 2015).

2.4. Water source and flow

Water from the W36 area receiving seepage from the toe of the Mill Valley Fill Extension (MVFE) was selected for the demonstration-scale CWTS testing as the leachate is similar to that expected upon closure in the MVFE area. The chemistry of this water at the time of bringing the demonstration-scale CWTS online (September 18, 2014) is provided in Contango, March 2015. In 2015 the water for the CWTS was pumped out of the sump at the toe of the MVFE. The Mill Valley Fill Extension Stage 2 (MVFE2) collection sump (W62 sump) was constructed from November 9, 2015 to February 7, 2016. The sump was constructed as a replacement for the sump used in 2015. The W36 sump was decommissioned in February, 2016 as part of the MVFE2 construction. The new sump approximately 30m downslope was the supply water for the CWTS for the summer of 2016 (Figure 2).

Figure 2 – Water source for the demonstration-scale CWTS in 2016.

After construction in 2014 and in early 2015, the flow rates for the systems were planned to be set to have a 10 day nominal hydraulic retention time (HRT), meaning water entering the wetland takes 10 days to exit. This is referred to as a nominal HRT because it is a calculation based on the size of the wetland and the amount of water entering, and not confirmed empirically using tracing dyes. This HRT is much longer than what is necessary to achieve treatment based on the pilot-scale systems (~3 days), and was chosen to facilitate plant establishment and maturation. However, due to the leachable copper concentrations in the soils used for construction, it was instead decided to run the systems at a faster flow to wash as much leachable copper from the soils as possible. As such, a shorter nominal HRT of ~20 hrs (Figure 3) was used as a starting point (HRT calculated using measured water depths of approximately 15 cm and negligible pore water involvement [30cm of soil at 10% pore volume] due to peat soils). Despite the shorter HRT resulting from the faster flow of water, the systems have acclimated and matured as was expected for the longer HRT. Because the sizes of the CWTS systems are slightly different, Series 1 (closer to the road) and Series 2 (further from road) are set with flow rates to result in similar HRTs in each system. Flow rates were monitored and adjusted throughout 2015 based on CWTS establishment and maturation (further information in sections 3 and 4).

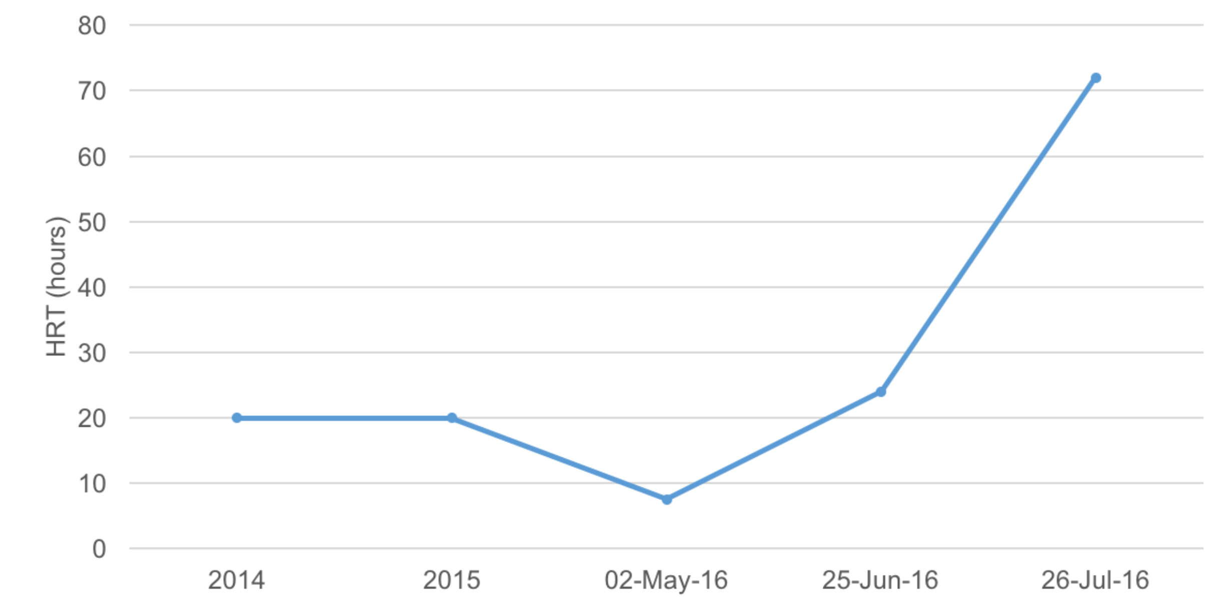


Figure 3 – Demonstration-scale CWTS targeted hydraulic retention time from construction to present.

Three flow rates were used during operation of the CWTS in 2016. At start up in May 2016 the nominal HRT was set to ~7.5 hours to further attempt to flush copper out of the soil (further enhancing the 2015 EDTA trials conducted in System 2 (section 6.3)). In early June, HRT was increased to ~24 hours to allow for a tracer study to be conducted during a 2-day site visit in attempt to determine the actual HRT (vs nominal, calculated HRT) of the CWTS (section 7). At the end of June, the HRT was lengthened to a calculated ~72 hours (3 days) for performance testing and remained at this HRT until the end of operations in September 2016. Due to pump and flow meter issues the actual flow rates varied from the target flow rates throughout 2016 operations. Table 5 outlines known pump and flow meter issues that occurred in 2016, and Figure 4 shows the fluctuation in actual vs targeted flow rates throughout the 2016 operations.

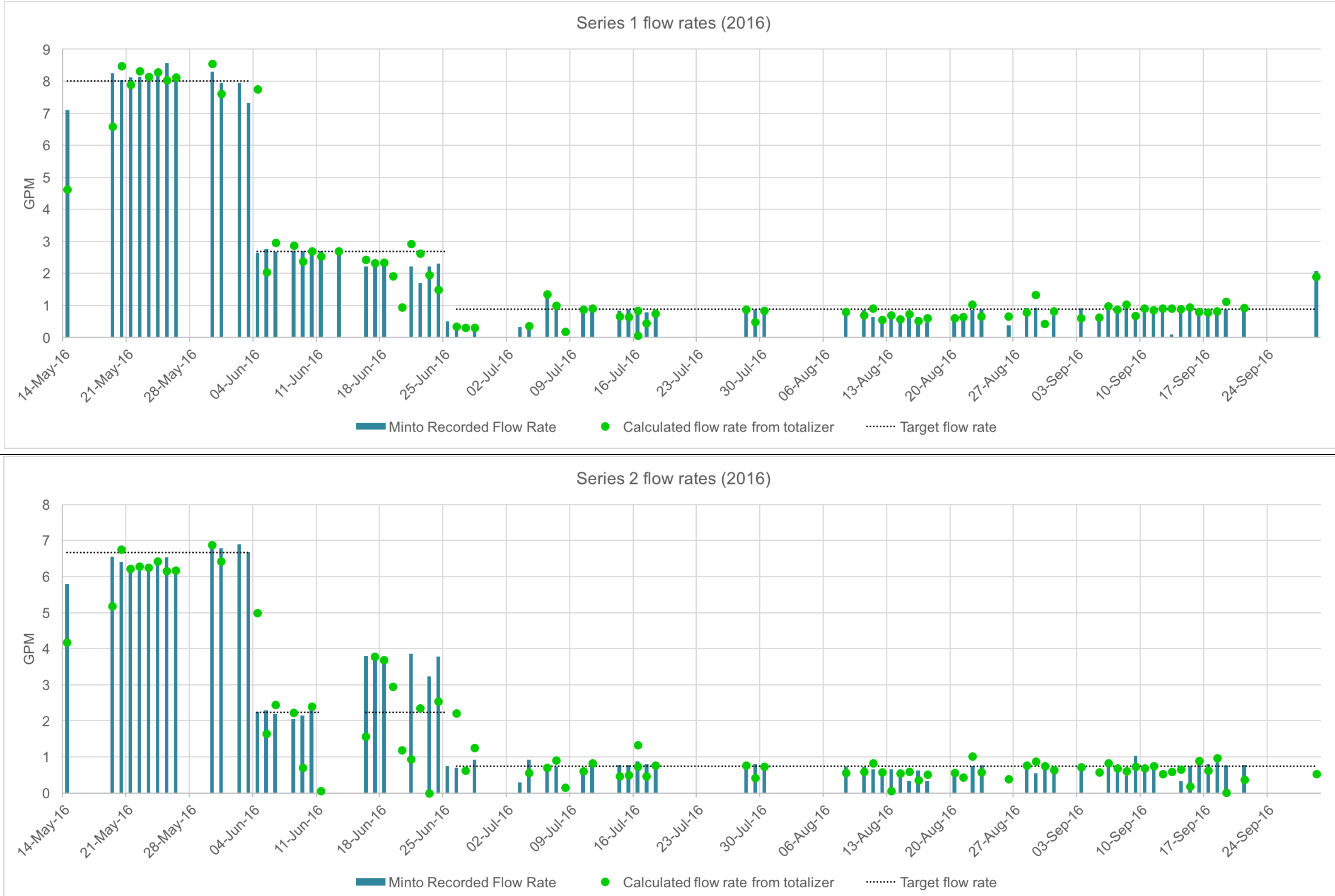


Figure 4 – Flow rates during CWTS operations in 2016.

Blue bars indicate flow rates displayed on meter, while green dots are flow rates calculated from the totalizer values (values from meter were recorded by Minto personnel. The totalizer value is the cumulative volume of water passing through the flow meter between two measurement dates. Areas with no blue bars or green dots are time periods where flow rates and totalizer values were not recorded.

3. Commissioning

The period between the construction of the CWTS and achieving the expected treatment performance is referred to as the commissioning period. During this period, the plant and microbial populations establish and mature, and construction effectiveness and optimization opportunities are evaluated to make operational adjustments (e.g., raising water depth, modifying outflow patterns) and inform on the full-scale system (Table 4). For the demonstration-scale CWTS the commissioning period was divided into two periods, commissioning-A, and commissioning-B. The end of the commissioning-A period and the beginning of the commissioning-B period was marked by the addition of organics on July 28, 2016.

Performance continues to be monitored and while full treatment functionality of the demonstration-scale system is not expected during the commissioning period, the information will aid in the development of the full-scale system in the following ways:

- Evaluation of construction effectiveness and potential optimizations.
- Assessment of timelines to reach targeted operational parameters to allow for effective phasing of implementation (e.g., soil redox, percentage and abundance of sulphate reducing bacteria).
- Assessment of the effectiveness of *Carex aquatilis* and aquatic moss transplantation to assess planting density, time period to full density, and if plant propagation and/or a replanting schedule is necessary.

However, there are aspects of the demonstration-scale CWTS that are not directly transferrable to the planned construction of the full-scale CWTS. Notably, the demonstration-scale CWTS was built with a different soil type and chemistry than recommended for the full-scale system. Therefore; it is taking a longer time to commission the demonstration-scale system as the copper in the soils needs to be treated in addition to the copper and other constituents in the water.

Based on pilot-scale testing (Contango, November 2014), the estimated commissioning period for the Minto demonstration-scale CWTS was 4 months of operation (i.e., period when water is flowing). In 2014, the demonstration-scale CWTS operated for less than one month prior to freezing, and was restarted along with spring thaw (freshet) in mid-May 2015. Based on these timelines, September 2015 was month 4 of commissioning, and the demonstration-scale system was trending towards performance as expected during the commissioning period (Contango, March 2016). However, as discussed further in sections 2.2 and 6.1, the soil used in the CWTS had high concentrations of leachable copper, and therefore optimization opportunities were evaluated throughout 2015, and adjustments were implemented in 2015 and 2016. The last operational adjustment during the commissioning period was the addition of organic material in 2016, which marked the end of the commissioning-A period and the beginning of the commissioning-B period. Organic material will also be added during construction of the full-scale design to enhance desired reducing conditions to establish in the CWTS until vegetation is sufficient to provide for this required component.

Table 4 – Operational adjustments made to the demonstration-scale wetland.

Year	Activity	Purpose
2014	Construction	Construction
2015	Increasing water depth	Plant acclimation and establishment
	Adding more aquatic moss	Increase moss density
	Modifying inflow and outflow distribution areas	Promote uniform flow field
	Removing *Carex utriculata*	Was erroneously planted
	Wrapping inflow tank	Prevent algal growth
	Fe-EDTA test on CWTS series 2	To test if non-invasive treatments could be used to further leach the metals and improve soil quality
2016	Adding sandbags to the perimeter of the CWTS	Promote uniform flow field and prevent short circuiting of water around perimeter
	Perform tracer study	Determine the actual hydraulic retention time (HRT) of the CWTS
	Increase water depth of Series 1	Bring to desired specification depth
	Evapotranspiration study	Determine the amount of water loss occurring (and therefore concentration of elements)
	Setting flow rates at a 3 day calculated HRT (compared to 20 hrs previously used)	Continue commissioning period and develop rate kinetics
	Adding organics (woodchips and straw)[1]	Enhance desired reducing conditions (will be added to full-scale design specifications)

[1] This marked the end of the commissioning-A period and the beginning of the commissioning-B period.

4. Timeline and sampling schedule

Major events and operational adjustments are listed in Table 5. The actual dates as well as relative days of operation are provided, which adjusts for time that the CWTS was not receiving water when it was frozen. The relative days of operation allows for comparison to expected timelines from the pilot-scale testing, and for planning and scheduling to be done for full-scale construction and commissioning in the context of mine closure planning.

The sampling schedules for 2015 and 2016 were conceptually developed prior to beginning construction of the demonstration-scale CWTS (Appendix A). Actual dates of sampling were dependent on timing of spring thaw and winter freeze-up, and the associated ability to have the pumps operating at the W62 sump to supply water to the demonstration-scale CWTS.

Table 5 – Events and sampling activities since construction.

Event	Key Activity	Flow Rate Setting m^3/day (gal/min)		Calendar Date	Day(s) of Operation
		CWTS Series 1	CWTS Series 2		
CWTS constructed and planted	First sampling, water started.	-	-	August 27 – 31, 2014	0-4
Freeze up for winter	Feed water pumps turned off.	-	-	September 19, 2014	23
Winter 2014/2015					
Start up for 2015	Feed water pumps turned on.	14.17 (2.60)	11.61 (2.13)	May 16, 2015	24
Contango Site Visit #1	Microbiology, soils, water tested. *Carex* stem counts. Added more aquatic moss. Put black wrap on water tank to prevent algal growth. Water depth adjusted with sandbags.			June 18, 2015	57
Flow rate increased	Flow rates increased.	17.44 (3.20)	15.81 (2.90)	July 13, 2015	82
Contango Site Visit #2	Microbiology, soils, water tested. Added more aquatic moss.			August 16, 2015	116
Contango Site Visit #3	Water tested. Started Fe-EDTA test on System 2.			September 17, 2015	148
	Microbiology, soils, plants, water tested.			September 18, 2015	149
Fe-EDTA Testing	Daily total and dissolved copper analysis conducted at Minto.			September 19 – 26, 2015	150-157
Freeze up for Winter	Feed water pumps turned off.	-	-	September 29, 2015	160
Winter 2015/2016					
Flow meters installed and pumps turned on	Flush copper leaching from soil (associated with 2015 EDTA test).	44.10 (8.09)	38.10 (6.99)	May 2, 2016	161
Start up for 2016	Feed water pumps turned on.			May 13, 2016	172
Pump problems	Getting proper pumps installed at new sump location.			May 13-17, 2016	172-176
Flow rate decreased	HRT increased to 24 hours.	14.39 (2.68)	12.26 (2.24)	June 4, 2016	194
Added sandbags	Added sandbags to perimeter of CWTS.			June 7, 2016	197
Contango Site Visit #4	Microbiology, soils, water tested.			June 13 – 15, 2016	203-205
	Tracer test for HRT.			June 13 – 17, 2016	203 - 207

Table 5 – Continued.

Event	Key Activity	Flow Rate Setting m^3/day (gal/min)		Calendar Date	Day(s) of Operation
		CWTS Series 1	CWTS Series 1		
Inconsistent flow	Flow rates in series 2 inconsistent and above targeted flow rate.	14.39 (2.68)	20.71 (3.80)	June 16 - 24, 2016	206-214
Flow rate decreased	HRT increased to 72 hours.	2.73 (0.89)	4.09 (0.75)	June 25, 2016	215
Flow meter switched on series 1	Max flow on new flow meter is lower than targeted flow rate due to flow meter being installed backwards.	Unknown	4.09 (0.75)	June 25 – July 4, 2016	215-224
Flow meter for series 1 was on backwards resulting in unknown flow rates	Installed the flow meter correctly and reset flow rate to meet targeted HRT range of 72 hrs.	(0.89)	4.09 (0.75)	July 4, 2016	224
Evaporation Study	Flow stopped.	-	-	July 18 – 26, 2016	238-246
End of evaporation study	Flow turned back on.	2.73 (0.89)	4.09 (0.75)	July 26, 2016	246
Contango Site Visit #5	Microbiology and water tested.	2.73 (0.89)	4.09 (0.75)	July 27 - 28, 2016	247-248
Contango Site Visit #5	Added organic material (straw and woodchips)	2.73 (0.89)	4.09 (0.75)	July 28, 2016	248
Flow interruptions	Flow meters plugged.	2.73 (0.89)	4.09 (0.75)	August 15 –18 2016	266-268
Contango Site Visit #6	Microbiology, soils, water, and plants tested.	2.73 (0.89)	4.09 (0.75)	September 7 – 8, 2016	289-290
Freeze up for Winter	Feed water pumps turned off.	-	-	September 30, 2016	312

5. Monitoring explanatory parameters

Explanatory parameters are quantifiable aspects of a CWTS environment that can be used to assess feasibility of treatment for a range of constituents, and therefore 'explain' the performance of a CWTS. These parameters, which often include acidity, alkalinity, conductivity, dissolved oxygen (DO), pH, oxidation reduction potential (ORP), ion balance, available electrons donors (e.g., organic carbon, reduced elements), and temperature, can be used to predict, promote, and/or optimize the ability of the system to treat different constituents (Haakensen et al., 2015). A YSI ProPlus meter was used in the field to test for water temperature, DO, conductivity (and specific conductivity; SPC), pH, and ORP.

Average water temperature of the demonstration-scale CWTS in 2015 was 12.9°C, ranging from 0.5°C to 25°C, and in 2016 was 10.2°C, ranging from 0.8°C to 23.2°C. As would be expected, both the month of testing and time of day were found to affect temperature variation (section 7). DO concentrations in the CWTS cells were on average 10 mg/L in 2015, 15.9 mg/L in 2016 prior to commissioning being complete, and 8.4 mg/L in 2016 after commissioning was complete, which is higher than the pilot-scale systems (average 4.8 mg/L). This higher DO concentration makes the system more oxidizing and therefore more difficult to carry out nitrate and selenium treatment, and produce sulphides for copper and cadmium treatment. However, the conductivity, pH and ORP of the demonstration-scale CWTS cells are all very similar to the pilot-scale systems (Table 6).

Table 6 – Average in situ measurements from the pilot scale and demonstration-scale system.

Testing Period		DO (mg/L)	SPC (µS/cm)	pH	ORP (mV)	Soil redox (mV)
Pilot 2014[1]		5.73	990.0	7.71	159	-185
Demonstration-scale 2015		10	817.9	8.11	147.9	-52
Demonstration-scale 2016	commissioning-A[2]	15.9	890.9	7.79	143.7	-85
	commissioning-B[3]	8.4	1020	7.59	157.6	-89

[1] Pilot system data is from the low N system with moss and *Carex*. This was the system that was used as the foundational design.
[2] Data for commissioning-A period is from May 2-July 28, 2016.
[3] Data for commissioning-B period is from July 29-September 30, 2016.

An additional explanatory parameter that can be used to monitor maturation of the wetland during the commissioning period is the soil redox potential, which is measured using platinum tip probes (in soil) and Calomel electrodes (in water). This measurement offers insight into the direction of electron flux between the sediment/soil/pore water and overlying water column (Faulkner et al., 1989; Huddleston & Rodgers, 2008), and can be used to confirm reducing conditions in the soil. Based on the information gathered in pilot-scale testing, the targeted soil redox for the demonstration-scale CWTS is between -100 and -250 mV. In these redox ranges, bacterial sulphide-production through reduction of sulphur compounds (e.g., sulphate) is expected. Sulphide production directly results in metals and metalloid treatment for elements such as cadmium, copper, molybdenum, nickel, lead, and zinc by precipitation as metal sulphides (Figure 5).

This maturation period is necessary for sufficient quantities of microbes to populate the wetland and become active in decomposing organic material. It is the electrons produced by the decomposition of organic material that is reported by the soil redox measurements. The decomposition of organic material then feeds the sulphate-reducing bacteria the type of energy they need to produce the sulphides that remove the copper, cadmium, molybdenum, and zinc from the water. The microbial activity of the system is discussed further in Section 10.3.

$$\text{Organic Carbon} + SO_4^{2-} \rightarrow HCO_3^- + HS^- + H_2O$$

$$HS^- + M^{2+} \leftrightarrow MS + 2H^+$$

M = divalent metals (e.g., Cd, Cu, Fe, Mo, Ni, Pb, Zn)

Figure 5 – Example equation of sulphate reduction and resultant metals mineralization and treatment.

Equation is not balanced; demonstrates sulphate reduction with creation of alkalinity and sulphides, which can then form metal sulphide complexes.

As expected from the pilot-scale testing, the soil redox in all the demonstration-scale CWTS cells has decreased over time, indicating maturation of the system (Figure 6). At the end of 2015, only Series 1 had begun to achieve targeted soil redox values that are conducive to sulphide production (ahead of anticipated schedule). It is possible that Series 1 had more organic material in the soils than Series 2, because of how construction occurred and this wasn’t reflected in the small sample size sent for analytical testing.

Some soil redox probes were reporting negative values in the targeted range by July 18, 2015 (87 days); however, in general the CWTS took approximately 4 months of operation to establish generally reducing conditions. By September 17, 2015 (day 148), most of the soil redox probes within Series 1 were reporting redox values within the targeted range, with Series 2 still trending downwards but not yet within the targeted range. In comparison, the pilot-scale systems were stable and reducing within approximately 4 months of construction (Figure 6). In early 2016, the soil redox in both series was not being maintained within the targeted range, which indicated that additional organics may be needed in the CWTS to enhance maturation.

5.1. Addition of organics

Since the demonstration-scale system was not achieving stable redox values (nor associated performance expectations) within the targeted range, woodchips and straw were added to the demonstration-scale CWTS on July 28, 2016. Because the demonstration-scale system takes time for plants to mature (and generate organic carbon for the microbes to feed on), the addition of organics early in the operation of the system can supplement the carbon sources needed for sulphate-reducing bacteria, and produce the desired sulphur- and selenium-reducing conditions (section 10.3). This will be included in the full-scale system design specifications.

One compressed 20-liter pail of woodchips was spread across the surface of each of the four CWTS cells (Figure 7). The A cells also each received one 0.16 m^3 bale of straw while the B cells received half of a straw bale of the same size. In the A cells, the straw was added along the inflow, outflow and along the sides of the cell in between the sand bags. In the B cells, straw was added at the inflow before and after the sand bags, and along the sides in between the sand bags (Figure 7).

By September 8, 2016 (final redox readings of 2016) redox values for cell 2B were consistently within the targeted range, and the redox values for series 1 were achieving targeted ranges 50% of the time (3 of the 6 in situ probes were reading within the targeted range). It is anticipated that the addition of organics will continue to provide the necessary carbon source to stimulate desired reducing conditions in 2017.

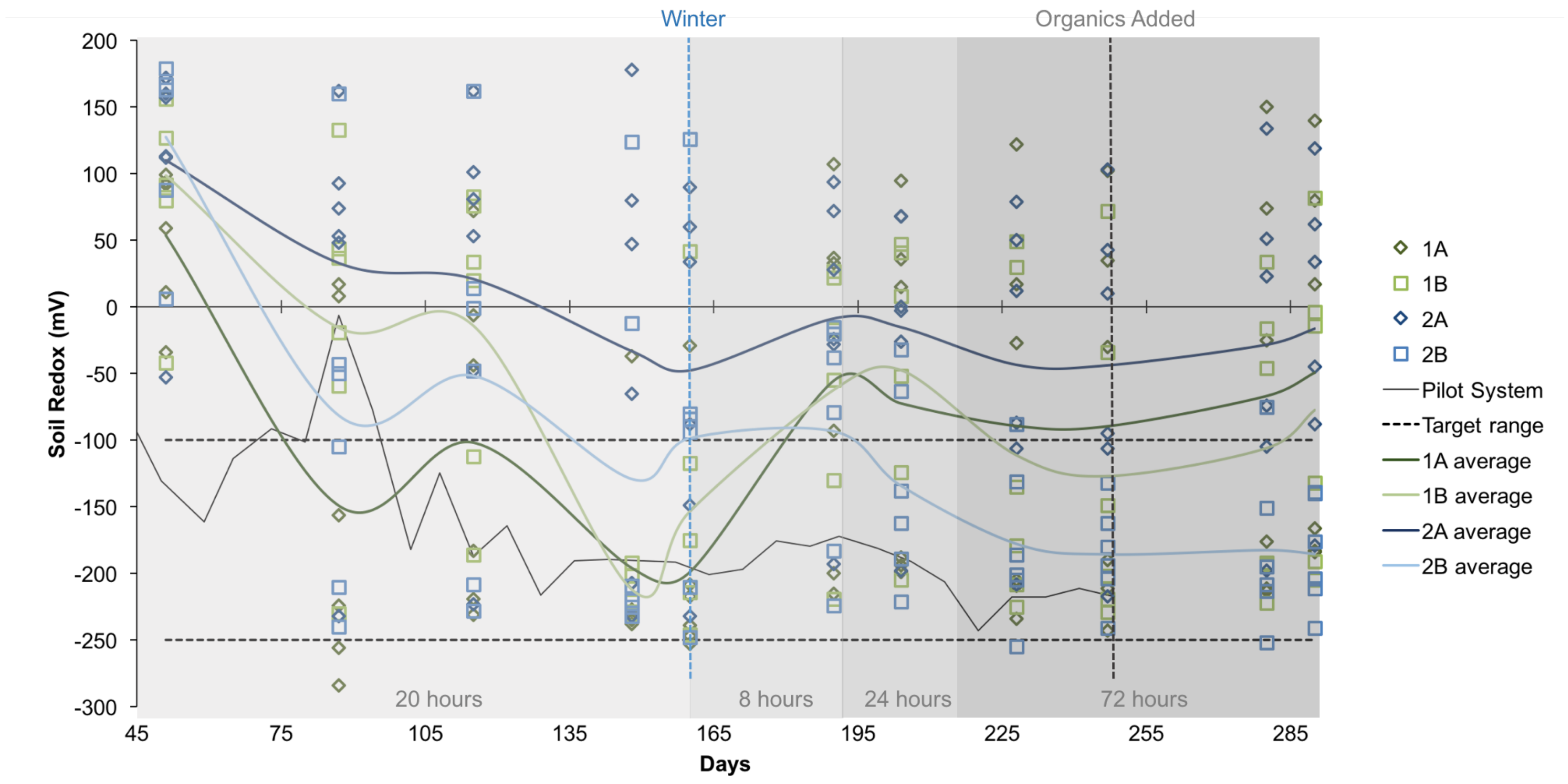


Figure 6 – Soil redox potential of each CWTS cell over time.
All demonstration-scale CWTS soil redox measurements are plotted, along with the average soil redox of the pilot-scale systems. Targeted soil redox values based on pilot-scale testing are indicated with dotted lines. The blue dotted line indicates break in measurements for winter 2015. Hours and associated grey shading indicate the HRT.

Figure 7 – Addition of organics on July 28, 2016.
Top picture shows cell 1A with woodchips that were added (floating on water surface). Bottom picture shows cell 2A with straw that was added after woodchips.

6. Performance progress during commissioning period and early operation

6.1. Soils

6.1.1. Methods

Although unintentional, the use of soils in the CWTS with high initial leachable copper concentrations (Table 3) allowed for additional types of testing to be carried out on these systems. Because the soil substrates used for construction of the CWTS were from overburden sources, the copper was not in a mineral form that would typically be found in a reducing CWTS (i.e., negative relative soil redox). Therefore, there has been some initial leaching of copper (and other elements, such as aluminum) from the soils into the water (Table 8, Figure 10, and Figure 12).

To assess the effect of the elevated metals (aluminum and copper) in the soils used in construction on CWTS functionality, four soil analytical test methods were used:

- Total concentration of elements in the soils by ICP,
- In 2015, leachable concentrations of elements in the soils by Synthetic Precipitation Leaching Procedure (SPLP), which is a method to assess the mobility of elements in soils at the pH of rain water (i.e., if the wetland were to entirely dry out, then be subjected to leaching by rain water) (EPA Method 1312/6010B)
- In 2016 a leach method was used. This analysis was carried out using a leaching procedure which involved the gentle tumbling of a sample in a specified leaching solution (water from the CWTS) for 2 hours. The resulting extract is then analyzed by inductively coupled plasma – optical emission spectrophotometry (EPA method 6010A). This method was selected in 2016 to determine the concentration of metals that are being released from the soil into the overlying water column.
- Sequential extraction procedure for the speciation of particulate trace metals (Tessier *et al*, 1979, EPA 6020A) to assess the stability and form of elements in soils (Table 7).

Table 7 – Summary of extractable fractions from sequential extraction procedure for the speciation of particulate trace metals[1].

Fraction	Description	Elements unstable when
1	Exchangeable fraction for adsorbed minerals	Readily released (i.e., soluble and exchangeable)
2	Mineral fraction bound to carbonates	Decreased pH
3	Mineral fraction bound to Fe-Mn oxides	Reducing conditions
4	Mineral fraction bound to organic matter and sulphides	Oxidizing conditions
5	Residual mineral fraction (primary and secondary minerals)	Not expected to be released in solution over time under conditions normally encountered in nature

[1] Method based on Tessier *et al.,* 1979.

6.1.2. Soil Aging

While the total copper concentrations have increased over time (with the addition of mineralized copper from the water), the leachable copper (measured by SPLP) in 2015 decreased over time. By day 58 of operation, the top 5 cm of soil was decreased to only 10-20% of the initial leachable copper concentration, and the lower 10-20 cm layers reached similar concentrations by day 149 (Table 8). In 2016 a new leach method was used to determine the concentration of metals that are being released from the soil into the overlying water column, rather than using the SPLP method which assumes leaching at rain water pH. The main difference between these methods is that the SPLP method uses laboratory water at the pH of rain water, while the new leach method uses a sample of the overlaying water in the CWTS. Therefore, the leach method is more representative of actual potential leachability of the soils into the wetland than is the SPLP method. In 2016 there was an overall decrease in leachable aluminum and copper from a depth of 0-10 cm (Table 8 and Appendix D). The B cells experienced a significant decrease of leachable copper of approximately 80% between June 15 and September 7, 2016. Cell 1A decreased 53%, and cell 2A had very little change in leachable copper. Cells 1A, 2A, and 2B experienced a similar decrease of leachable aluminum between 70% and 77%. Cell 1B experienced a decrease of leachable aluminum of 54%.

In 2016 there was an overall increase in leachable copper from a depth of 10-20 cm: cell 1A increased by 25%, cell 1B increased by 32%, cell 2A increased by 46%, and cell 2B increased by 7% (Table 8). In 2016 there was a decrease in leachable aluminum from 28% to 58% at a depth of 10-20 cm in cell 1A, 1B, and 2A. Cell 2B increased in leachable aluminum by 49% (appendix D).

Analysis of the soils by ICP-MS with sequentially extracted acid analysis shows that despite elevated initial leachable copper concentrations, the soils have become more stable (less leachable) over time in the wetland setting as the soils have aged (Figure 8). This beneficial aging of soils to a less soluble mineralized form of sulphide is expected for this type of treatment wetland design. It should be noted that due to the starting soil substrate containing leachable copper and other metals such as aluminum (Appendix B) that these elements are leaching from the substrate into the water, putting additional treatment demands on the systems.

The evapotranspiration study also confirmed that due to copper, metals, and metalloids in the initial substrates placed in the soils, constituents continue to leach from the substrate as these constituents shift from oxidized fractions 2 and 3 to reduced fraction 4 (Appendix B). Copper concentrations in the CWTS increased on average from 58 µg/L in in 2016 prior to evaporation study, to an average 80 µg/L during the evapotranspiration study. Additionally, aluminum concentrations in the CWTS in 2016 increased on average from 10.9 µg/L prior to evaporation study, to an average 32 µg/L during the evapotranspiration study. Molybdenum, selenium, and zinc all decreased in concentrations during the evapotranspiration study compared to the average concentration prior to the study in 2016. Molybdenum decreased from ~7.5 µg/L to ~6.0 µg/L, selenium decreased from ~3.3 µg/L to ~1.3 µg/L, and zinc decreased from ~52 µg/L to ~28 µg/L. Cadmium concentrations were so low that there was not a notable change in concentration during the evaporation study.

It is noted that the increase in copper concentration during the evapotranspiration trial is not representative of what would occur during periods with no flow in a full-scale system, where soils with minimal leachable copper are used and copper is deposited in sulphide form (fraction 4) by the biogeochemical activity of the CWTS. Rather, enhanced removal of constituents such as copper and selenium is expected during these periods as the system becomes more reducing with no flow. In the case of the demonstration-scale wetland, due to the elements switching from oxidized to reduced forms in the soils, the increased concentration of some constituents is seen despite a substantial decrease of sulphate. That is, there are more metals switching from oxidized to reduced forms, than sulphides being produced during this time based on available organic carbon to produce the sulphides (sulphate decreased from ~134 mg/L to ~104 mg/L). This was one of the pieces of data that prompted the addition of carbon sources to the wetland to initiate commissioning-B and address these remaining oxidized metals in the CWTS. If metals continue to leach in 2017, flows could be stopped temporarily to promote this shift from oxidized to reduced forms, with the additional carbon sources of straw and wood chips now available for the bacteria to use to produce more sulphides for metals treatment.

For the CWTS to treat the copper from the soils, additional organic carbon is needed beyond that necessary for the waters alone. Organic carbon is contributed to the CWTS through decomposition of plant material as the wetland matures. However, in 2015 the CWTS did not host enough plants that would decompose and contribute organic carbon in 2016 to the wetland, as plants were still establishing. Therefore, in 2016 additional carbon was added to the wetland in the form of woodchips and straw (Section 5.1). Organic carbon is used as food by the microbes, which in turn produce sulphides which drive metals treatment through mineralization by coupled biogeochemical processes. Presently, as there are excess copper forms transitioning from oxidized to reduced in the soils, these will bind to the sulphides, transforming them to the sulphide bound fraction 4 (Table 7). This in turn impacts the ability to treat water, as it uses the available electrons and results in insufficient sulphides to treat metals in the water. When the mineral fractions of the soils have completed transforming the oxidized copper in the soils to a sulphide bound fraction 4 mineral, the soils will no longer be sulphide hungry, allowing for the soil-produced sulphides to be utilized for metals treatment in the water. This progress can be followed by the Tessier extractions, and also by the appearance of acid volatile sulphides (AVS) in the soils. AVS was tested for in 2016 prior to adding the straw and wood chips and was non-detectable (hence, the decision to add the straw and wood chips). The appearance of measurable AVS over time will indicate that the microbes in the soil have worked through the additional copper and the wetland should start performing the way it should have had soils with high leachable copper not been used. In 2017 an AVS soil test should be conducted to determine if the soils have completed the transition to fraction 4.

It is recommended that for construction of the full-scale systems, soils with low total and leachable copper concentrations should be used. Additionally, to supplement carbon until the vegetation has fully established, solid phase organic carbon (e.g., straw, woodchips) should be mixed into the soils. After plants have begun to grow, but are not yet fully mature and able to provide enough annual carbon to the wetland through their growth, solid phase organic carbon can also be added into the wetland in the same way as was done in the demonstration-scale CWTS in 2017.

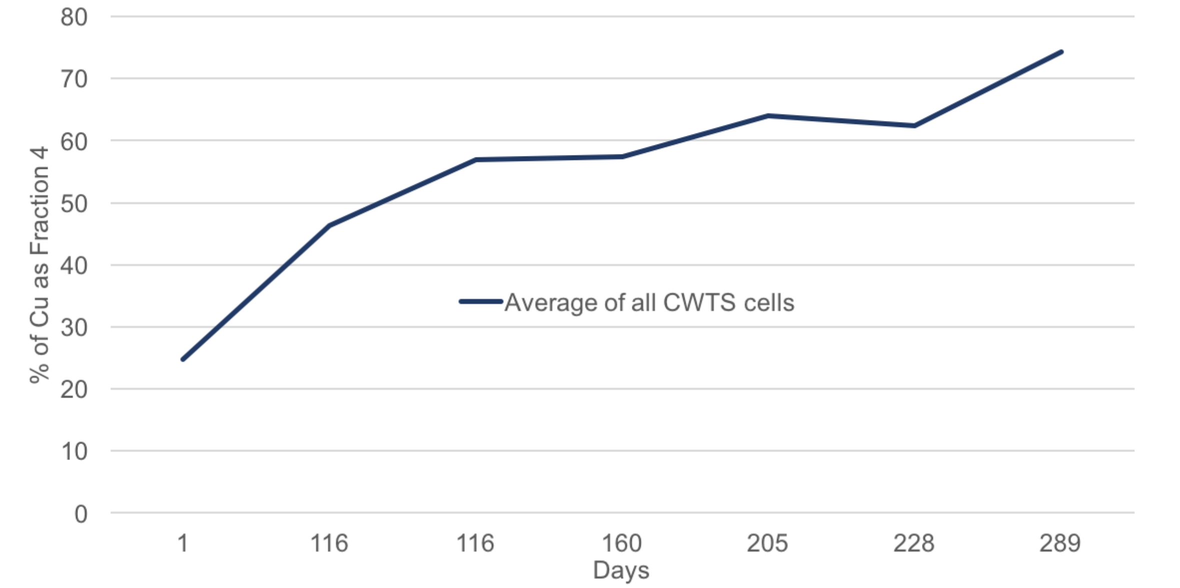
Table 8 – Total and leachable soil copper concentrations in first year of operations.

CWTS Cell	Sampling Date	Days in Operation	Sample Depth (cm)	Total Cu (mg/kg)	SPLP Cu (mg/L)	Leachable Cu (mg/kg)
1A	28-Aug-14	1	Initial Composite	-	0.298 (0.148-0.608)	-
	19-Jun-15	58	0-5	960	0.055[1]	-
	16-Aug-15	116	10-20	950	0.187	-
	18-Sep-15	149	10-20	1300	0.049	-
	29-Sep-15	160	10-20	910	0.069	-
	15-Jun-16	194	0-10	1440	-	0.953
	15-Jun-16	194	10-20	1210	-	0.66
	8-Jul-16	217	0-10	1430	-	0.603
	8-Jul-16	217	10-20	1730	-	0.832
	7-Sep-16	247	0-10	1290	-	0.449
1B	28-Aug-14	1	Initial Composite	-	0.298 (0.148-0.608)	-
	19-Jun-15	58	0-5	1400	0.033[1]	-
	16-Aug-15	116	10-20	1400	0.209	-
	18-Sep-15	149	10-20	830	0.065	-
	29-Sep-15	160	10-20	880	0.059	-
	15-Jun-16	194	0-10	1130	-	1.01
	15-Jun-16	194	10-20	1240	-	0.822
	8-Jul-16	217	0-10	1250	-	1.11
	8-Jul-16	217	10-20	1620	-	1.21
	7-Sep-16	247	0-10	1190	-	0.197
2A	28-Aug-14	1	Initial Composite	-	0.298 (0.148-0.608)	-
	19-Jun-15	58	0-5	1175	0.037[1]	-
	16-Aug-15	116	10-20	660	0.139	-
	18-Sep-15	149	10-20	880	0.081	-
	29-Sep-15	160	10-20	1000	0.073	-
	15-Jun-16	194	0-10	1100	-	0.823
	15-Jun-16	194	10-20	1280	-	0.900
	8-Jul-16	217	0-10	1450	-	0.963
	8-Jul-16	217	10-20	1150	-	1.68
	7-Sep-16	247	0-10	1290		0.838

Table 8 – Continued.

CWTS Cell	Sampling Date	Days in Operation	Sample Depth (cm)	Total Cu (mg/kg)	SPLP Cu (mg/L)	Leachable Cu (mg/kg)
2B	28-Aug-14	1	Initial Composite	-	0.298 (0.148-0.608)	-
	19-Jun-15	58	0-5	1100	0.039[1]	-
	16-Aug-15	116	10-20	1000	0.201	-
	18-Sep-15	149	10-20	830	0.078	-
	29-Sep-15	160	10-20	540	0.059	-
	15-Jun-16	194	0-10	1040	-	0.771
	15-Jun-16	194	10-20	1310	-	1.16
	8-Jul-16	217	0-10	1070	-	1.38
	8-Jul-16	217	10-20	1180	-	1.25
	7-Sep-16	247	0-10	1520	-	0.123

[1] Samples collected in June 2015 were at a shallow depth (0-5 cm) and copper content had therefore likely already been removed by washing from the faster flows of the CWTS system. The aging of the deeper (10-20 cm) soil copper concentrations over time to a less soluble form is shown in Figure 8.
The blue shading indicated samples that were taken from a shallower depth.



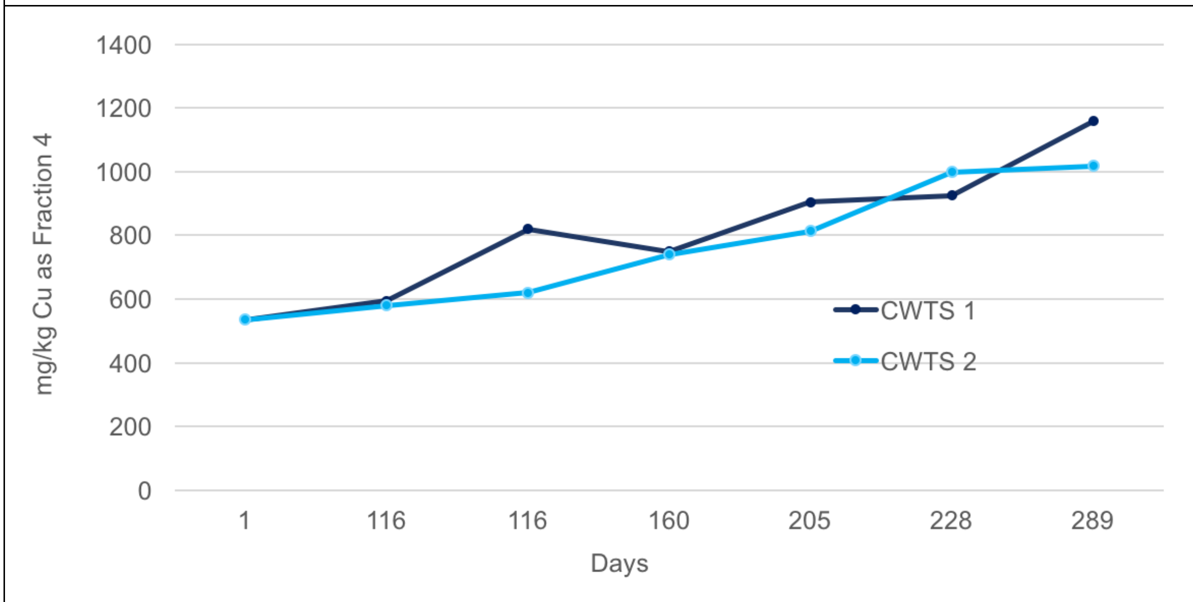


Figure 8 – Copper as sequential leach fraction 4 over time.
Copper in the form of the targeted Fraction 4 (sulphide mineral form and bound to organics), increased in the CWTS over time as the soils matured. Additional information in Appendix B.

6.2. Water

6.2.1. Pilot-scale testing performance

Pilot-scale testing was performed with water that mimicked the worst-case long-term post-closure water chemistry (mean influent concentrations of 146 µg/L copper and 10.2 µg/L selenium). In contrast, the on-site demonstration-scale system uses water from the sump downslope of the dry stack tailings facility and the MVFE (W36 or W62) and therefore has inflow concentrations that are currently occurring during operations (mean influent concentrations of 58 μg/L copper and 6 μg/L selenium). Because of this, a lower percent removal will achieve the same extent of removal and associated outflow concentrations than was required in the pilot-scale systems. For example, the pilot-scale system achieved on average 92% removal of copper (mean outflow of 11.3 μg/L) and 41% removal of selenium (mean outflow of 6 μg/L). To achieve these same outflow concentrations with the demonstration-scale system, 80% removal of copper and minimal (or no) removal of selenium would be needed.

6.2.2. Demonstration-scale metal leaching from soils

The treatment of copper has been improving through commissioning as the system has matured (Figure 16). However, as shown in Figure 10 and Figure 12 several elements are being released through the wetland by the soils, such as aluminum, and copper (as discussed in Section 6.1). Because of this, negative percent removals of copper have been observed, especially in early operations (Appendix B). It was initially theorized that this was occurring when the May and June 2015 data reported outflow concentrations higher than the influent. This paired with the soils data (Section 6.1 and Appendix A) led to the design of a new sampling scheme to determine whether detectable levels of metals were being released from the soils within the wetland (2015) and to monitor this (2016). For two timepoints in 2015 (August 15, 2015 and September 17, 2015) and 2 timepoints in 2016 (June 14, 2016 and September 7, 2016), water was sampled not only at the feed and the outflow of each cell, but also through the cell. Beginning at the outflow of cell B and working upwards towards the feed, samples were taken at the B cell outflow, B cell mid-point, and B cell inflow, and then the same 3 points for the A cell (Figure 9). In each case, the sample was taken from within a reaching distance of the side shore to ensure that sediments were not suspended in sampling.

Since the beginning of operations of the demonstration-scale CWTS, significant concentrations of copper have been leaching from the wetlands soils of all cells (Figure 12). Moreover, metal types and concentrations (e.g., Aluminum, Appendix B) that could not be accounted for by the influent water chemistry were elevated at random points within the wetland. This suggested that because of metals leaching from the soils, the treatment occurring within the wetlands was far greater than what was being observed by simply measuring the inflow and outflow points (Figure 16). For example, in August of 2015, influent copper concentrations were measured as 50 μg/L, but within the first meter of cell 1A increased to 100 μg/L, and by the outflow of cell 1A, down to 42 μg/L (58 μg/L decrease), they then increased to 70 μg/L at the beginning of cell B, and again were treated to a final outflow concentration of 40 μg/L (30 μg/L decrease) for a total of at least 88 μg/L removed by Series 1 of the treatment wetland. This suggested the wetland is achieving much greater copper treatment (88 μg/L removed), than would be suggested by only measuring the inflow and outflow of the system (suggests 10 μg/L removed). Similar leaching was observed through the wetland during testing in September 2015.

When the flow through the wetland was tested for metals leaching from soils in September 2016, influent copper concentrations were measured as 51 μg/L, but within the first meter of cell 1A increased to 74 μg/L, and by the midpoint of cell 1A they decreased to 36 μg/L and at the outflow of cell 1A, increased to 40 µg/L (i.e., a net 39 µg/L decrease, although only appearing as 14 µg/L compared to inflow). Copper concentrations were 34 µg/L at the beginning of cell B, and again were treated to a final outflow concentration of 28 µg/L (6 µg/L decrease) for a total of at least 45 µg/L removed by cells A and B of Series 1 of the treatment wetland. This suggests the wetland is achieving much greater copper treatment (45 µg/L removed), than would be suggested by only measuring the inflow and outflow of the system (suggests 23 µg/L removed). Copper continues to leach from the wetland soils, however the amount of leaching has decreased in 2016, with an 80% decrease in leachable copper from the soil in B cells, and 50% decrease in leachable copper in cell 1A, and cell 2A has become more stable with little change in leachable copper through 2016 (Figure 12).

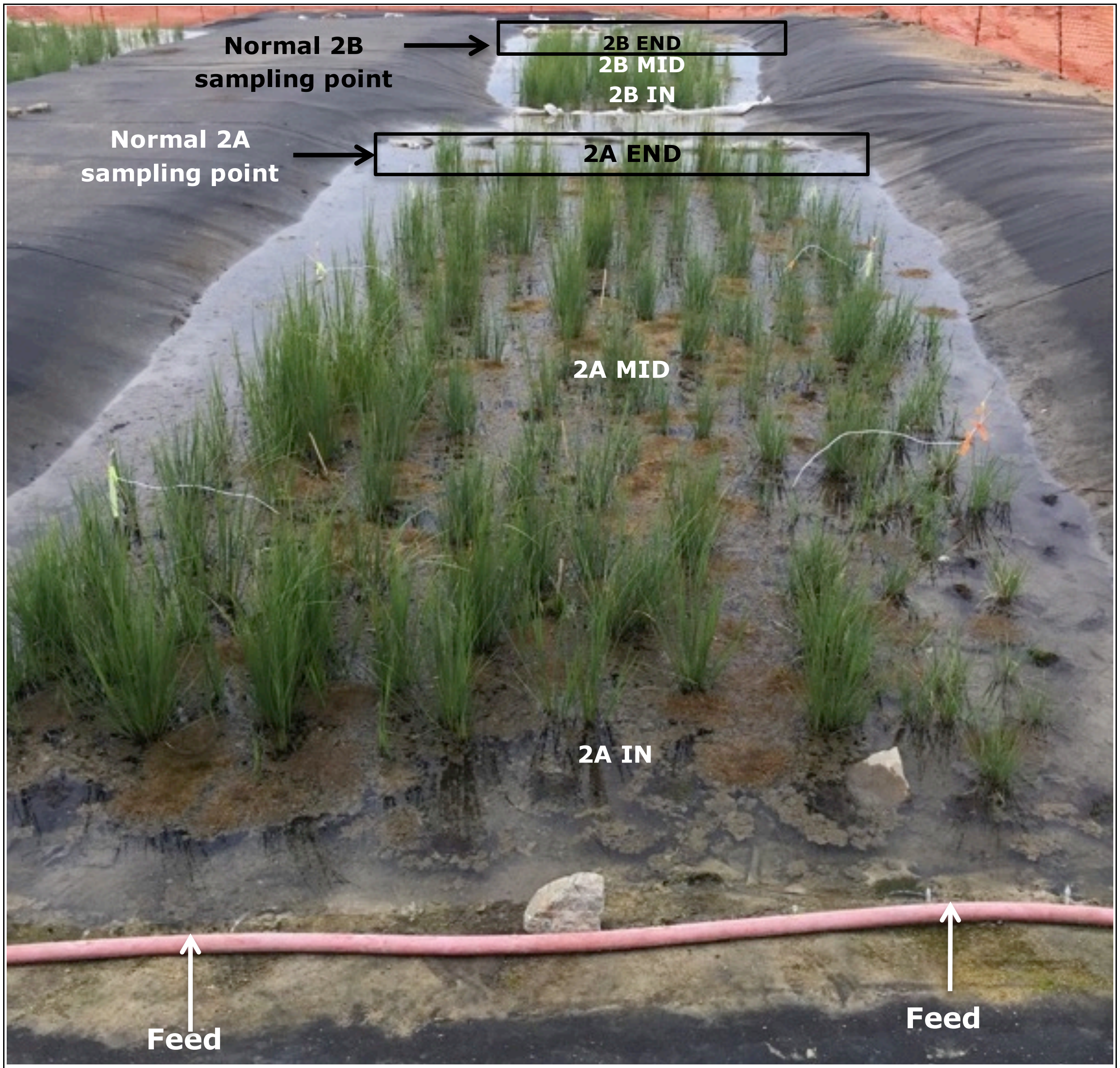


Figure 9 – Sampling points through the CWTS (Photo taken August 16, 2015).

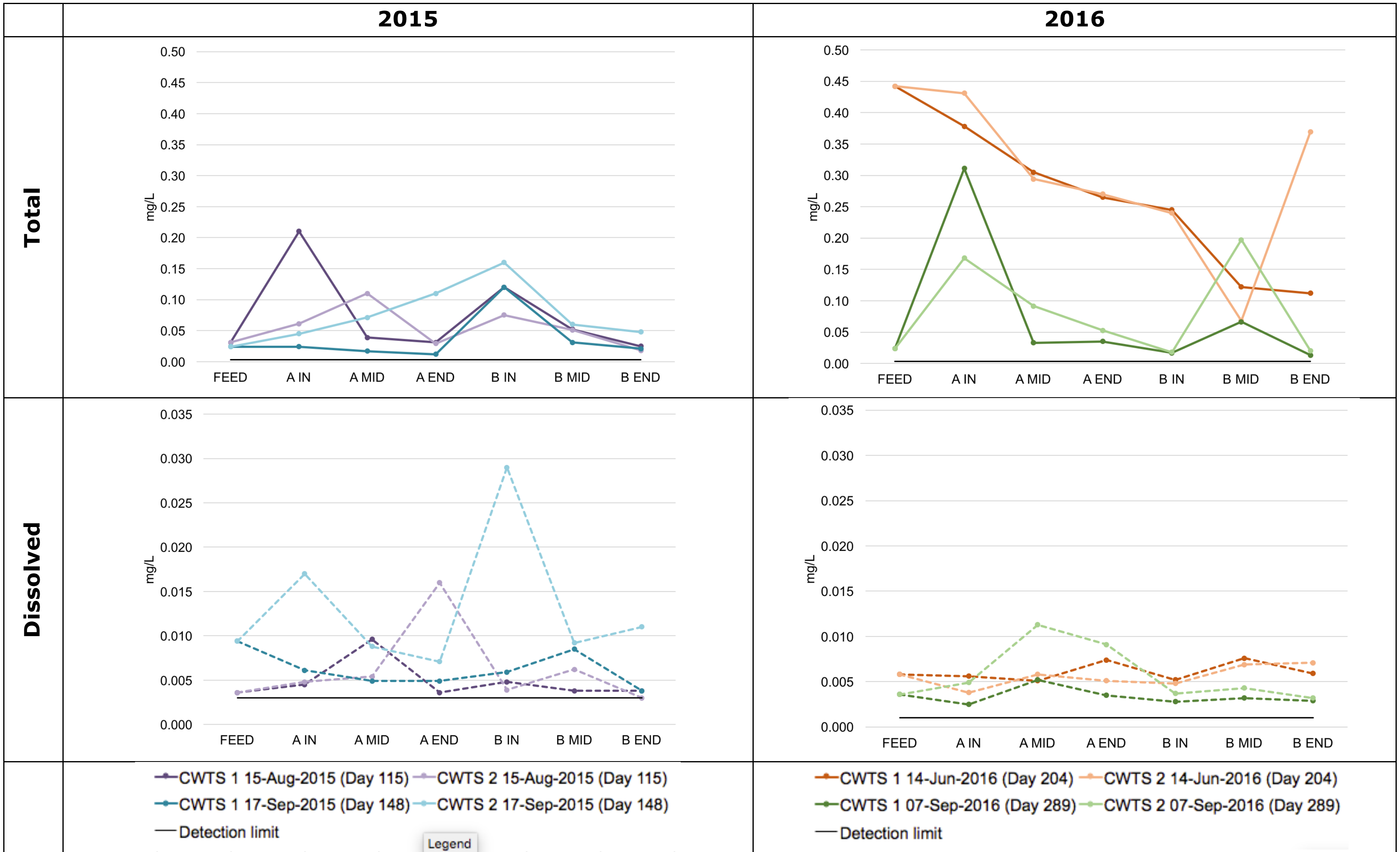


Figure 10 – Aluminum concentrations through the CWTS.

Left is 2015, right is 2016, top graphs are total concentrations and bottom graphs are dissolved concentrations. Data shown for four timepoints, where water was sampled at 7 locations through the flow path of the CWTS to assess for treatment fronts within the wetland, or possible leaching of elements from the soils into the CWTS. Y-axes are set to be the same for total and the same for dissolved. The Maxxam (2015 results) detection limits for aluminum are 0.0030 mg/L. The ALS (2016 results) dissolved aluminum detection limit is 0.0010 mg/L, and the total aluminum detection limit is 0.0030 mg/L.

Figure 11 – Cadmium concentrations through the CWTS.
Left is 2015, right is 2016, top graphs are total concentrations and bottom graphs are dissolved concentrations. Data shown for four timepoints, where water was sampled at 7 locations through the flow path of the CWTS to assess for treatment fronts within the wetland, or possible leaching of elements from the soils into the CWTS. Y-axes are set to be the same for total and the same for dissolved. The Maxxam (2015 results) detection limits for cadmium are 0.020 µg/L. The ALS (2016 results) detection limits are 0.005 µg/L.

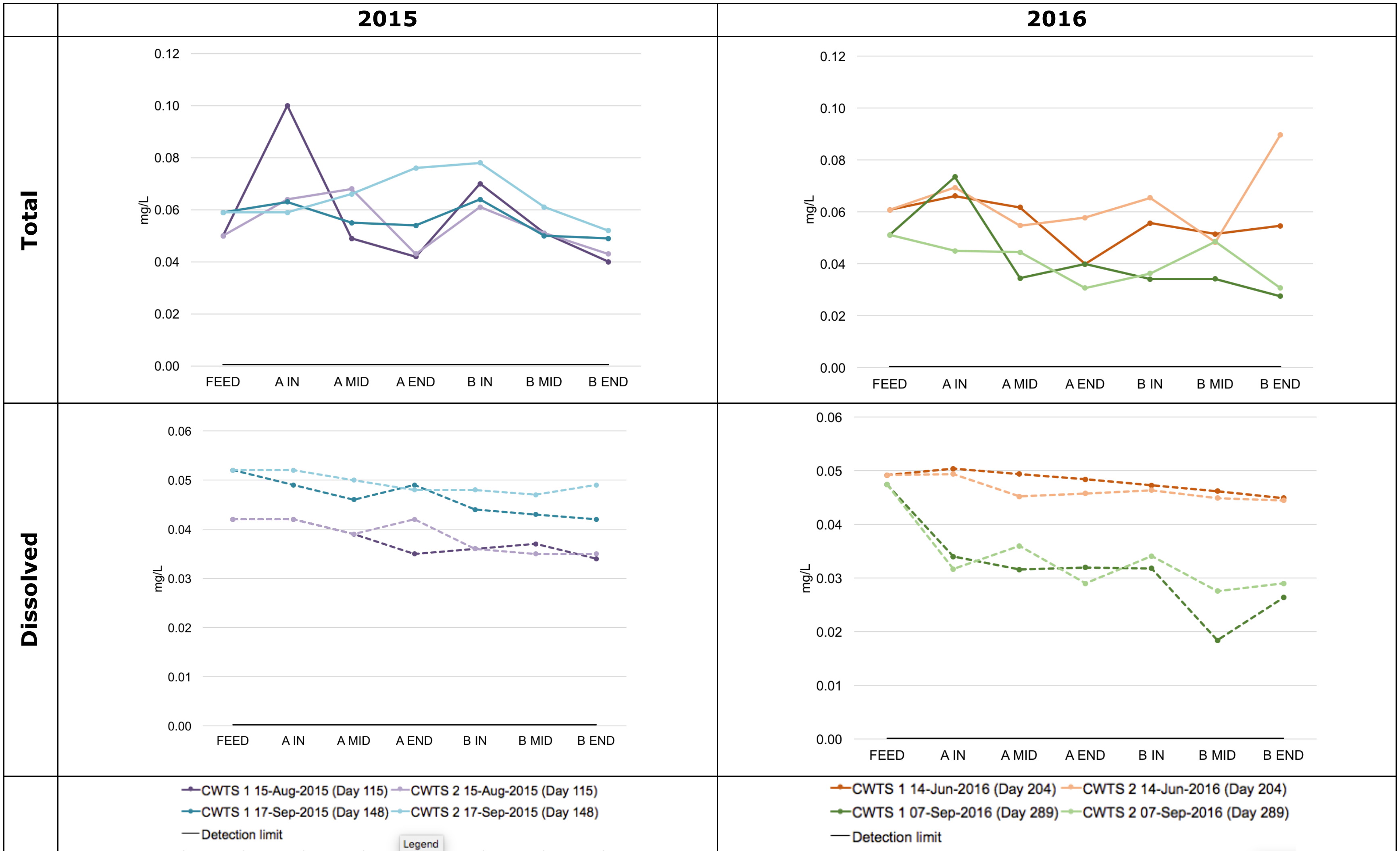


Figure 12 – Copper concentrations through the CWTS.
Left is 2015, right is 2016, top graphs are total concentrations and bottom graphs are dissolved concentrations. Data shown for four timepoints, where water was sampled at 7 locations through the flow path of the CWTS to assess for treatment fronts within the wetland, or possible leaching of elements from the soils into the CWTS. The Maxxam (2015 results) detection limits for copper are 0.0002 mg/L. The ALS (2016 results) detection limits for copper are 0.0005 mg/L.

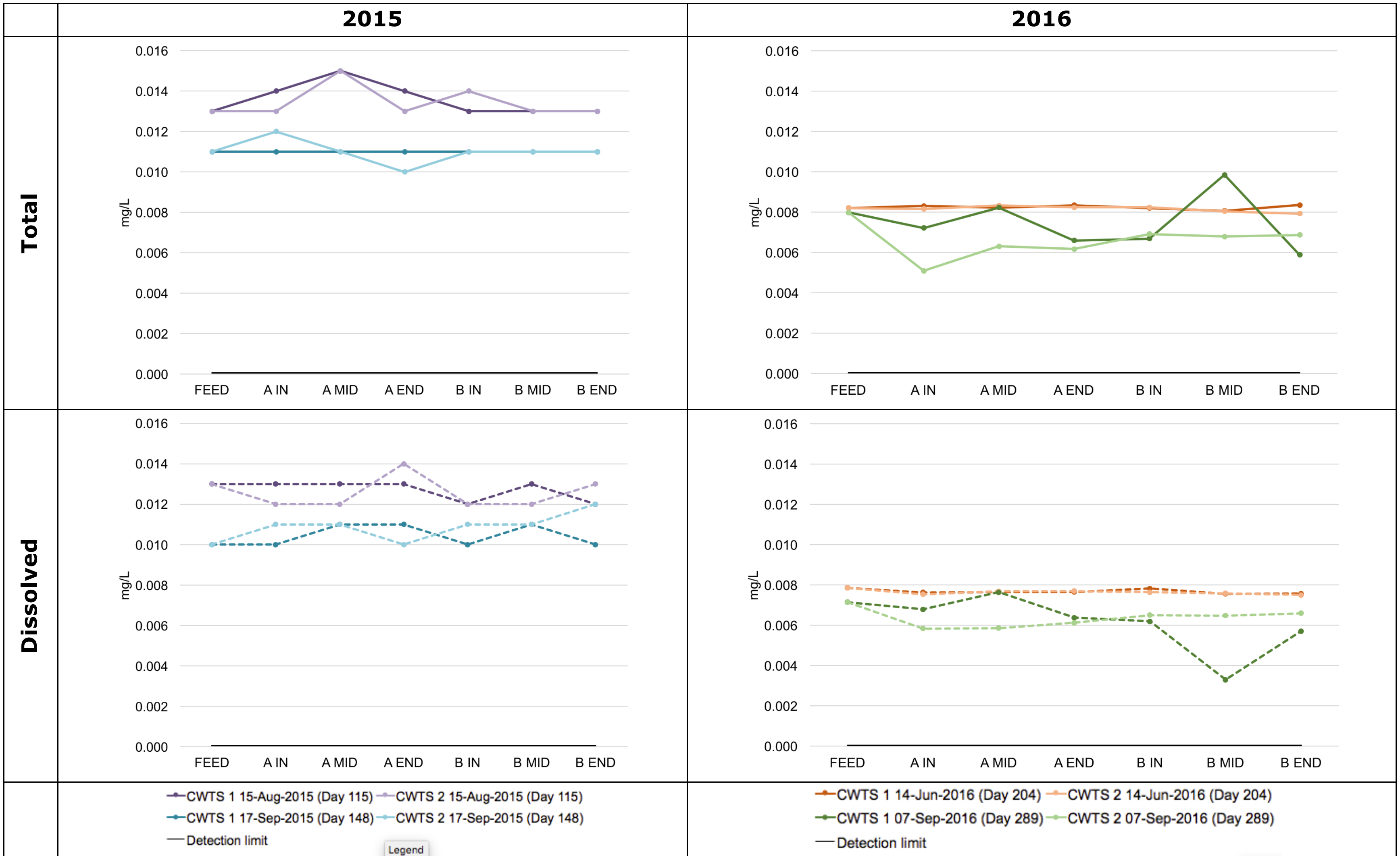


Figure 13 – Molybdenum concentrations through the CWTS.

Left is 2015, right is 2016, top graphs are total concentrations and bottom graphs are dissolved concentrations. Data shown for four timepoints, where water was sampled at 7 locations through the flow path of the CWTS to assess for treatment fronts within the wetland, or possible leaching of elements from the soils into the CWTS. Y-axes are set to be the same for total and dissolved. The Maxxam (2015 results) detection limits for molybdenum are 0.0002 mg/L. The ALS (2016 results) detection limits are 0.000050 mg/L.

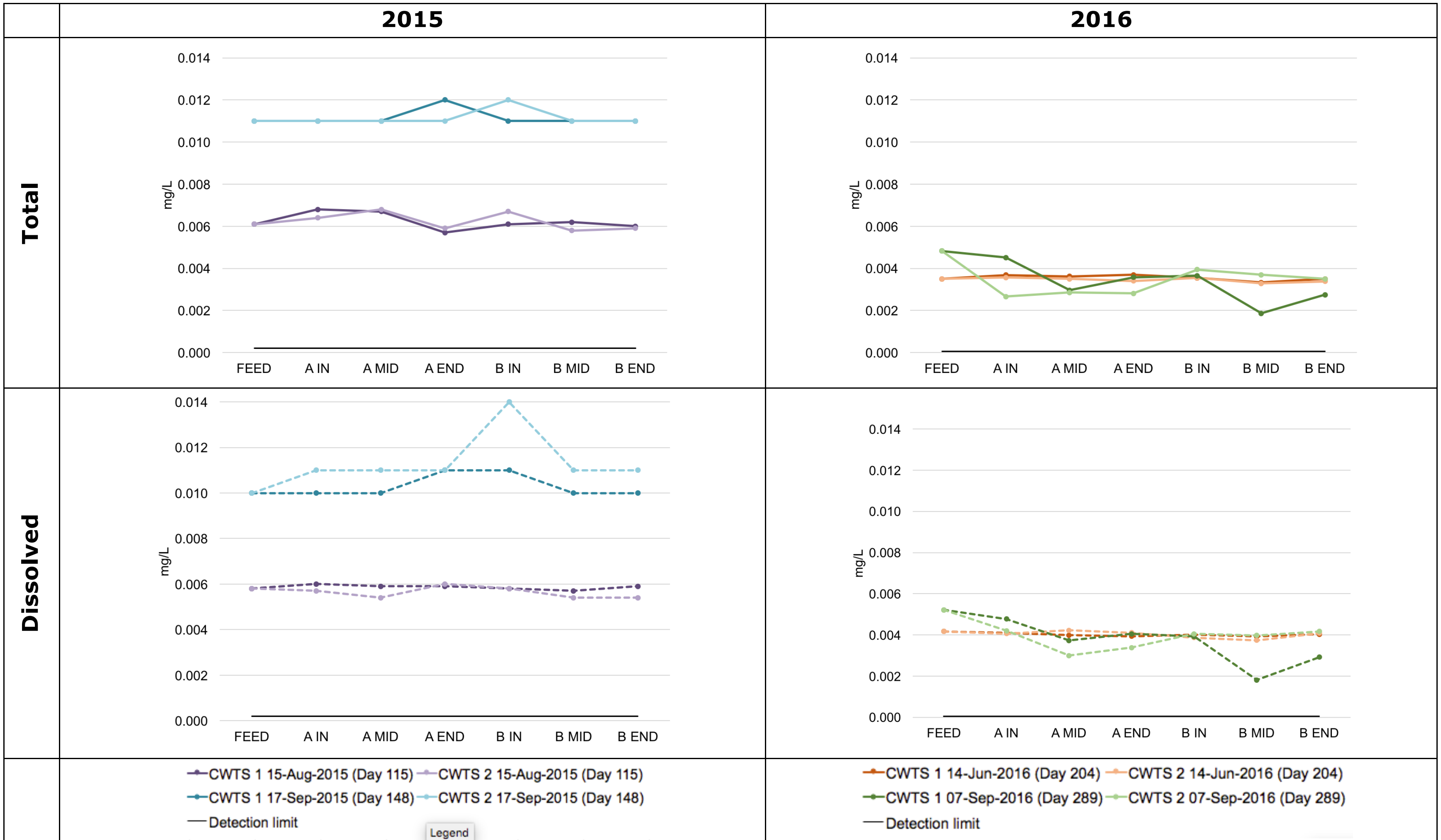


Figure 14 – Selenium concentrations through the CWTS.
Left is 2015, right is 2016, top graphs are total concentrations and bottom graphs are dissolved concentrations. Data shown for four timepoints, where water was sampled at 7 locations through the flow path of the CWTS to assess for treatment fronts within the wetland, or possible leaching of elements from the soils into the CWTS. Y-axes are set to be the same for total and dissolved. The Maxxam (2015 results) detection limit for selenium is 0.0002 mg/L. The ALS (2016 results) detection limit is 0.000050 mg/L.

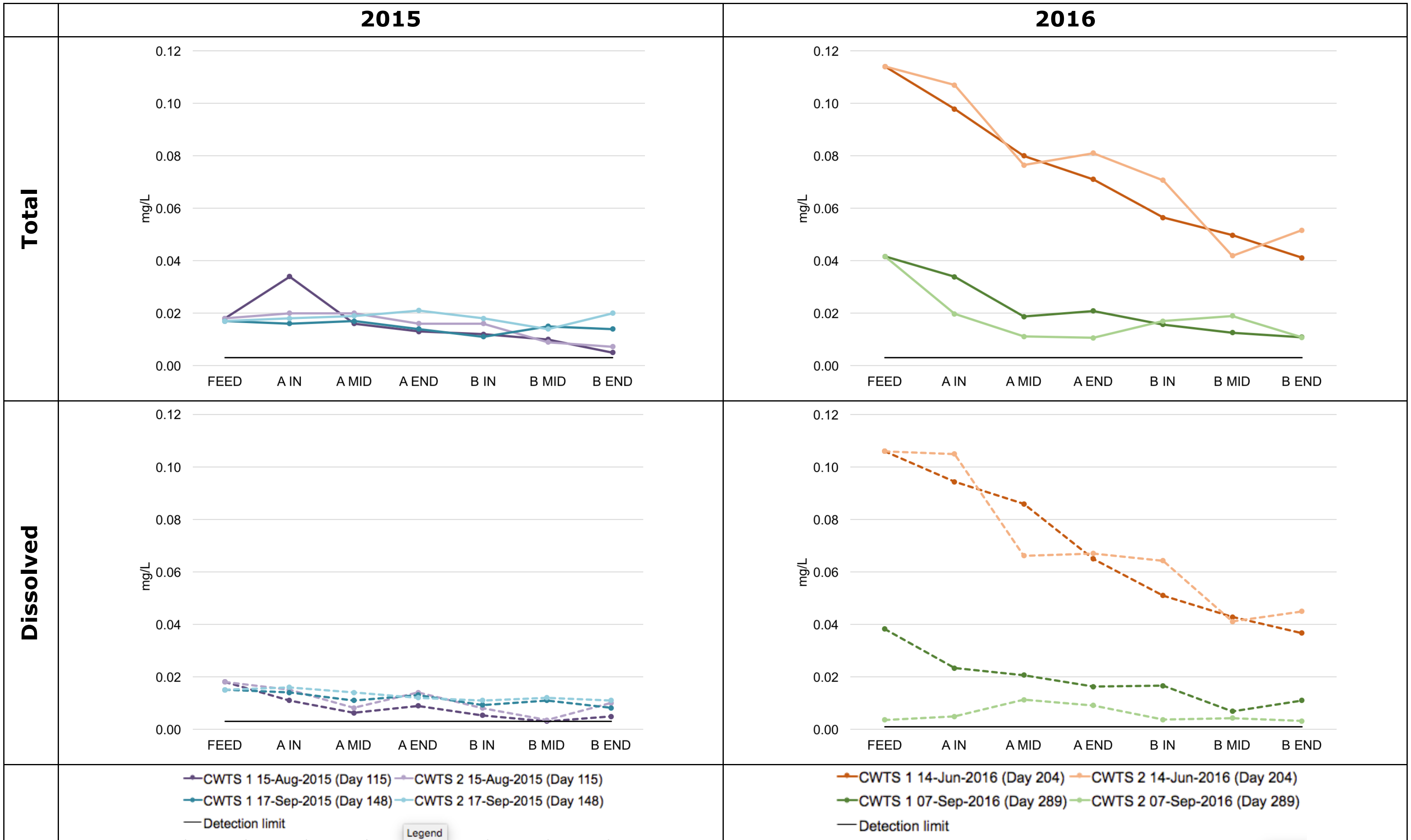


Figure 15 – Zinc concentrations through the CWTS.
Left is 2015, right is 2016, top graphs are total concentrations and bottom graphs are dissolved concentrations. Data shown for four timepoints, where water was sampled at 7 locations through the flow path of the CWTS to assess for treatment fronts within the wetland, or possible leaching of elements from the soils into the CWTS. Y-axis is set to be the same for total and dissolved. The Maxxam (2015 results) detection limit for zinc is 0.0030 mg/L. The ALS (2016 results) detection limit is 0.0010 mg/L.

6.2.3. Demonstration-scale performance during commissioning-A

By the end of 2015 the outflow concentration for dissolved cadmium, was on average 49% lower than influent concentrations, with average influent concentrations of 0.0505 µg/L decreasing to an average outflow concentration of 0.0248 µg/L. During commissioning-A in 2016 treatment decreased to an average removal of 40%, with average influent concentrations of 0.0240 µg/L decreasing to an average outflow concentration of 0.0142 µg/L. Dissolved copper also experienced the same trend with an average outflow concentration 17% lower than influent concentrations at the end of 2015, with average influent concentrations of 54.5 µg/L decreasing to an average outflow concentration of 45.0 µg/L. During commissioning-A in 2016, treatment decreased to an average removal of 8%, with average influent concentrations of 61.6 µg/L decreasing to an average outflow concentration of 56.7 µg/L. Molybdenum experienced no treatment through commissioning-A in 2015 and 2016, with average outflow concentrations being very similar to average influent concentrations. Dissolved selenium also experienced no treatment through commissioning-A in 2015, however by the end of commissioning-A in 2016 dissolved selenium was on average 8% lower than influent concentrations, with average influent concentrations of 3.7 µg/L decreasing to an average outflow concentration of 3.4 µg/L. By the end of 2015 the outflow concentration for dissolved zinc, was on average 42% lower than influent concentrations, with average influent concentrations of 12.3 µg/L decreasing to an average outflow concentration of 6.8 µg/L. During commissioning-A in 2016 treatment increased to an average removal of 47%, with average influent concentrations of 92.8 µg/L decreasing to an average outflow concentration of 49.0 µg/L lower than influent concentrations.

6.2.4. Elevated zinc in influent in 2016

The concertation of zinc in the influent to the CWTS increased significantly in 2016 compared to 2015 concentrations (Table 9, Figure 15, and Figure 20). It is uncertain whether the increase in zinc is a result of the change in sump source water location at the toe of the MVFE, where a metal culvert was installed at the beginning of operations in 2016 (Section 2.4), or if this is a result of seasonal variation.

6.2.5. Demonstration-scale performance during commissioning-B

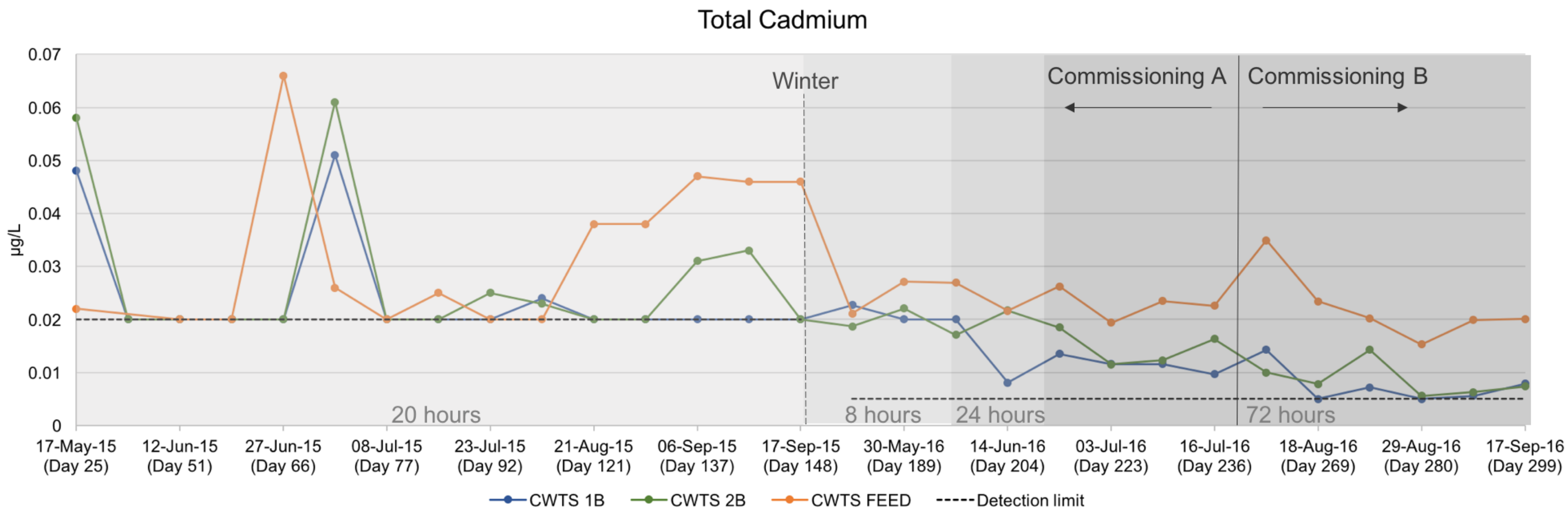
After commissioning-A was complete at the end of July 2016, cadmium, copper, molybdenum, selenium, and zinc were being treated by the CWTS (Figure 16 to Figure 21 and Appendix B), while other metals/metalloids of potential concern as outlined in the Adaptive Management Plan (AMP) (Minto, 2016) were below the non- degradation central tendency water quality objectives (NDCT-WQO) for the Lower Minto Creek (W2) area.

Dissolved cadmium treatment improved through the commissioning-A period in 2016 to achieve on average 64% removal during the commissioning-B period from July 29 to September 30, 2016, with average influent concentrations of 0.0185 µg/L decreasing to an average outflow concentration of 0.0066 µg/L (Table 9, Figure 16 and Appendix B) Copper, and zinc experienced the same trends with treatment improving through the commissioning-A period in 2016 to achieve on average 37% and 69% removal during the commissioning-B period from July 29 to September 30, 2016 (Table 9, Figure 17, Figure 20, and Appendix B). During the commissioning-B period, the average influent concentrations for copper (46.1 µg/L) decreased to an average outflow concentration of 28.8 µg/L. During the same time period the average influent concentrations for zinc (37.6 µg/L) decreased to an average outflow concentration of 11.6 µg/L. The treatment of molybdenum and selenium in 2016 is notable as there was minimal treatment in 2015, improving through 2016 to achieve on average 21% and 41% removal during the commissioning-B period from July 29 to September 30, 2016 (Table 9, Figure 18, Figure 19, and Appendix B). This suggests that not only is the wetland maturing as expected, creating reducing sulphide-producing conditions, but that it is already performing far beyond what was anticipated from the design, sequestering orders of magnitude more copper than would be apparent by looking at the influent water alone (i.e., is also removing copper that has leached from the soils over time). All constituents of concern have percent removal rates that continue to trend upward and are becoming more stable as the wetland matures.

Table 9 – Percent removal of constituents in the demonstration-scale CWTS.

Element (µg/L)		Pilot-scale[1]	Demonstration-scale			
		2013	2014	2015[2]	2016 [3]	2016[4]
Cd	In	0.336	NA	0.0505	0.0240	0.0185
	Out	0.027	NA	0.0248	0.0142	0.0066
	%	**92**	NA	**49**	**40**	**64**
Cu	In	146	NA	54.5	61.6	46.1
	Out	11.3	NA	45.0	56.7	28.8
	%	**92**	NA	**17**	**8**	**37**
Mo	In	13.0	NA	11.0	7.6	7.3
	Out	10.4	NA	11.3	7.6	5.7
	%	**20**	NA	**0**	**0**	**21**
Se	In	10.2	NA	11.0	3.7	5.7
	Out	6	NA	11.3	3.4	3.3
	%	**41**	NA	**0**	**8**	**41**
Zn	In	40	NA	12.3	92.8	37.6
	Out	3.2	NA	6.8	49.0	11.6
	%	**92**	NA	**42**	**47**	**69**

[1]The pilot-scale system operated from Nov 4, 2013 to July 16, 2014. The data used in this table is from the low N period in the *carex* and moss system which operated from April 13, 2014 to May 28, 2014.
[2] Values calculated from end last two sampling event in 2015 before the addition of EDTA (September 9 and 17, 2015).
[3] Commissioning-A (May 2, 2016 to July 28, 2016).
[4] Commissioning-B (July 29, 2016 to September 30, 2016).



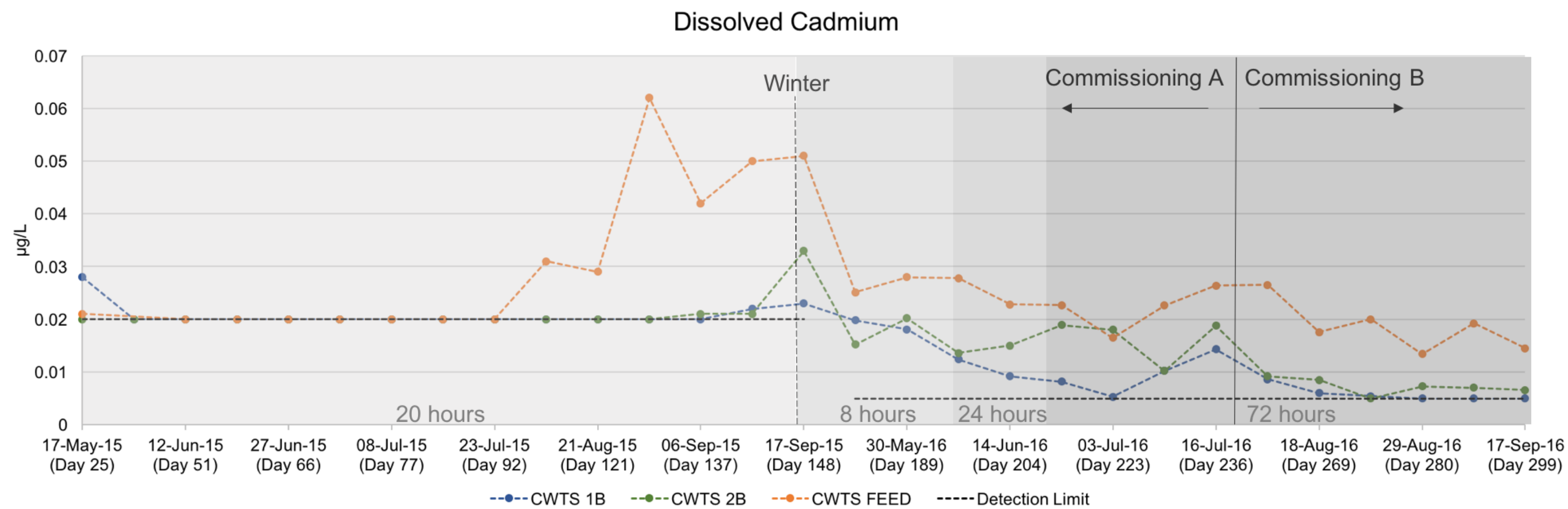
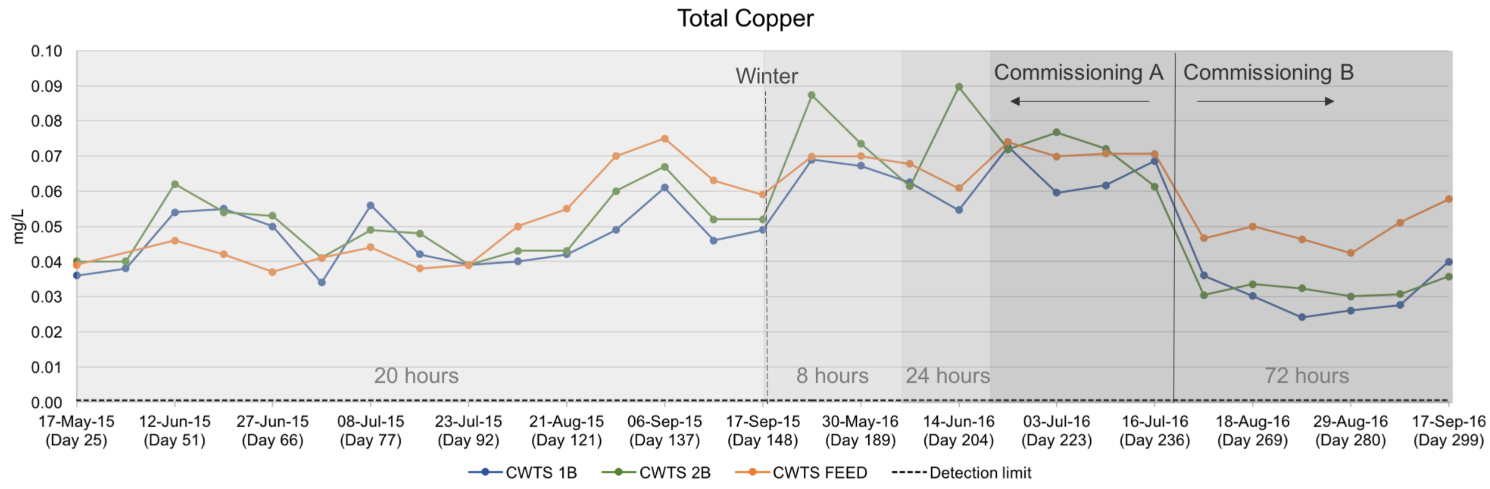


Figure 16 – Cadmium concentrations in the demonstration scale wetland.
The HRT is indicated by grey shading and the duration in hours. The Maxxam (2015 results) measurement uncertainty (MU) for cadmium is +/- 0.020 µg/L. The ALS (2016 results) MU is +/- 0.005 µg/L. Timepoints where the dissolved concentration is higher than the total concentration are within the limit of uncertainty.



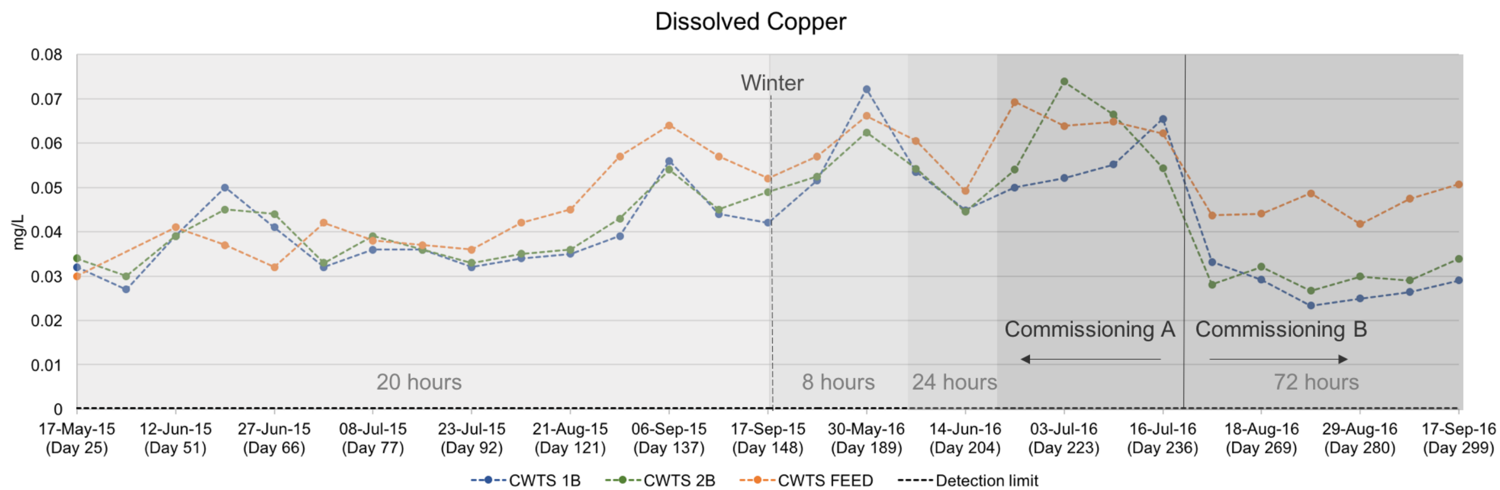
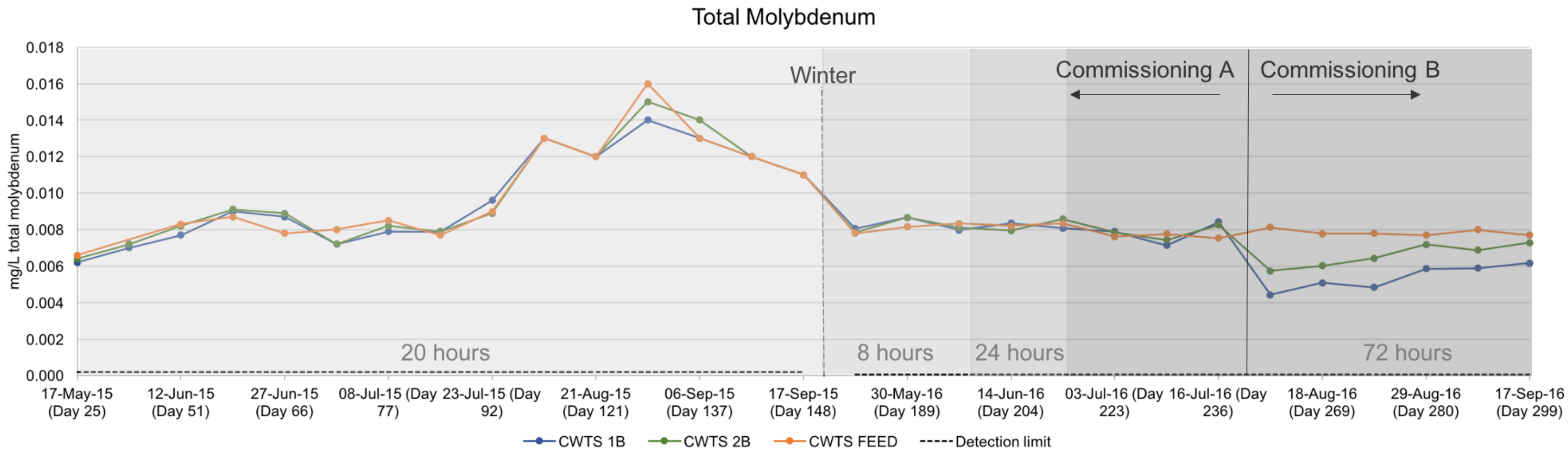


Figure 17 – Copper concentrations in the demonstration scale wetland.
The HRT is indicated by grey shading and the duration in hours. The Maxxam (2015 results) and The ALS (2016 results) measurement uncertainty (MU) for copper is +/- 0.0002 mg/L. Timepoints where the dissolved concentration is higher than the total concentration are within the limit of uncertainty.



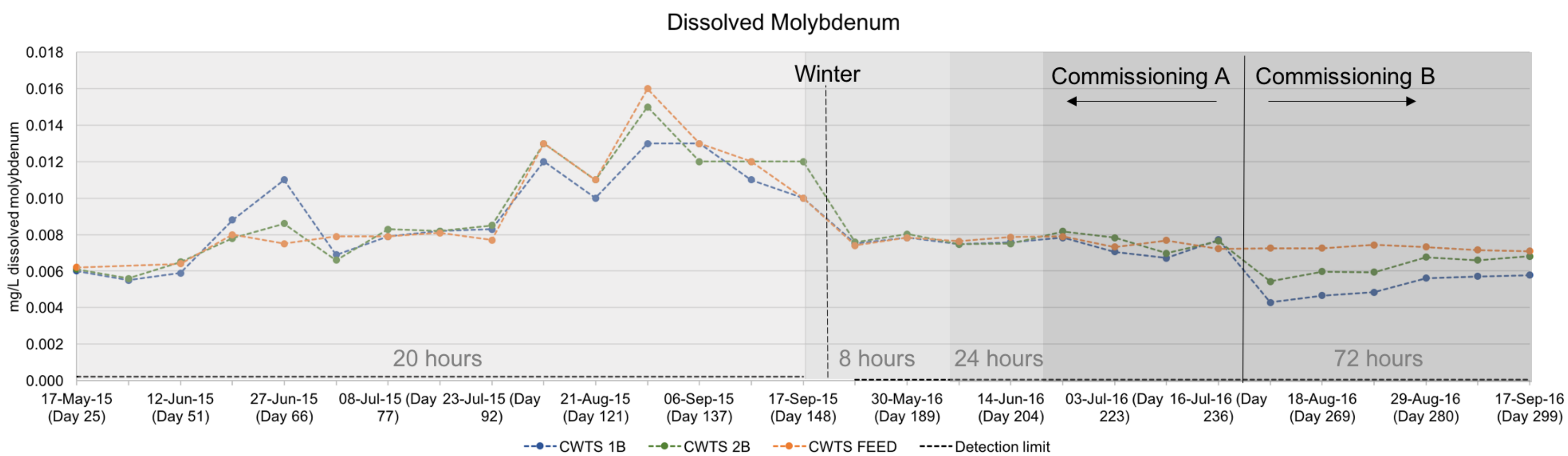


Figure 18 – Molybdenum concentrations in the demonstration scale wetland.
The HRT is indicated by grey shading and the duration in hours. The Maxxam (2015 results) measurement uncertainty (MU) for molybdenum is +/- 0.0002 mg/L. The ALS (2016 results) MU is +/- 0.000050 mg/L. Timepoints where the dissolved concentration is higher than the total concentration are within the limit of uncertainty.

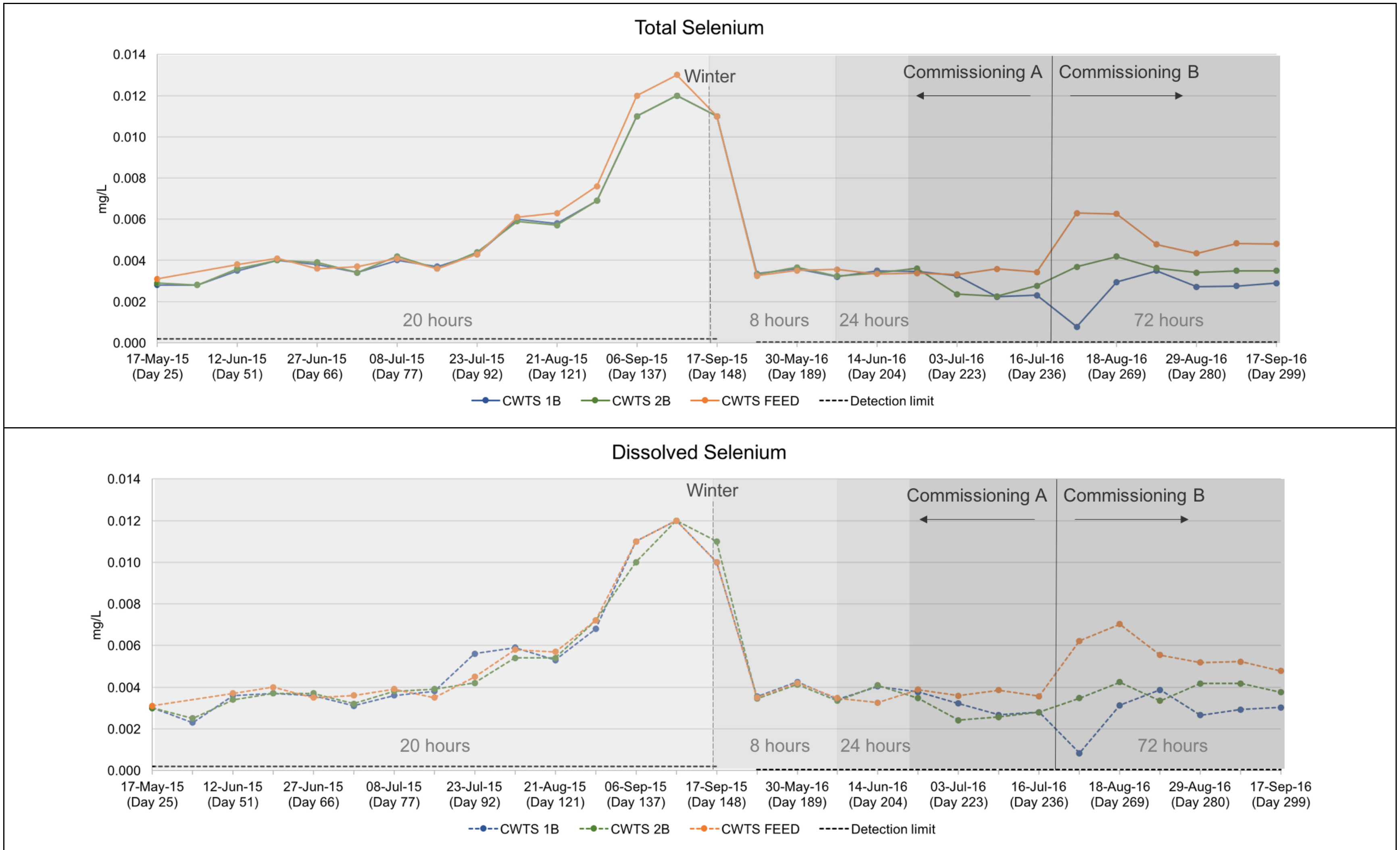
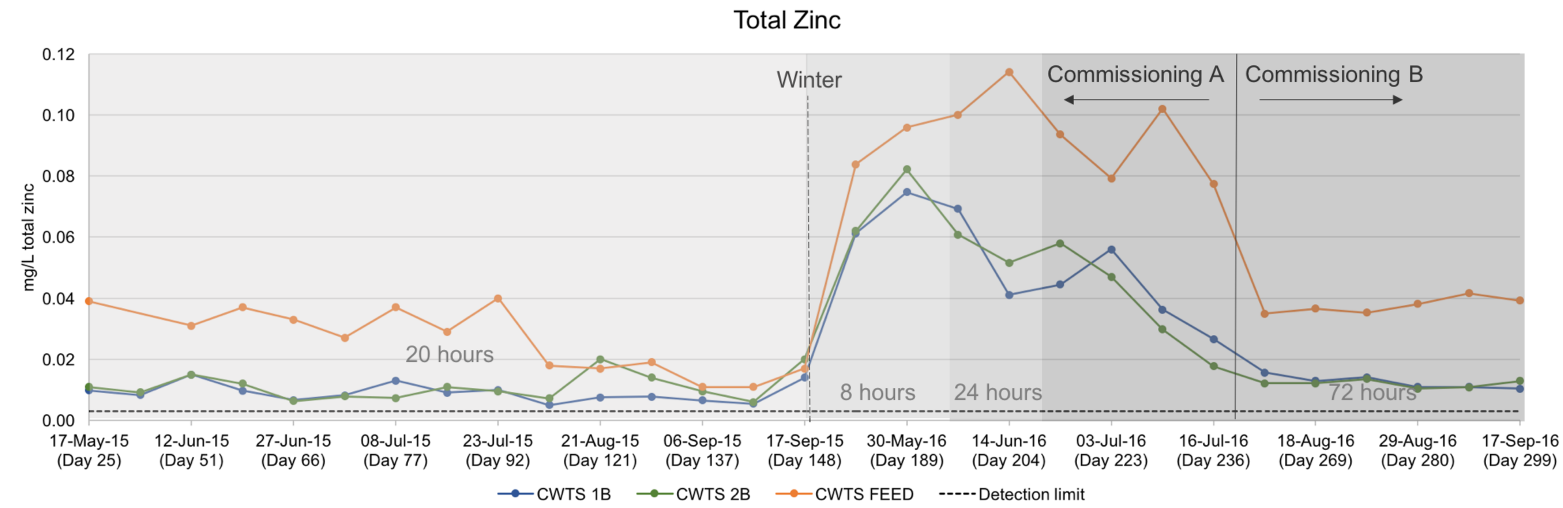


Figure 19 – Selenium concentrations in the demonstration scale wetland.
The HRT is indicated by grey shading and the duration in hours. The Maxxam (2015 results) measurement uncertainty (MU) for selenium is +/- 0.0002 mg/L. The ALS (2016 results) MU is +/- 0.000050 mg/L. Timepoints where the dissolved concentration is higher than the total concentration are within the limit of uncertainty.



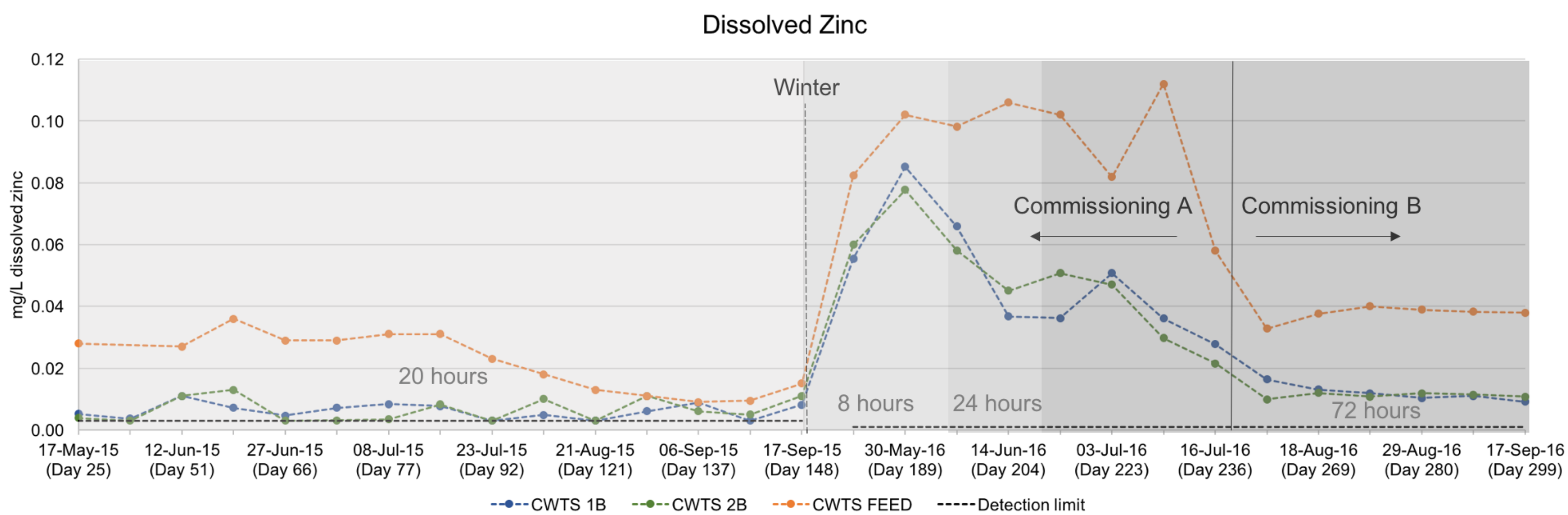


Figure 20 – Zinc concentrations in the demonstration scale wetland.
The HRT is indicated by grey shading and the duration in hours. The Maxxam (2015 results) measurement uncertainty (MU) for zinc is +/- 0.0030 mg/L. The ALS (2016 results) MU is +/- 0.0010 mg/L. Timepoints where the dissolved concentration is higher than the total concentration are within the limit of uncertainty.

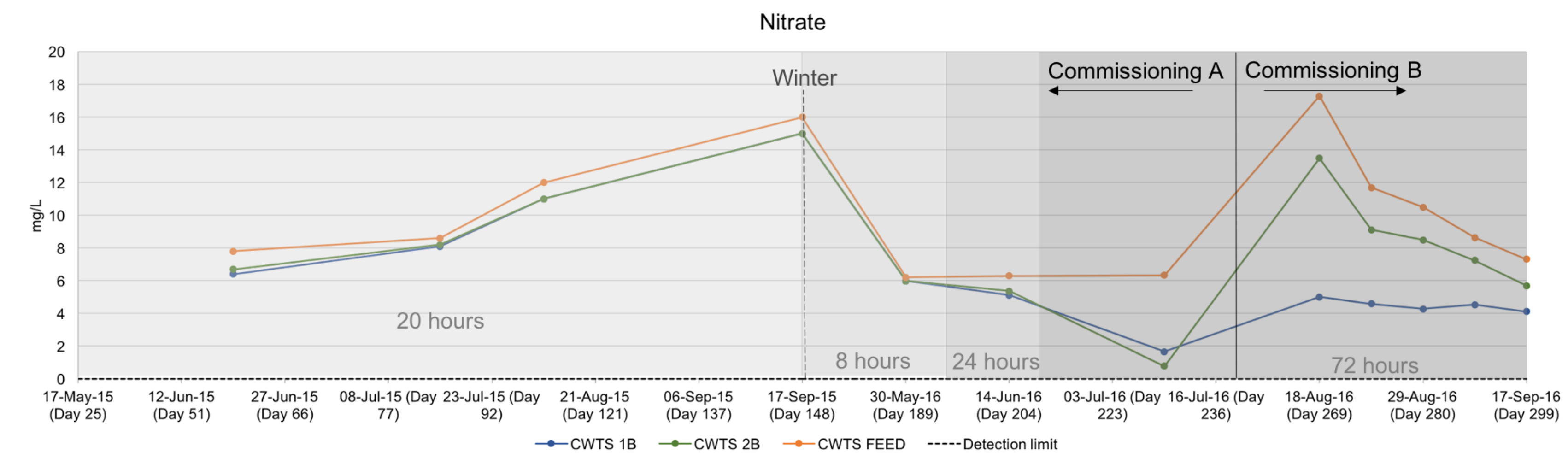


Figure 21 – Nitrite as N (NO_2) and Nitrate as N (NO_3) concentrations in the demonstration scale wetland. The HRT is indicated by grey shading and the duration in hours. The Maxxam (2015 results) measured uncertainty (MU) for nitrite is +/- 0.010 mg/L. The ALS (2016 results) MU is +/- 0.0010 mg/L. The Maxxam (2015 results) measured uncertainty for nitrate is +/- 0.010 mg/L. The ALS (2016 results) MU is +/- 0.0050 mg/L.

6.3. Chelated iron (fertilizer micronutrient) treatment

Because elevated metals were present in the soils used for construction, there was an opportunity to assess whether non-invasive treatments could be used to further leach the metals and improve soil quality. A chelated iron (Fe-EDTA) product was added to the Series 2 wetland on September 17, 2015. The Fe-EDTA treatment was performed on Series 2, with Series 1 remaining untreated for comparison purposes. Increases in copper concentrations were observed in the outflow from both cells in CWTS Series 2 after the addition of Fe-EDTA. In the 10 days following the addition of Fe-EDTA, approximately 75 g of copper was removed from the wetland Series 2. This is approximately 1.25 g of copper per m^2 of wetland. Elevated flow rates were selected for CWTS start up in 2016 to flush copper leaching from soil (associated with 2015 EDTA test).

7. Hydraulic retention time tracer study

A tracer study was conducted from June 13-15, 2016 on cell 1A of the CWTS with a flow rate of 2.43 GPM (13.25 m^3/day). The purpose of the tracer study was to determine the actual hydraulic retention time, and the flow path of water through the CWTS. Salt (NaCl) was used as the tracer in this study. By adding a salt solution at the inflow of the wetland, and placing a YSI meter at the outflow of the wetland, it can be determined how long it takes for the salt to pass through the wetland by monitoring the specific conductance (SPC) in situ (as salt raises the SPC). The HRT of the CWTS can be determined through a calculation using the volume and concentration of salt solution added at the inflow of the wetland and the time over which the specific conductance remains elevated above background levels at the outflow.

The HRT tracer study used 1.87 kg of salt dissolved into 480L of water. The 480 L of water was gradually removed from the end of the CWTS, 20 liters at a time, dosed with salt, and added at the front of the CWTS. This method took 50 minutes to dose in the 480 liters of salt solution into the CWTS and was selected as it did not affect the total volume of water in the CWTS during the HRT tracer study. The volume of water and weight of salt was calculated based on the amount required to increase the specific conductance (SPC) of cell 1A to at least twice its background level (i.e., from 850 µs/cm, to 1700 µs/cm) (Oakton Instruments, 1997). The volume of water used was then selected to ensure the concentration of the salt solution was sufficiently diluted and would mix with the water of the CWTS (i.e., wasn't so dense that it would stratify and sink to the bottom of the CWTS).

In situ monitoring of the HRT tracer study was carried out from June 13, 2016 at 14:52 until June 15 at 12:12. This time period was selected because Contango was on site for 2 days to conduct the HRT tracer study and to collect data. Also the battery life of the YSI unit was approximately 2 days, and at the time, it was not feasible to implement dosing pumps and in situ monitoring (data logging) for a longer period of time. The YSI unit was placed in the wetland for approximately 20 mins prior to starting the HRT tracer study to record background levels before dosing of the salt solution into the CWTS. The background SPC prior to commencing the HRT tracer study was approximately 900 µS/cm. During the tracer study, there were two tracer breakthroughs. The first breakthrough was at 1.03 days (24.72 hours), with peak SPC at 2228 μS/cm. The second breakthrough was at 0.75 days (18 hours), with a peak SPC of 1928 μS/cm. Based on the results of the two breakthroughs in the HRT tracer study, it is possible that there are two flow paths through the wetland, however, this may also be due to how the salt solution was added to the CWTS.

In 2017 it is recommended that another 1 m^3 tank be added to the CWTS area, and another HRT tracer study be conducted. The second 1m^3 tank could provide a way to mix a lower concentration salt solution, and dose it into the CWTS over a longer period at a constant flow using a metering pump. This would allow the flow rate to be calculated for the duration of time the salt solution is dosed into the CWTS. To conduct the HRT tracer study over a longer period, the YSI unit would need to be connected to a power source due to a limited battery life. By conducting the tracer study in 2017 as described above it is anticipated that only one breakthrough would occur, providing more accurate results.

The data from the 2016 HRT tracer study suggests that the HRT of cell 1A is 0.89 days (21.36 hours), the average of the two breakthroughs. It is possible that not all the tracer salt had yet flowed through the wetland, as SPC had not yet reached original background levels, and so the average HRT may be longer slightly than the 0.89 days observed here. By comparison, the calculated HRT was 0.53 days (12.82 hours), therefore the actual HRT was approximately 40% slower than the calculated HRT. Most of this difference in calculated vs tracer study HRT is owing to the exclusion of pore water involvement in the calculated HRT (because of the soil type used, it was an unknown factor that could not be inferred from the off-site pilot-scale trials). However, part of this difference can also be attributed to loss of water through evapotranspiration (Section 9) which results in a lower flow and therefore longer HRT.

Based on the results of the HRT tracer study, the depth of cell 1A including pore water involvement was able to be calculated following Equation 1. The actual HRT of 0.89 days (21.36 hours) was used to solve Equation 1, resulting in a total depth of 0.35 meters. The measured depth of water in cell 1A was then subtracted from total depth (0.35 meters – 0.16 meters), to obtain a pore water involvement of 0.19 meters. The measured depth of cell 1A was obtained from the depth sticks that were installed in the CWTS in June 2016 (Figure 23).

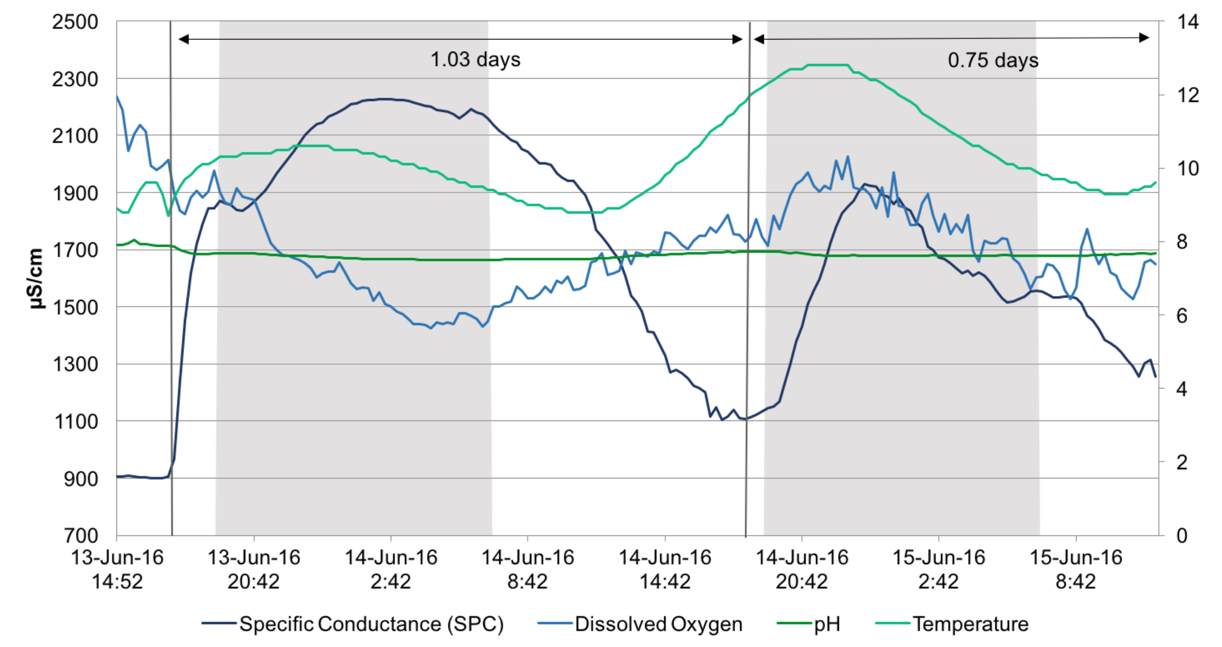


Figure 22 – Tracer study results.
SPC (µS/cm) on primary y-axis. Dissolved oxygen (mg/L), pH, and temperature (°C) on secondary y-axis. The grey shading indicated a 12-hour night period from 7am to 7 pm. The vertical black lines indicate the beginning and end of the tracer breakthrough.

$$\text{Depth} = \left({}^{Q}\!/_{length * width} \right) * \text{ HRT}$$

Equation 1 – Equation for calculation of the CWTS depth including pore water involvement.
Q is the flow rate.

8. Calculations of rate coefficients (*k*)

8.1. Rate coefficients

An important factor for CWTS design is the rate of treatment, also known as the treatment (or removal) rate coefficient (*k*). The rate coefficient is based on the treatability of a specific compound and the hydraulic retention time of the system, both of which are site-specific based on water chemistry, wetland designs, and characteristics of the system. A treatment rate coefficient (*k*) was applied for cadmium, copper, molybdenum, selenium and zinc, to develop a conceptual size for the Minto CWTSs and determine which elements and load sources were key for treatment (Table 10). Based on pilot-scale testing for the Minto CWTS, in this site-specific situation, the treatment rate coefficient (*k*) for selenium follows a zero-order reaction kinetic, while the rate coefficients for cadmium, copper, molybdenum, and zinc follow first-order kinetics.

In Equations 2-3, *Cf* is final concentration, *Ci* is initial concentration, and *HRT* is *the* hydraulic retention (Equation 4) time calculated using the CWTS depth result of the tracer study (Equation 1). The HRT was calculated using the volume of each CWTS series including the pore water involvement calculated from the results of the tracer study (Equation 1), and the flow rate from during the time period that *k* was calculated for in 2016 (from August 10 – September 17, 2016) to obtain the HRT.

Using the removal rate coefficients (*k*) in Table 10 and Equations 2-4, parameters can be rearranged to solve for those of interest, such as the volume needed, that in turn determines the area of wetland required which is dependent upon the design. Analytical results from August 10 – September 17, 2016 were chosen to calculate *k* because this is the period after the final operational adjustment were completed in 2016 (addition of organics) and flow rates were stable and at targeted values. The treatment rate coefficients applied here are intended to be a conservative estimate for conceptual sizing purposes, and will need to be refined through further demonstration-scale (on site) testing.

$$k = \frac{-\ln\left(\frac{Cf}{Ci}\right)}{\mathrm{HRT}}$$

Equation 2 – Equation for calculation of first-order removal rate coefficient.
k is the removal rate coefficient, *Cf* is the final concentration, *Ci* is the initial concentration, and HRT is the hydraulic retention time.

$$k = \frac{(Ci - Cf)}{\mathrm{HRT}}$$

Equation 3 – Equation for calculation of zero-order removal rate coefficient.
k is the removal rate coefficient, *Cf* is the final concentration, *Ci* is the initial concentration, and HRT is the hydraulic retention time.

$$HRT = {}^{V}\!/_{Q}$$

Equation 4 – Equation for calculation of hydraulic retention time.
HRT is the hydraulic retention time, V is the volume of the wetland, and Q is the flow rate.

Table 10 – Rate coefficients (k) for elements in exceedance of proposed WQO's[1].

Element[2]	Pilot k*hour^{-1}	Demonstration[6] k*hour^{-1}				Demonstration[6] k*day[1]			
		Series 1		Series 2		Series 1		Series 2	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
First order removal rate coefficients									
Cd	0.0476[4]	0.00817	0.00803	0.00610	0.00640	0.196	0.193	0.147	0.154
Cu[3]	0.0497[5]	0.00365[3]	0.00341[3]	0.00283[3]	0.00276[3]	0.0876[3]	0.0819[3]	0.0680[3]	0.0661[3]
Mo	0.0042[4]	0.00248	0.00273	0.000989	0.00117	0.0594	0.0655	0.0237	0.0280
Zn	0.0477[4]	0.00824	0.00790	0.00799	0.00752	0.198	0.190	0.192	0.181
Nitrate	0.0380[4]	N/A	0.00610	N/A	0.00149	N/A	0.147	N/A	0.0358
Zero order removal rate coefficients									
Se	7	0.0000179	0.0000160	0.0000118	0.0000103	0.000430	0.000385	0.000284	0.000246

[1] Non- degradation central tendency water quality objectives (NDCT-WQO) for the Lower Minto Creek (W2) area from the Adaptive Management Plan (Minto, 2016).

[2] All treatment rate coefficients are for first-order reaction kinetics except for selenium which is a zero-order reaction rate kinetic.

[3] Rate coefficients for copper in demonstration scale system are artificially lower than actual due to leaching of copper into water from soils, which increases outflow copper concentrations and affects the k calculation (Section 6.2.2).

[4] Values calculated from data in Table 8 of the pilot-scale report (Contango, November 2014).

[5] Value retrieved from Table 10 of the pilot-scale report (Contango, November 2014).

[6] Analytical results from August 10 – September 17, 2016 were used to calculate k.

9. Evapotranspiration study

An evapotranspiration study was conducted in a controlled greenhouse at Contango in April 2016 using the same general summer temperatures and vegetation types as the Minto CWTS. Total evapotranspiration from the system is the combined effects of open water evaporation and plant transpiration (Beebe *et al*, 2014). The purpose of calculating the evapotranspiration of a system is to understand the amount of water lost, which in turn concentrates elements and should be considered in the context of the difference of decrease in outflow concentration (or not) and outflow load reduction. The findings of the controlled environment (off site) evapotranspiration study suggested that on average 15.53 $L/m^2/day$ would be lost from a CWTS design such as that at Minto through evapotranspiration. This would result in an equivalent concentration of elements (the actual percentage concentration being dependent on the amount of water in the system).

An evapotranspiration study was then performed on site July 18-25, 2016. The flow to the CWTS was shut off on July 18, 2016 and depth measuring sticks were installed at each end of the wetland to record the amount the water level decreases due to evapotranspiration (Figure 23). However, this time period experienced rain, and also the Minto weather station was not functional at this time, and therefore the evapotranspiration rates of the on-site wetland could not be determined and it is recommended this study should be repeated in 2017.

Applying the findings of the off-site evapotranspiration study to the demonstration-scale CWTS, series 1 could lose 1,085 L/day and series 2 could lose 903 L/day in dry periods. Using the 3 different HRT under which the demonstration-scale CWTS was operated in 2016, evapotranspiration loss could result in a concentration of elements in the outflow water from 3 – 31 % (Table 11), meaning the actual load removed is this much greater than would be appreciated by looking at the concentrations alone. An on-site evaporation trial in 2017 can determine if these findings are accurate for the Minto CWTS. Evapotranspiration must be accounted for in sizing of a full-scale wetland.

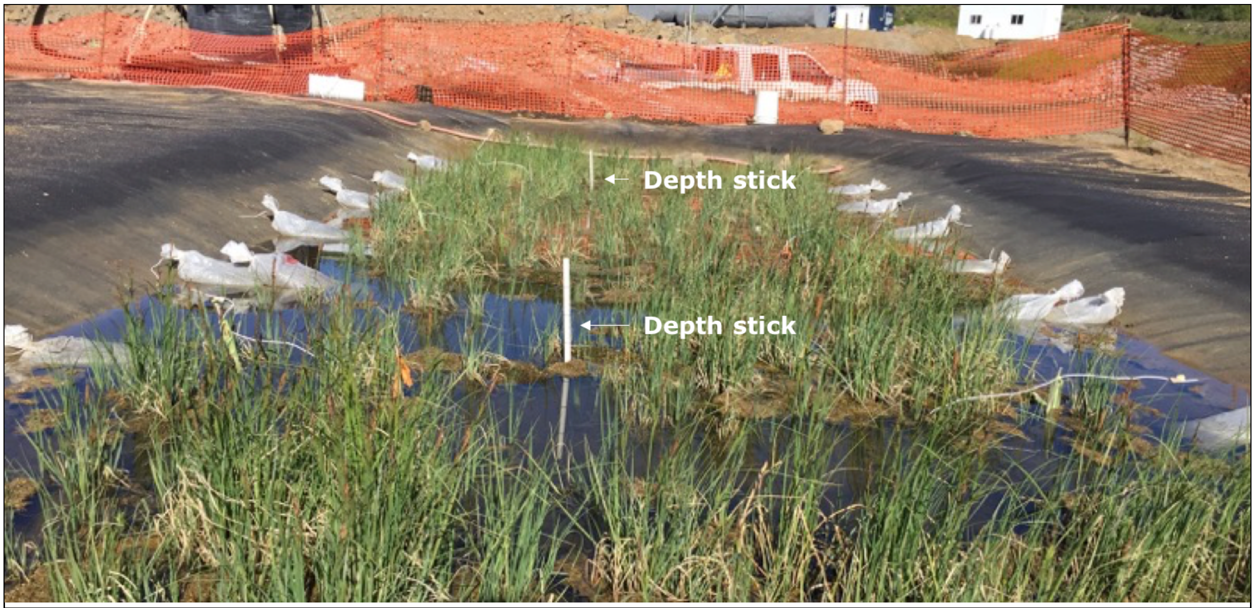


Figure 23 – Depth sticks installed in CWTS to record evapotranspiration.

Table 11 – Potential loss of water through evapotranspiration in the CWTS .

HRT (days)	L/day through series		L/day lost		% Lost /day
	Series 1	Series 2	Series 1	Series 2	
0.3	34,998	28,638	1,085	904	3
1	10,510	8,600			10
3	3,503	2,867			31

10.Vegetation

10.1. Health and establishment

10.1.1. Carex aquatilis

During the commissioning period, plants establish and mature, with density expected to increase over time. When counted at the first site visit in June 2015, >95% of the plants were found to have survived their first winter. This survival rate is impressive considering the late fall planting of August 28, 2014 and suggests the *C. aquatilis* are very robust and reaffirms they are a good candidate for use in the full-scale CWTS at Minto. Additionally, there was a greater than 20% increase in total stems in the short growing season up to June 2015 (as counted by new shoots/runners). By the second site visit in August 2015, the plants were too dense to count stems, and therefore the survival and establishment was considered a success and no longer monitored by counting (Figure 26). By the second site visit in 2016 (July) the CWTS cells hosted a dense monoculture of *C. aquatilis* that continued to thrive until the end of operations in 2016.

Pilot-scale testing suggested that *C. aquatilis* would increase more quickly the number of stems once the maximum plant height was achieved, and that maximum plant height is dependent upon water depth (with deeper water resulting in taller plants). This was also seen in the demonstration-scale wetland on site, with the density of plants filling in greatly through July and August 2015 and throughout 2016 (Figure 26).

Of note, it was observed that during the last site visit of the year by Contango (September 17-18th, 2015), the *C. aquatilis* in the demonstration-scale CWTS were still predominantly green, while other plants in the area had turned brown. This suggests that the CWTSs may have a longer range of activity than natural systems in the area, possibly due to liners and separation from colder ground water.

10.1.1.1. Aphids

Aphids were observed in all CWTS cells in July 2016 (Figure 28), and had originally been noticed in cell 2A in August 2015. Aphids occur naturally in the area and have been observed during site visits and background sampling in the Yukon and Northwest Territories on *Carex* and *Typha*. The effects of aphids on a CWTS are not expected to be pronounced unless it has a large buffer zone between it and other insect habitat (e.g., forest, prairie, etc), which prevents predator insects from also colonizing and keeping the aphids at a lower population density. At Minto, there is a large buffer area (MVFE) around the demonstration-scale CWTS, and as such, the aphids may colonize more robustly than anticipated in the full-scale CWTS at site, which would not have the same buffer zone. The aphids will continue to be watched in 2017, and other background areas (e.g., W10 and W15) compared to see if increases in aphid populations are specific to the CWTS, or general in the area.

10.1.2. Moss

Despite several mosses drying out during the winter of 2015 after planting, there was 100% survival and establishment. However, their growth was much slower than the sedge and therefore they were supplemented with additional aquatic moss (harvested from the same W10 area as the original plants for the CWTS) in June and August 2015 to augment their general abundance and bring the CWTS through commissioning more quickly (Figure 24). Mosses continued to mature and expand in size through 2016. The mature mosses are beginning to show characteristics of the desired coupled transfer (sorption, filtration) and transformation (mineralization, reduction) processes, with the top of the moss growing and producing new biomass (i.e., is green new growth; transfer sites), and the older bottom of the moss turning black (i.e., beginning to decompose producing sulphidic reducing zones; transformation reactions) (Figure 24).

10.2. Metals uptake

Concentrations of various elements in *C. aquatilis* and moss from the demonstration-scale systems were compared to those from pilot-scale testing. It is expected that the concentrations would be higher in the demonstration-scale system as the CWTS is not yet fully functional (i.e., elements are in greater bioavailability when in dissolved form) and also due to the composition of the soils used for construction.

C. aquatilis and moss in the demonstration-scale system had higher copper concentrations than the pilot systems. However, concentration of copper in the *C. aquatilis* at the end of 2015 was not significantly different than that of the plants borrowed from the W10 area for planting of the systems in 2014. Concentration of copper in the *C. aquatilis* in series 1 at the end of 2016 were comparable to the 2015 concentrations, however the concentration of copper in series 2 was higher (Figure 30). This is possibly due to the increased soluble (i.e., bioavailable) copper in series 2 after the addition of Fe-EDTA in September 2015. The moss had higher copper concentrations compared to the initial moss sample in all cells in 2015, and increased to nearly double the 2015 values by the end of 2016 (Figure 30). Mosses remove metals from water through sorption, which is different than the plant uptake that occurs in macrophytes such as *Carex* (and therefore, expected to release copper when exposed to EDTA, rather than have an increased uptake). Additionally, because the mosses were being added through 2015 (from the W10 source), it is expected that mosses would have lower metals concentrations (of any element) in 2015 compared to 2016 as they were not exposed to the CWTS water chemistry for the full year. It should be noted that over time, the mosses convert the sorbed elements to reduced minerals, rendering them lower bioavailability (Section 10.1.2.). As mosses are not a significant food source for any fauna, this is a safe mechanism to transfer elements from water eventually into stable mineral forms in the wetland soils and substrate.

Cadmium concentrations were either below or close to the detection limit in *Carex* in 2015 and 2016 (Figure 29). Additionally, cadmium concentrations in moss and selenium concentrations in both plant types tested were lower in the demonstration-scale (2015 and

2016) compared to pilot-scale. This result was presumably due to lower concentrations of both cadmium and selenium in the water of the demonstration-scale system than pilot scale. In 2016 molybdenum concentrations in *Carex* tissue were higher than the pilot-scale system, but lower than the 2015 CWTS concentrations. In 2016 zinc concentrations in *Carex* tissue has increased compared to the pilot-scale system and the 2015 demonstration-scale system concentrations. This could be attributed to the increase in zinc in the feed water in 2016 (Figure 20). Additionally, in 2016 molybdenum, selenium, and zinc concentrations in moss increased compared to the 2015 concentrations, which suggests that as mosses are continuing to grow and fill in the wetland. Selenium treatment performance is increasing as mosses are a source of sorption, and also harbor a high abundance of selenate-reducing microorganisms (see Section 10.3.2).

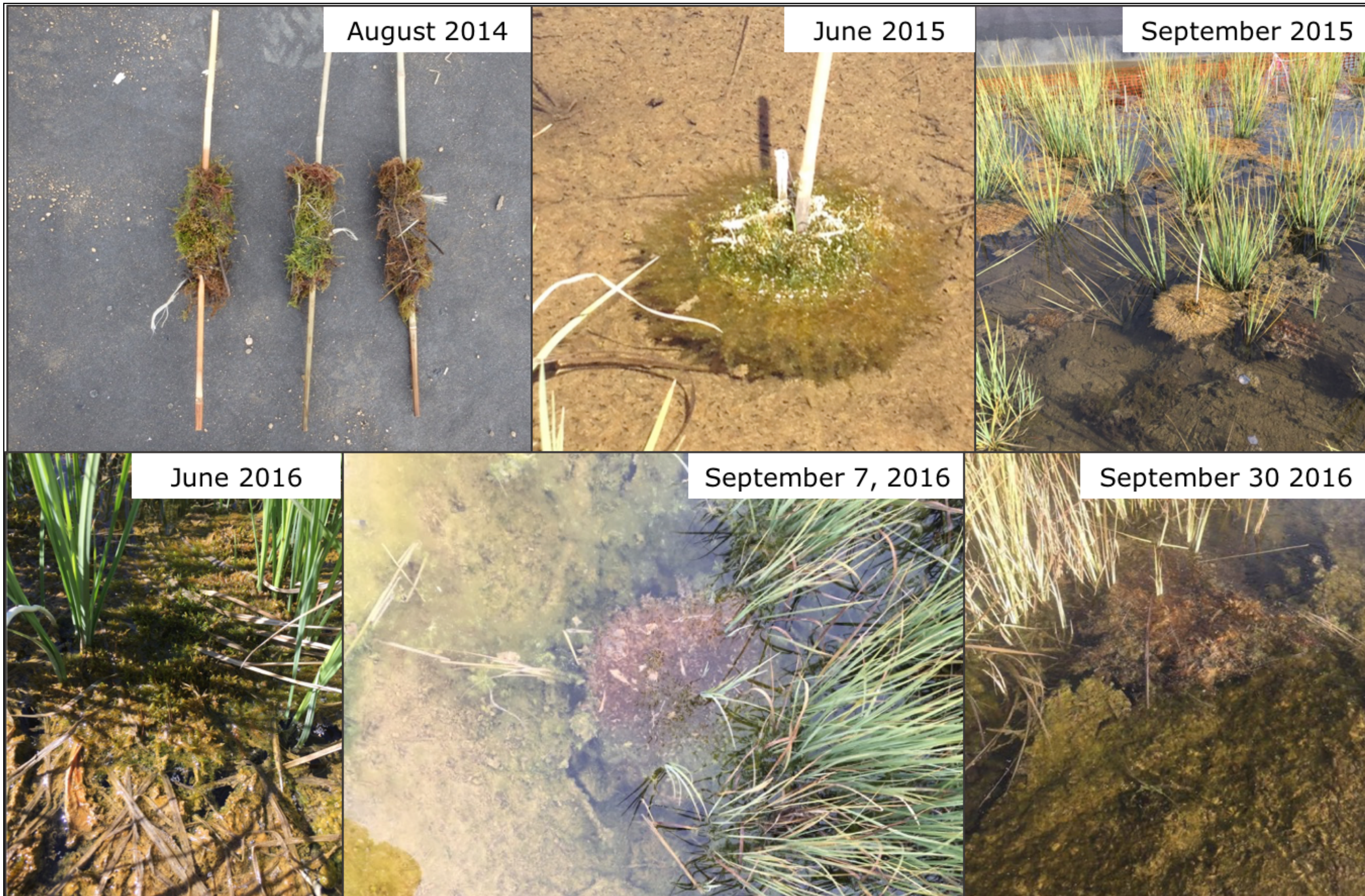


Figure 24 – Moss maturation in CWTS.

Figure 25 – Moss top, bottom, and side view June 2016.

Figure 26 – Maturation of the CWTS from construction to year-end 2016.
Top left picture is of cell 1A, top right picture is of cell 2B, bottom left picture is of cell 1B, and the bottom right picture is of cells 2A and 2B. Continued next page

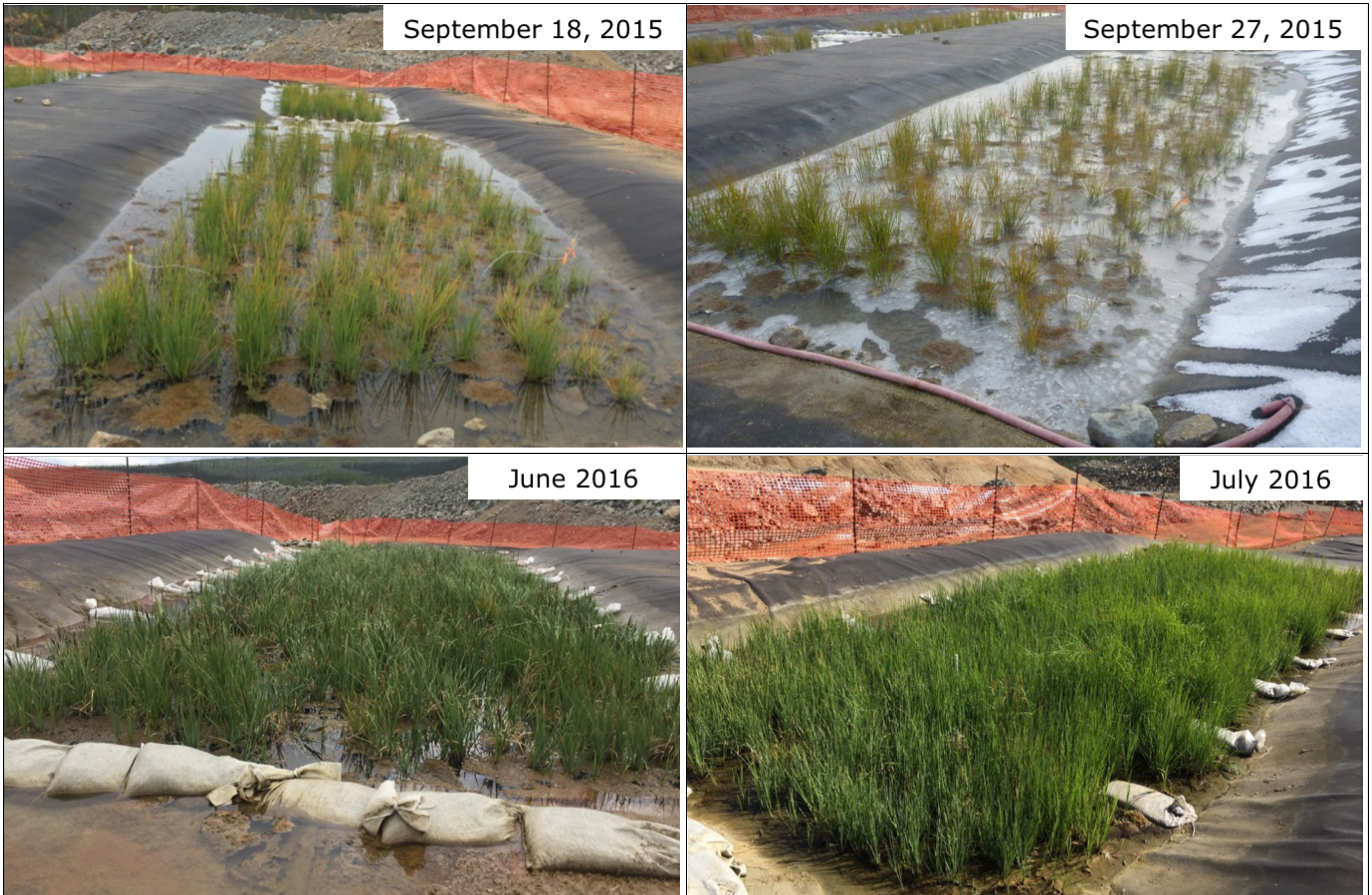


Figure 26 – Continued.
Top pictures are of cell 2A, and bottom picutes are of cell 1B.

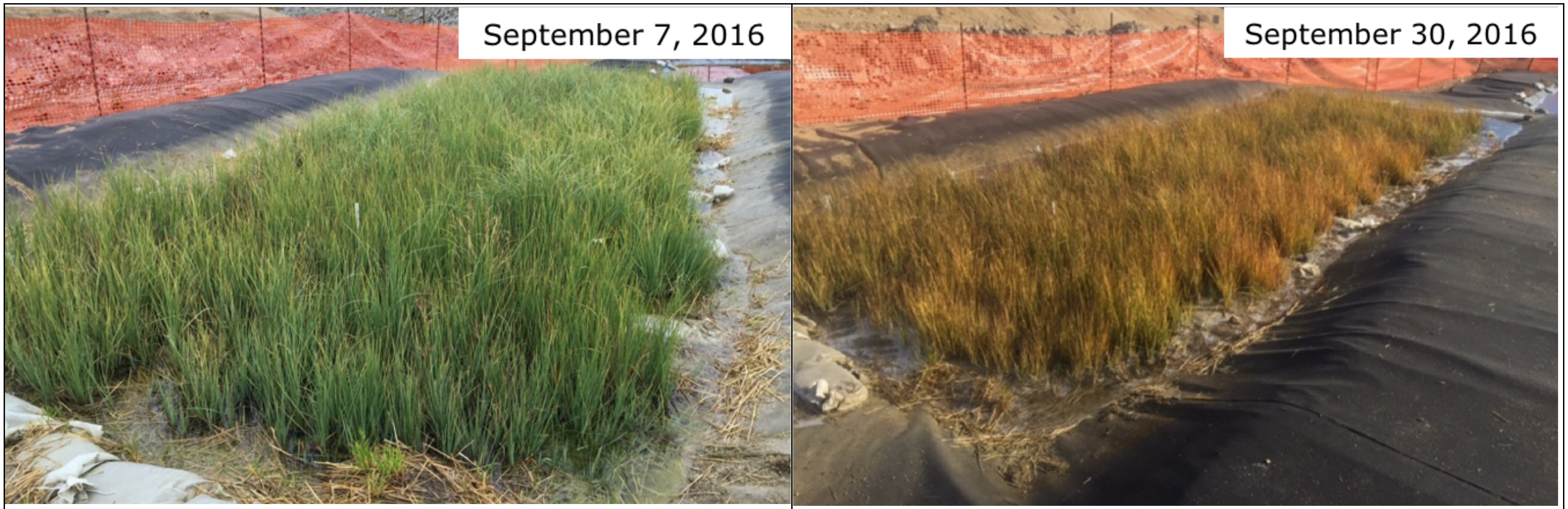


Figure 26 – Continued.
Pictures are of cell 1B.

Figure 27 – Aphids observed in cell 1A and 2A.
Left picture is of cell 1A. Right picture is of cell 2A. Note the increased yellowing in cell 2A due to a denser aphid population.

Figure 28 – Aphids observed on Carex (September 8, 2016).
The top picture is of cell 2A, the bottom picture is of cell 1B. Note cell 2A has more yellowing due to larger aphid population.

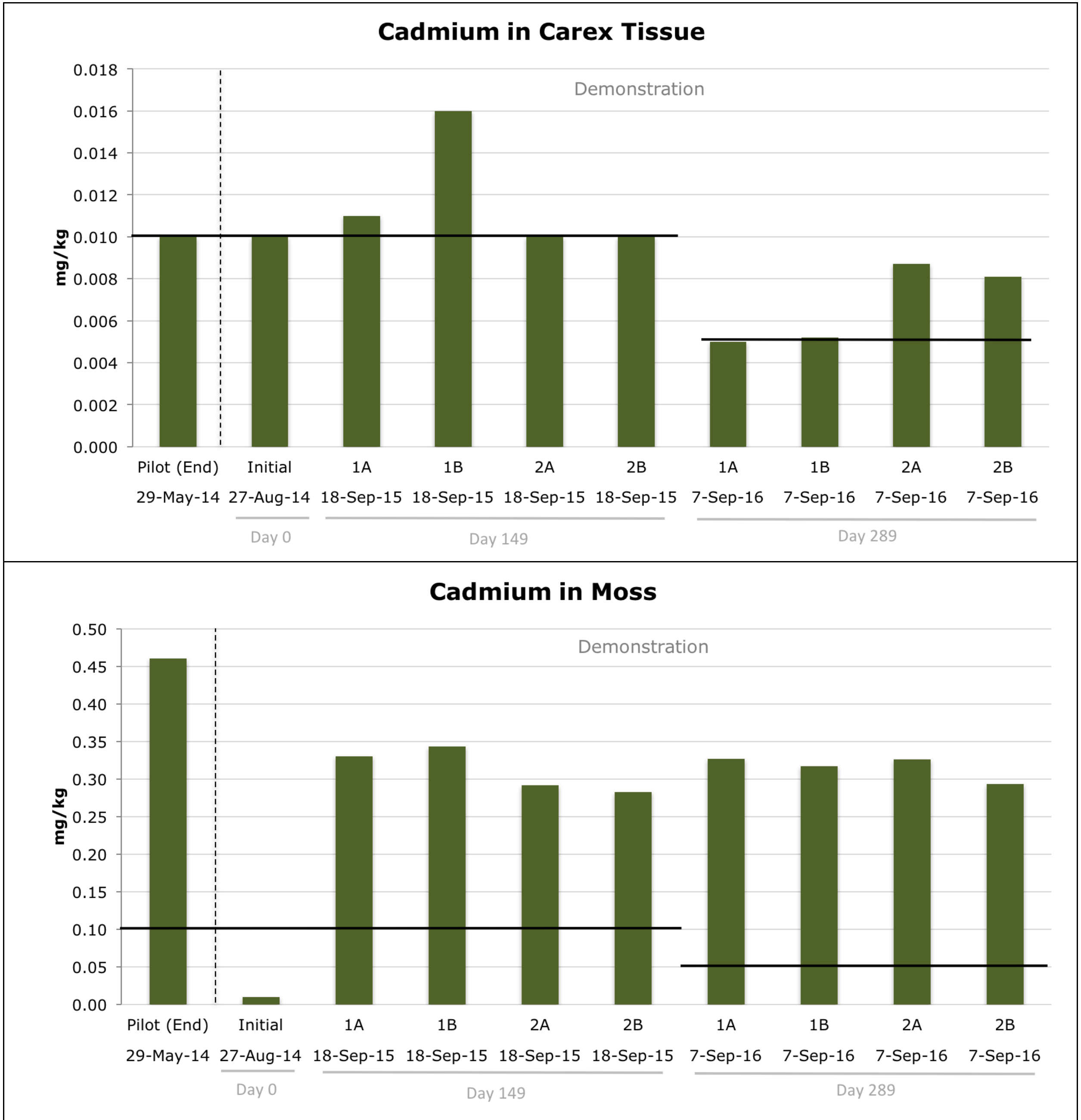
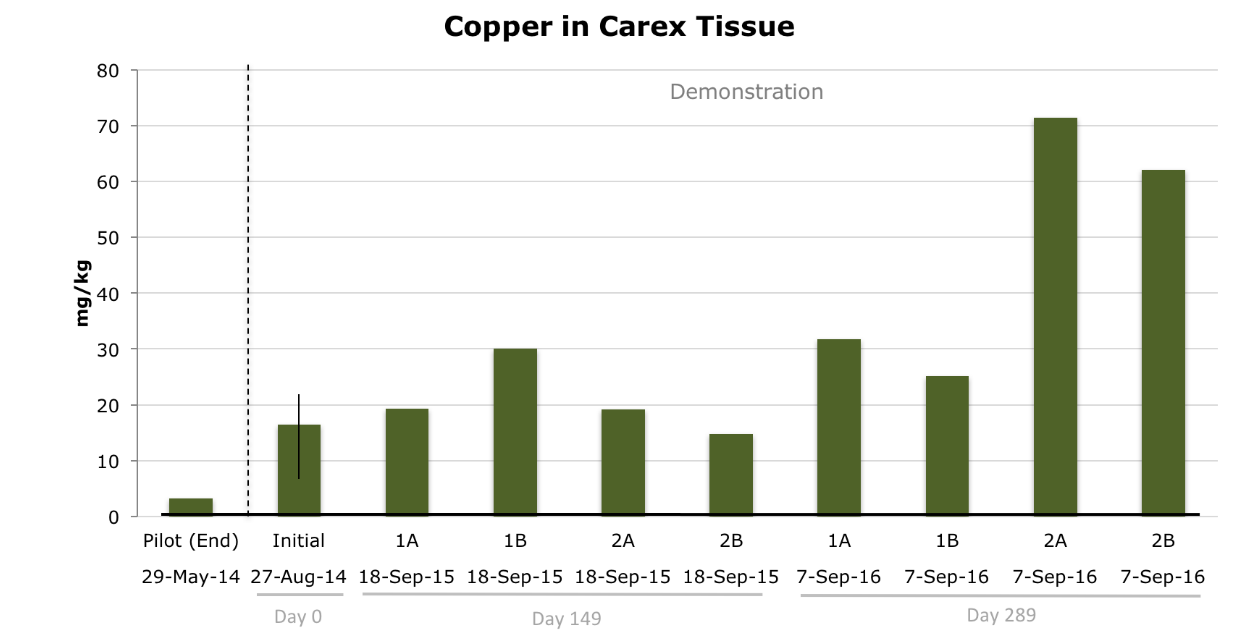


Figure 29 – Cadmium concentrations in plant tissue.
The 2014 and 2015 DL for Cadmium is 0.10 mg/kg. The initial data set is the average value of CWTS 1A-2B. The error bars indicate the minimum and maximum values in that data set.



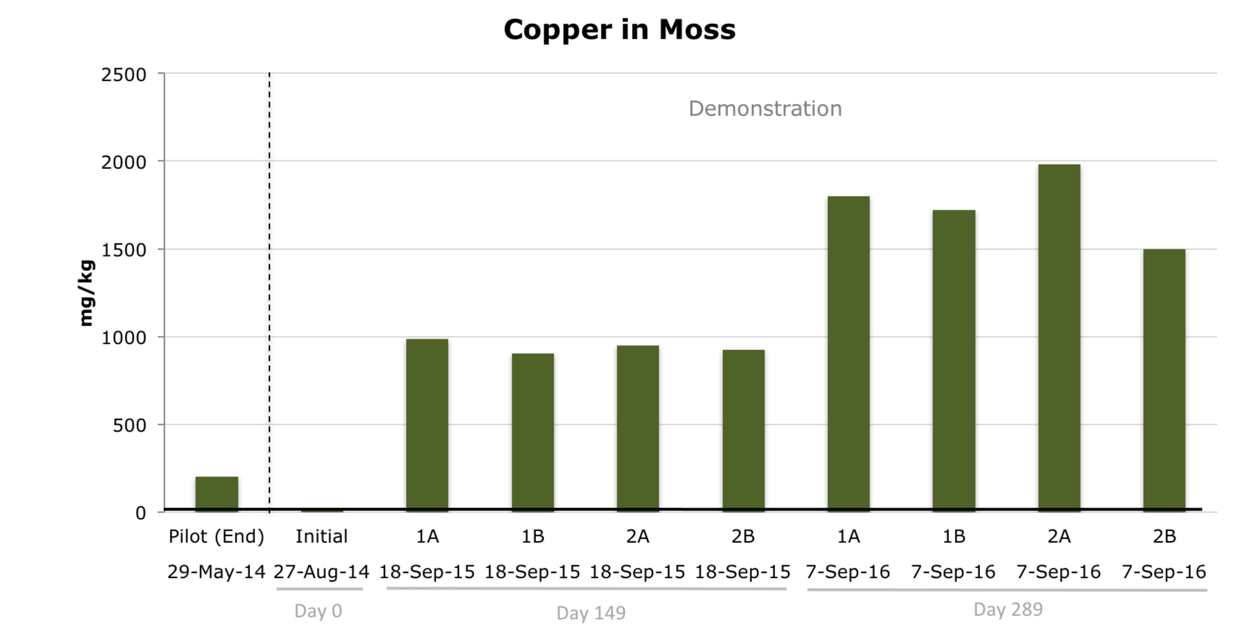
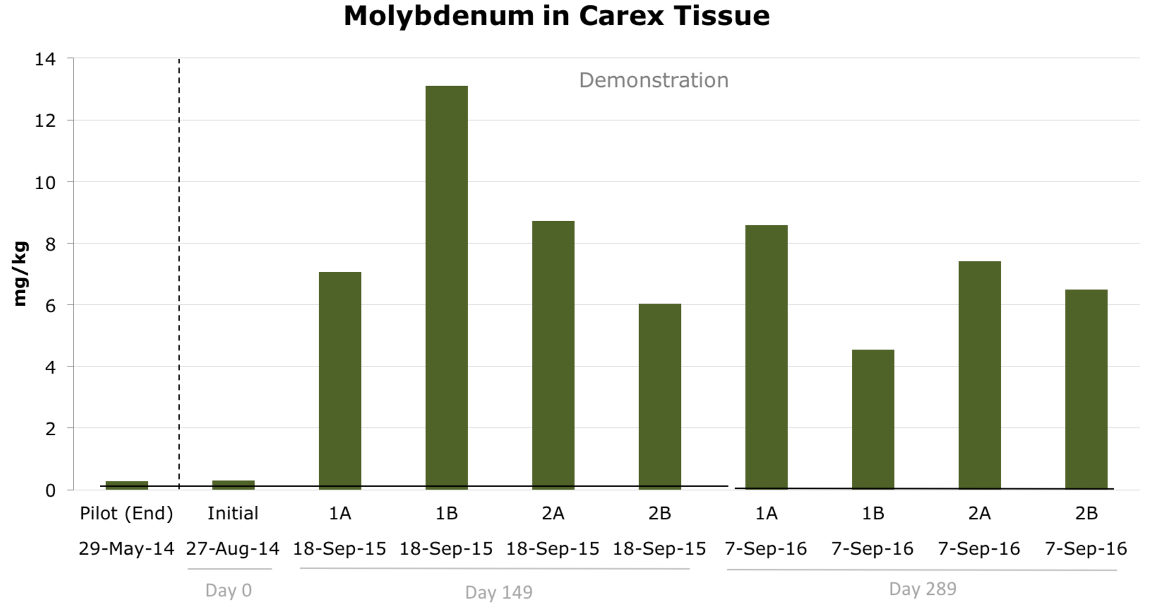


Figure 30 – Copper concentrations in plant tissue.
The 2014 DL for Copper is 0.5 mg/kg, the 2015 DL is 0.1 mg/kg, and the 2016 DL is 0.05 mg/kg. The initial data set is the average value of CWTS 1A-2B. The error bars indicate the minimum and maximum values in that data set.



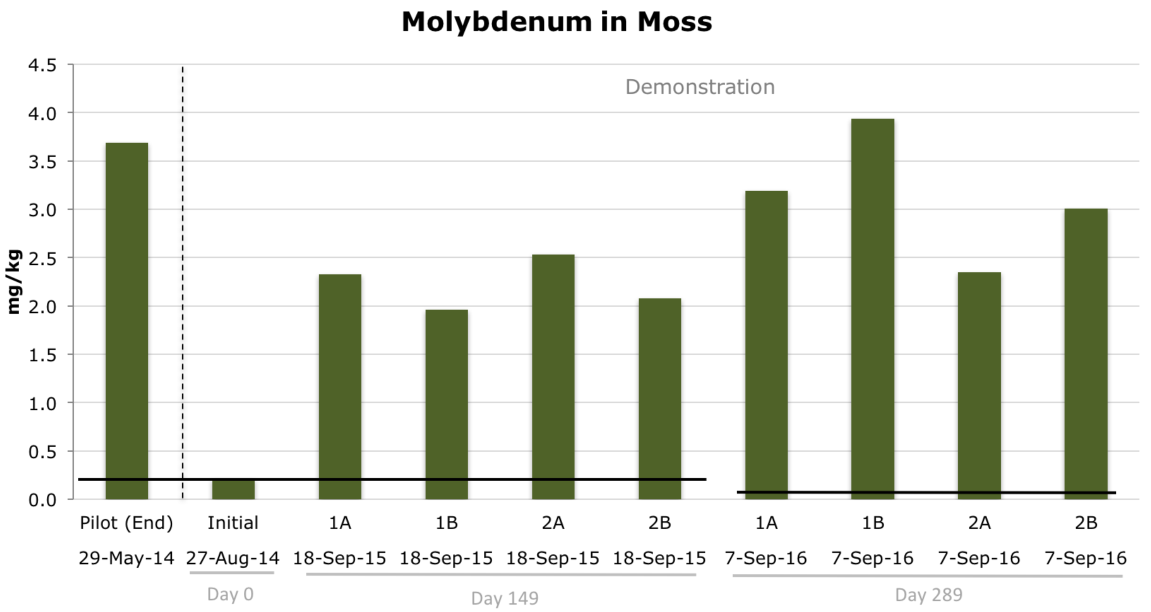
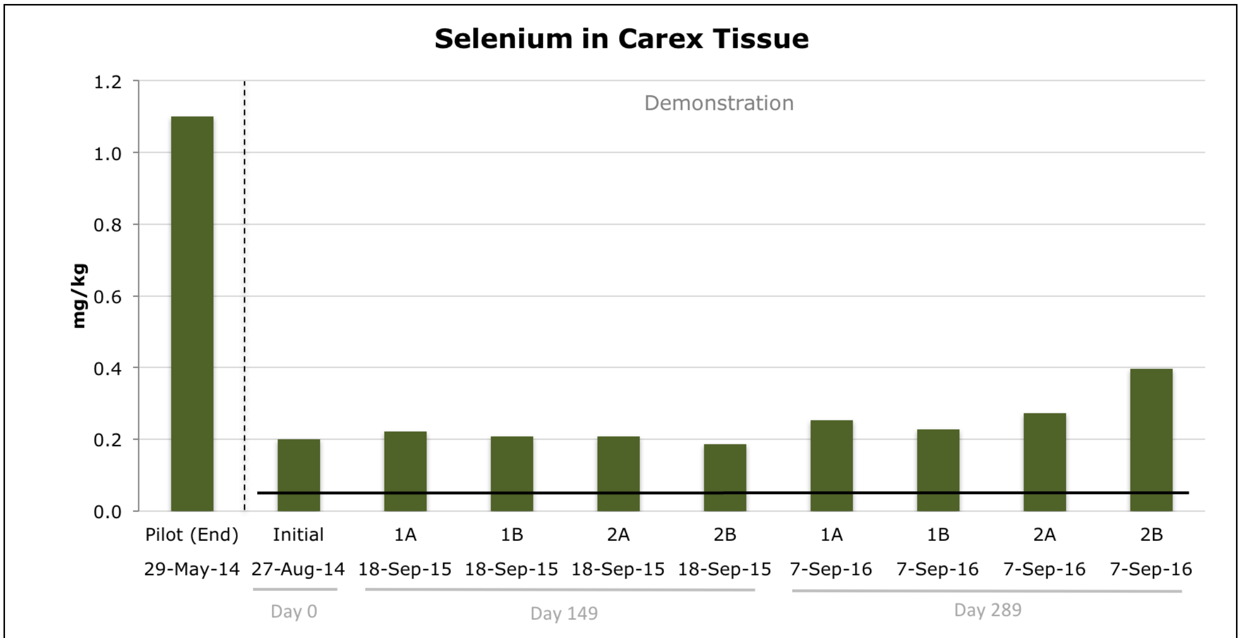


Figure 31 – Molybdenum concentrations in plant tissue.
The 2014 and 2015 DL for Molybdenum is 0.05 mg/kg, the 2016 DL is 0.020 mg/kg. The initial data set is the average value of CWTS 1A-2B. The error bars indicate the minimum and maximum values in that data set.



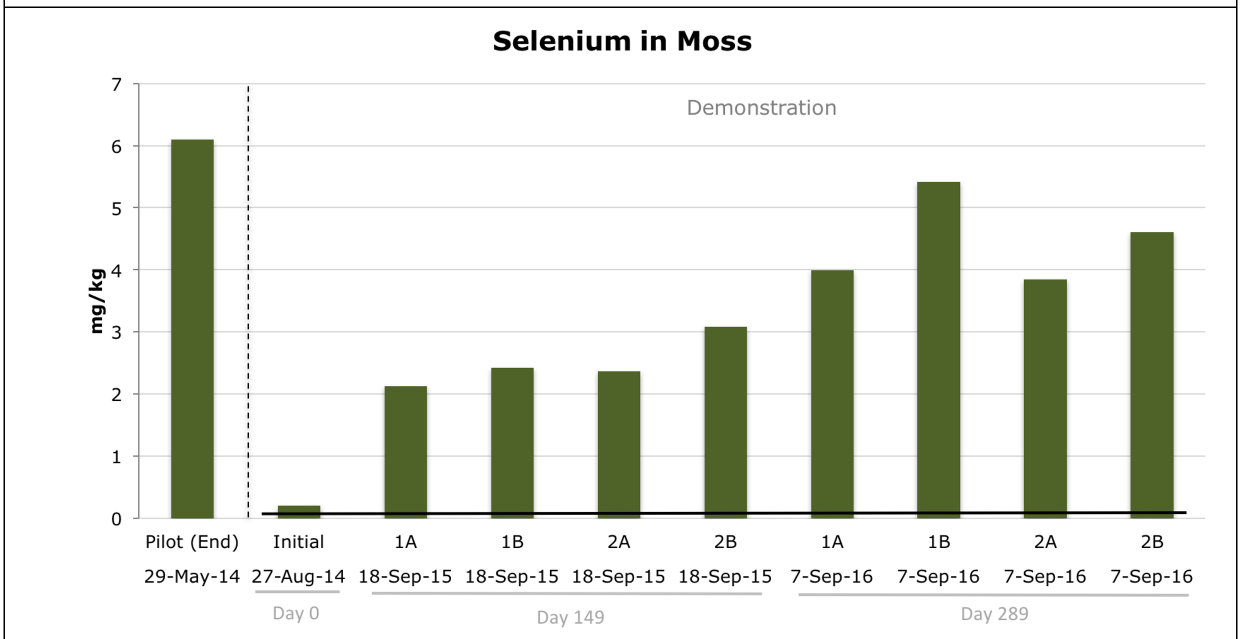


Figure 32 – Selenium concentrations in plant tissue.
The method detection limit for Selenium is 0.2 mg/kg. Initial data set is the average value of replacates used for planting of all CWTS cells. Error bars indicate the minimum and maximum values in that data set.

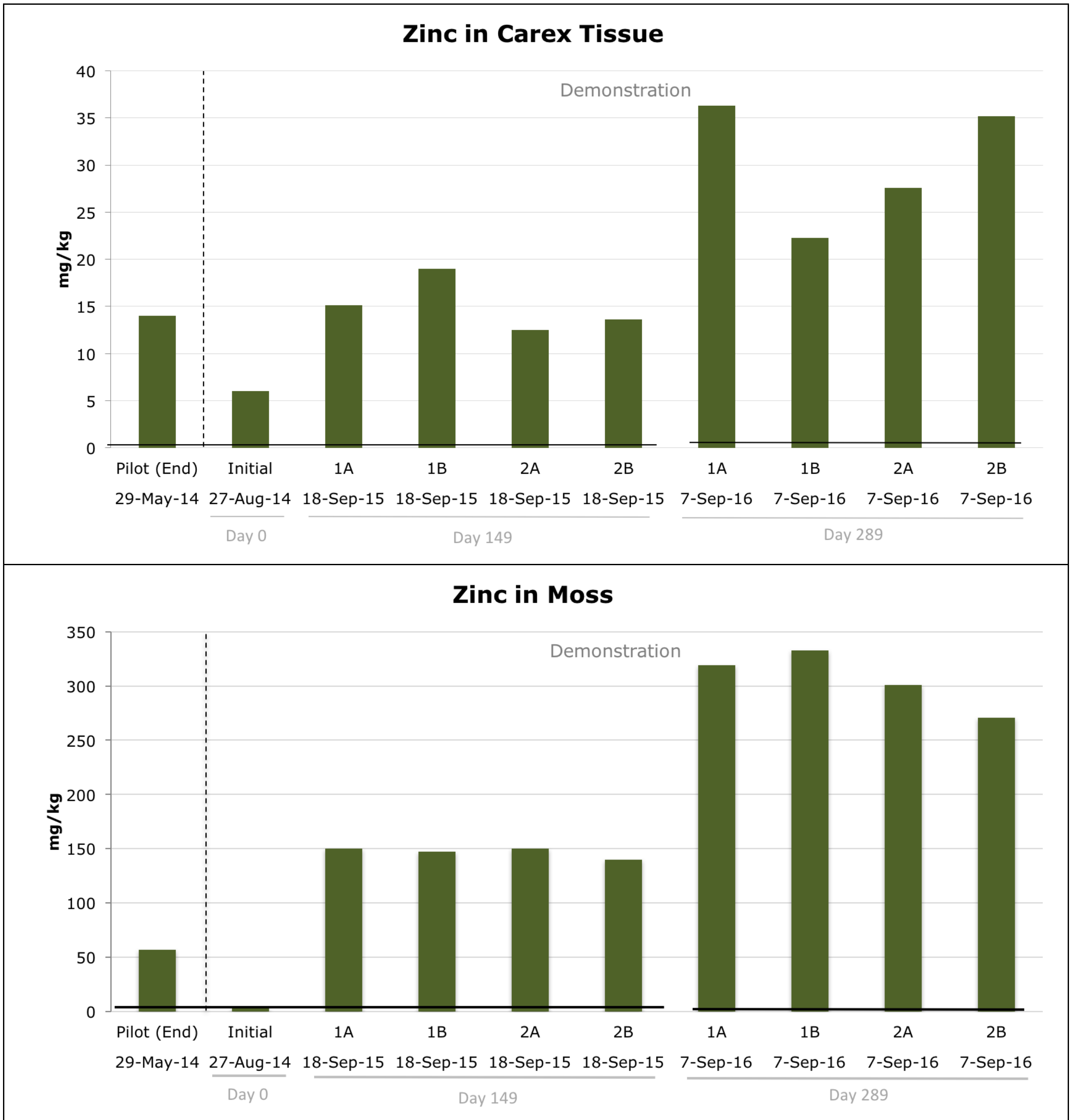


Figure 33 – Zinc concentrations in plant tissue.
The 2014 DL for Zinc is 2.0 mg/kg, the 2015 DL is 0.002 mg/kg, and the 2016 DL is 0.5 mg/kg. The initial data set is the average value of CWTS 1A-2B. The error bars indicate the minimum and maximum values in that data set.

10.3. Beneficial microbes

Microbes are the driving force of many treatment pathways that are targeted in CWTSs. The beneficial microbes in these systems catalyze biogeochemical cycles for remediation of specific constituents of concern. Careful design of CWTSs can create the environmental conditions needed to enhance the abundance and metabolic activity of these beneficial microbes. Accordingly, complimentary methods of genetic and growth-based testing were used to characterize the microbial populations associated with a range of microbial habitats in the demonstration-scale CWTS (e.g., soils, sediment, biofilms, aquatic mosses, and plant roots).

In the context of the Minto Mine CWTS, beneficial microbes include those that are involved in the reduction of selenium (selenate and selenite), nitrate, and sulphur compounds (which in turn can treat copper, cadmium, molybdenum, and zinc). Information on each of these mechanisms and the associated microbial populations in the demonstration-scale system is outlined in the following sections.

10.3.1. Sulphide-producing bacteria

Treatment is achieved by targeting the lithic biogeochemical sequestration of divalent metals through sulfide (i.e., S^{2-}, HS^{-}) precipitation as mineralized species (e.g., chalcocite [CuS], covellite [Cu_2S]). These sulfide bound species are relatively insoluble (CuS; $K_{sp}=10^{-16}$; Stumm and Morgan 1996), and are transferred from the water column into the CWTS soil as non-bioavailable fractions (Murray-Gulde et al., 2003; Huddleston et al., 2008). Moreover, similar reactions occur with cadmium and zinc, rending them non-bioavailable. As such, sulphide production is a key biogeochemical treatment mechanism for water treatment at Minto Mine. Sulphides can be created by beneficial microorganisms through the reduction of sulphur-containing compounds, such as sulphate, sulphite, thiosulphate, and elemental sulphur.

Based on the information gathered in pilot-scale testing, the targeted soil redox for the demonstration-scale CWTS is between -100 and -250 mV. This is in agreement with literature that indicates anaerobic conditions with relatively low ORP (-250 to -100 mV) are necessary for promoting anaerobic metabolisms in bacteria which oxidize organic matter, producing electrons which reduce sulfate to hydrogen sulfide (H_2S) and other reduced sulfide species (i.e. bisulfide ion (HS^{-}), sulfide ion [S^{2-}]; Mitsch and Gosselink 2007). In these redox ranges, bacterial sulphide-production through reduction of sulphur compounds is expected, alongside increases in the proportion (percentage) and abundance of these microbes.

As expected, the proportion of sulphide-producing bacteria increased as the soil redox decreased in the demonstration-scale system through commissioning (Figure 34). The *C. aquatilis* roots were found to harbor high proportions of beneficial sulphide-producing bacteria (SPB), as well as a diversity of SPB (Table 12) which were different types than those found in the soil (Figure 34). This is good as it increases the diversity of bacteria in the CWTS that can carry out the beneficial reaction under a wider range of conditions than a small diversity of organisms could. Mosses, algae, and biofilms were typically associated with low proportions of sulphide-producing bacteria (data not shown), as would be expected in these photosynthetic and oxidizing environments.

Table 12 – Average number of different types of sulphide-producing bacteria in different sample types.

Sample Type	Before organics (all cells)	A cells post organic	B cells post organic
algae/biofilm	2	NT	NT
detritus	NT	6	8
moss	5	4	5
root	9	8	15
soil	7	11	15

NT – not tested. Post organic addition are samples collected in September 2016. The number of different types is based on counting the number of operational taxonomic units (clustered at 97% identity) that are classified as known sulphide-producing bacteria.

In addition to assessing the proportion of the community that are SPB, the inferred abundance of SPB was analyzed for all sample types (Figure 35). Soil and root samples were found to have the highest inferred abundances of sulphide-producing bacteria per gram of sample, while mosses typically had lower abundances. The black bottom part of the moss had ~100x more sulphide-producing bacteria per gram than the top part of the moss collected from the same location (Figure 24). This is desired as the mature mosses begin to show characteristics of the desired coupled transfer and transformation processes (with new biomass, and decomposition of older bottom; Section 10.1.2).

The overall abundance of sulphide-producing bacteria in the B cells have also increased in the soil and *C. aquatilis* root samples of the CWTSs over time, particularly in series 1 after the addition of organics (Figure 35). There was also an increase in the average number of different types of sulphide-producing bacteria in samples after the addition of organics (Table 12, Figure 34). The addition of organics was done to provide carbon sources needed by sulphide-producing bacteria and to provide the desired sulphur- and selenium-reducing conditions. It is anticipated the addition of organics will continue to provide the necessary carbon source to stimulate desired reducing conditions and microbial populations in 2017, and until the vegetation has established sufficiently to provide this carbon source annually going forward.

The microbial analysis of various sample types in the CWTS has therefore confirmed that the commissioning period is proceeding as expected, with beneficial sulphide-producing bacterial populations establishing in the soils alongside reducing conditions, which will continue to be monitored for stability or further improvement in 2017.

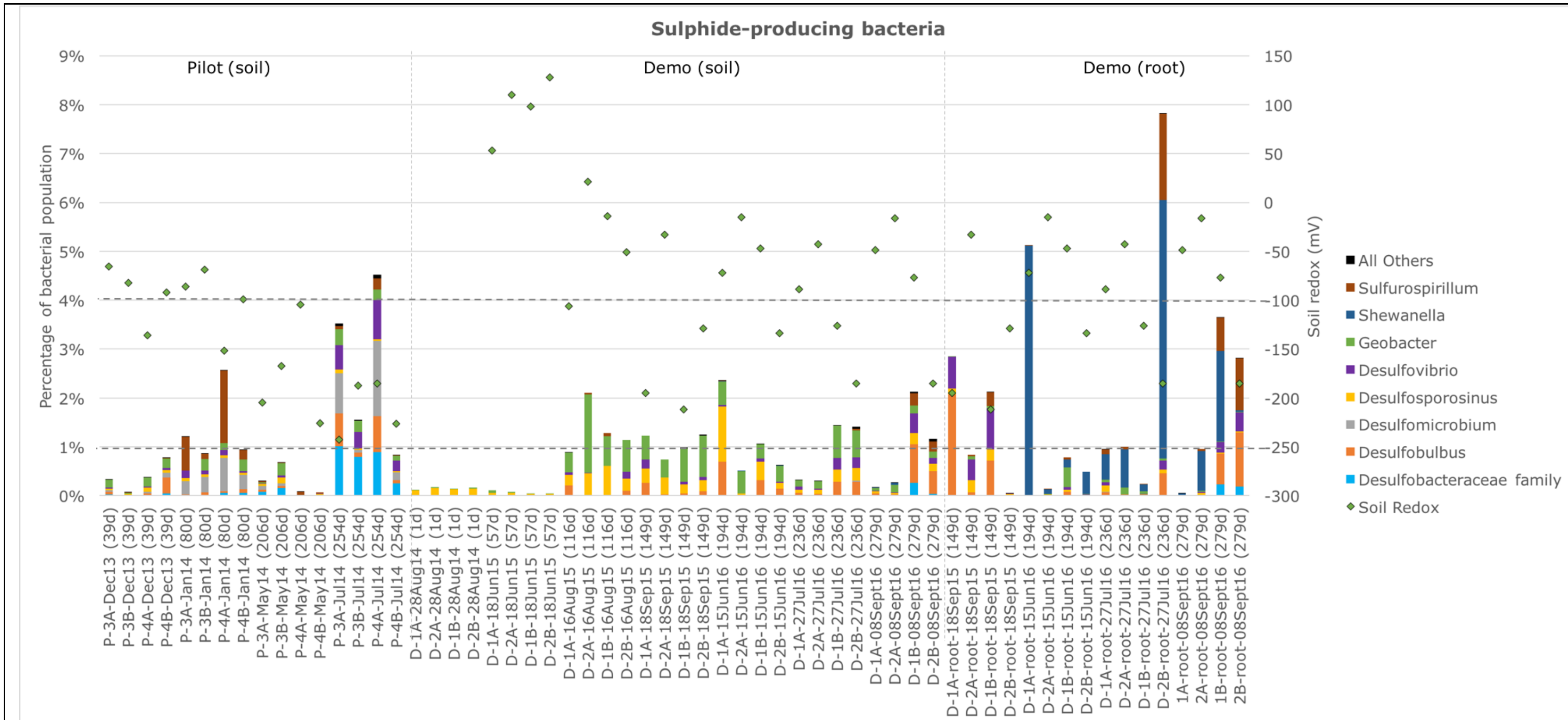


Figure 34 – Percentage and identity of sulphide-producing bacteria in soil of the pilot-scale and demonstration-scale CWTSs.

The vertical dashed lines separate the pilot-scale system data from the demonstration-scale system 1 and system 2 data. The horizontal dashed lines indicate the targeted soil redox range. Organism classifications and data analysis methods have been updated from Contango (March 2016).

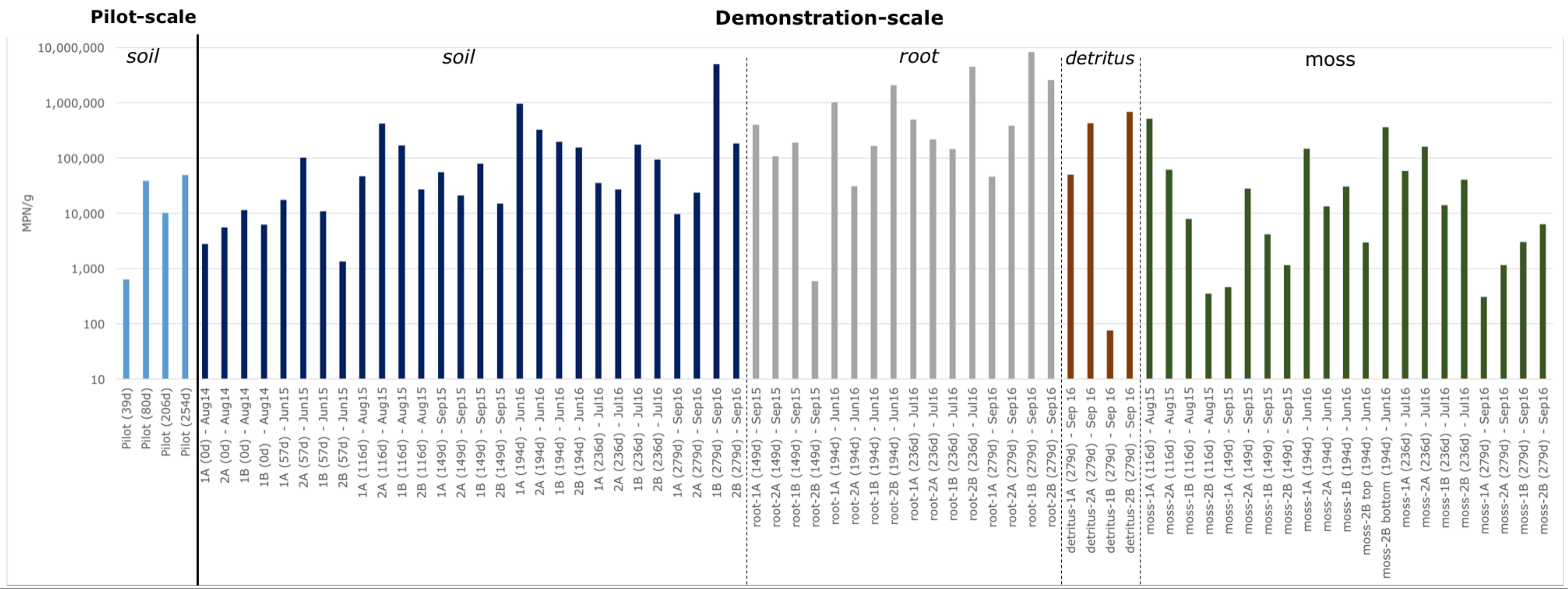


Figure 35 – Inferred abundance of sulphide-producing bacteria in soil of the pilot- and demonstration-scale CWTSs.

Inferred abundance is calculated based on a combination of genetic and growth-based data.

Shallow soil (0-5 cm); deep soil (10-20 cm); soil at 0d was that used for construction of wetland.

10.3.2. Selenium-reducing bacteria

The targeted selenium treatment pathways in the Minto CWTS include sorption to moss and soils, and subsequent microbial reduction of soluble (sorbed) selenate (Se(VI)) and selenite (Se(IV)) to insoluble elemental selenium (Se(0)). This reductive process can also be achieved directly in the water column, but is more effective associated with mosses and biofilms due to their sorptive properties that bring the selenium in contact with beneficial selenium-reducing bacteria. This is achieved within the range of soil redox conditions targeted for sulphate-reduction as suggested by pilot-scale testing and literature (see Section 5).

Selenite-reducing organisms are ubiquitous in nature and as expected, were detected in all sample types, including algae, biofilm, moss, soil, sediment, roots, and detritus. Although organisms that reduce selenate to elemental selenium (rather than intermediary selenium compounds) are generally less abundant in the environment, they were found associated with all sample types, indicating that the conditions conducive to their proliferation have been created within the CWTS. Moreover, the abundance of selenite- and selenate-reducing organisms increased over time in the demonstration-scale system during the commissioning period (Figure 36). Aquatic mosses were found to initially host the highest abundances of both selenate- and selenite- reducing organisms, affirming the importance of the inclusion of moss in the CWTS. Over time, as the vegetation has established, selenium-reducing bacteria have increased in abundance on the roots of *C. aquatilis,* and were also found associated with the added organic material once it began decomposing (Figure 36

These findings indicate the demonstration-scale CWTS has established beneficial selenium-reducing microbes in several areas of the wetland, which would be involved in selenium removal in the CWTS (either by reducing selenium that has been sorbed to moss or detritus, or by interacting directly with selenium in water that has been drawn into the root zone by plants). Their abundance is similar to what was found during pilot-scale testing in the soil, indicating they have established as expected. Selenium-reducing microorganisms will continue to be monitored in 2017, alongside performance testing.

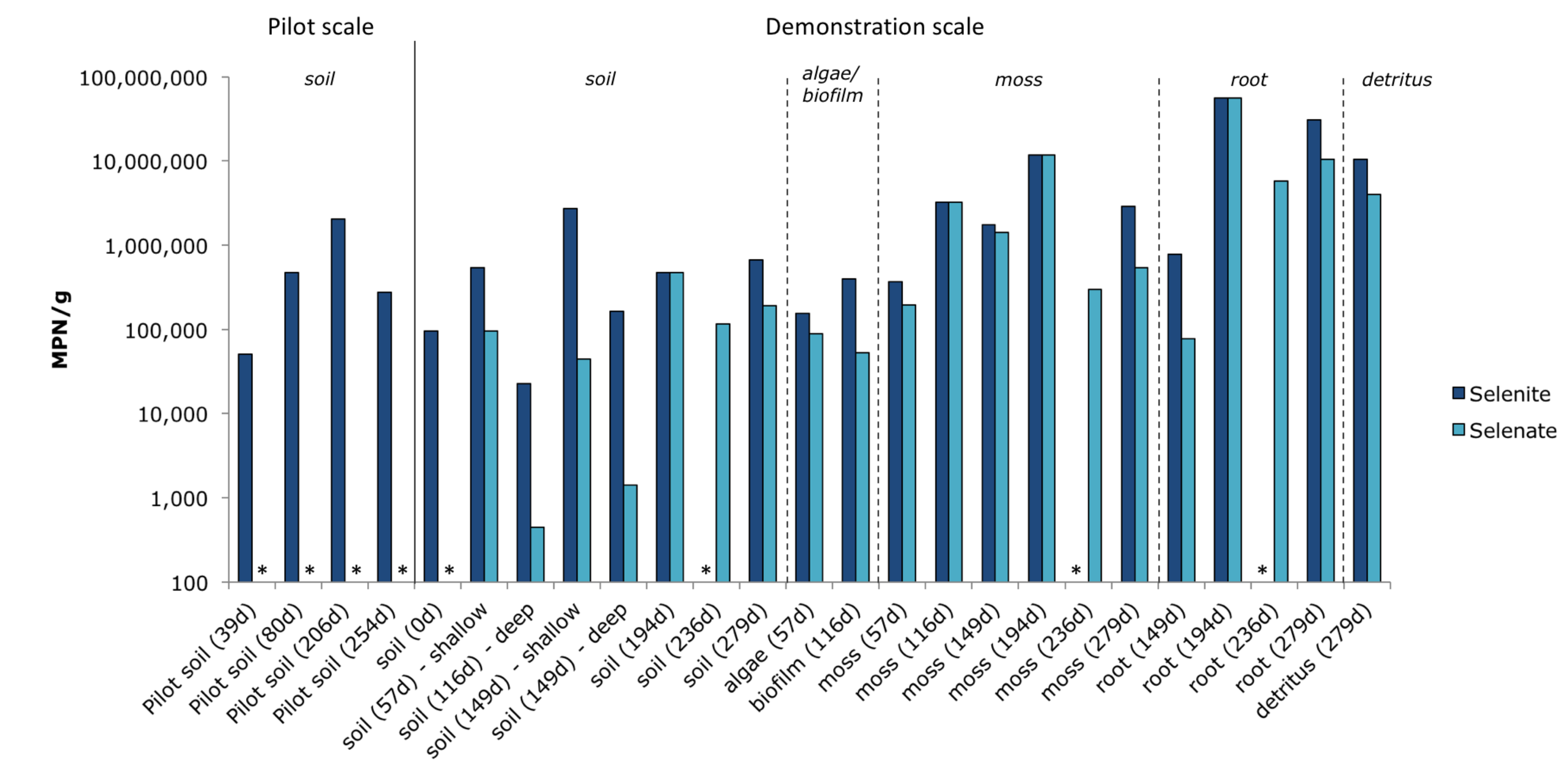


Figure 36 – Abundance of selenite- and selenate-reducing organisms in various CWTS sample types over time.
* Selenite or selenate not tested at this timepoint
Shallow soil (0-5 cm); deep soil (10-20 cm); soil at 0d was that used for construction of wetland. Organics material was added to the wetland after day 236.

10.1. Nitrate-reducing bacteria

Nitrate is sometimes a constituent of concern during operations and early closure owing to residuals from blasting activities. Even if not in exceedance of water quality guidelines in terms of receiving environment objectives, nitrate often requires attention to achieve treatment of other constituents. The presence of nitrate can interfere with the treatment of certain elements in water (such as selenium). Nitrate can be removed from water by different types of microbes, including nitrate reducing bacteria which can reduce nitrate (NO_3) to nitrite (NO_2), and also denitrifying organisms that are capable of fully reducing nitrate to nitric oxide (NO), nitrous oxide (N_2O), and dinitrogen gas (N_2 - which is the most abundant gas in air). MPN analysis was therefore used to quantify these organisms.

Nitrate-reducing and denitrifying organisms were found associated with all sample types in the demonstration-scale CWTS (Figure 37). Roots and detritus had a high abundance of both nitrate and denitrifying organisms, with soil being similar to what was found during pilot-scale testing. These results indicate nitrate reducers have established in the CWTS during the commissioning period as expected. Nitrate-reducing microorganisms will continue to be monitored in 2017, alongside performance testing.

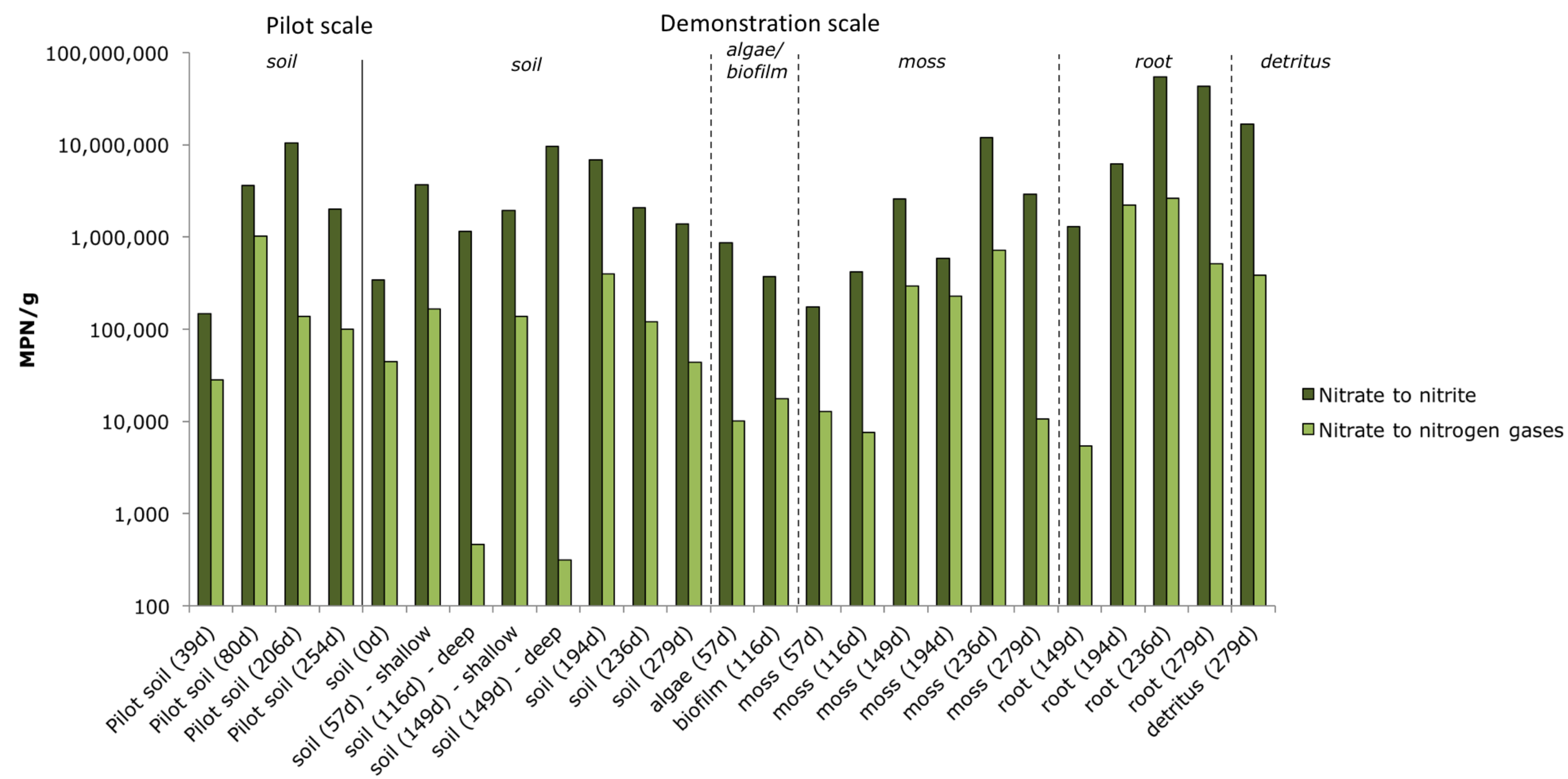


Figure 37 – Abundance of nitrate-reducing and denitrifying organisms in various CWTS sample types over time.
Nitrate-reducing = reduction of nitrate to nitrite; denitrifying = reduction of nitrate to nitrogen gases.
Shallow soil (0-5 cm); deep soil (10-20 cm); soil at 0d was that used for construction of wetland.

11.Summary of results

Table 13 summarizes results and findings from 2015 - 2016 commissioning of the demonstration-scale system at Minto.

Table 13 – Summary of Minto demonstration-scale 2015 - 2016 testing.

Objective	Purpose	Key Findings or Changes for Full-scale
Evaluate construction	Optimize construction and effectiveness of operation of full-scale systems	**Layout** -Outflow collection pond should have outflow at base (not top), with shutoff valve. -In 2016 sandbags were added at shores to prevent water short circuiting. Sandbags were also added to the outflow of series 1 to increase water depth.
		Soils -Use substrate with less total and leachable metals and metalloids (especially copper). -Higher sand content would improve hydrology, constructability (ability to level soils, ease of planting) and accessibility for sampling. -Organics should be mixed in bulk to soils prior to adding to cells.
Assess commissioning timelines	Allow for proper phasing of implementing full-scale systems for closure	**Water** -Commissioning-A period was complete at the end of July 2016 and the commissioning-B period (addition of organics to remediate the copper in substrates used) began July 29, 2016 and is ongoing. -Copper is being treated by the CWTS, and during the commissioning-B period the average influent concentration decreased by 37% compared to the average outflow concentration. -The wetland is achieving better treatment than suggested by inflow and outflow concentrations of the system, as soils are leaching aluminum and copper into the water. -Cadmium and zinc are also being treated in the CWTS, and during the commissioning-B period, the average outflow

Objective	Purpose	Key Findings or Changes for Full-scale
		concentrations were 64% and 69% lower than average influent concentrations respectively. - Molybdenum and selenium experienced notably greater treatment after during the commissioning-B period. The average outflow concentrations were 21% and 41% lower than average influent concentrations respectively. -The wetland is maturing as expected and is performing beyond anticipated based on the design. - Cadmium, copper, molybdenum, and selenium % removal and *k* rates are increasing over time. Zinc % removal is increasing over time. - HRT tracer study conducted in 2016 assessed hydrology and pore volume incorporation of the CWTS and determined HRT and removal rate coefficients for full-scale sizing. Rate coefficients should be re-evaluated after commissioning-B is completed. -Evapotranspiration study conducted to determine amount of evapotranspiration occurring in the CWTS in warmer months and to incorporate into load removal models. Due to rain the results were inconclusive and should be redone in 2017.
		Soils -Soil redox not consistently reaching targeted ranges by July 2016 therefore organics were added to stimulate desired reducing conditions, which marked the end of commissioning-A and the beginning of commissioning-B. -Cell 2B consistently reaching targeted ranges by the end of 2016. -In 2015 significant amounts of metals were leaching from soil substrate into water, putting additional treatment demands on system. In 2016 the amount of metals leaching from soil substrate into the water has decreased.
		Microbes -Sulphide-producing bacteria needed for copper and other metals removal have increased through the commissioning period as soil redox approached targeted ranges. Proportions are comparable to

Objective	Purpose	Key Findings or Changes for Full-scale
		those in pilot system at similar points in commissioning. After the addition of organics which marked the end of the commissioning-A period and the beginning of the commissioning-B period, sulphide-producing bacteria continued to increase, especially in the soil and roots in the B cells. -Abundance of selenium- and nitrate-reducing organisms are similar to those in pilot testing, indicating maturation as expected. -Selenium treatment performance increased through the commissioning period as mosses continued to grow, as they can sorb dissolved selenium and harbour highest abundance of selenate-reducing microorganisms to render the selenium insoluble. After the addition of organics which marked the end of the commissioning-A period, selenium-reducing bacteria were also associated with the added organic material once it started decomposing. Therefore the CWTS has established beneficial selenium reducing bacteria in several areas of the wetland (moss, detritus, roots, and soil).
Carex aquatilis transplantation effectiveness	Determine if plant propagation and/or replanting schedule will be needed for full-scale systems	->95% survival from transplanting. -Within first 2 months a further increase of >20%. -Full-scale system could be planted more densely to bring online faster, or less densely if time is less of an issue than sourcing plants (the plants are vigorous and will fill in the wetland in due time). - By the end of 2016 the plants had densely filled in the CWTS and transplanting was considered a success.
Moss colonization/distribution		-100% survival from transplanting. -Slower to spread, needs to be started more densely. -Staking helps maintain moss in 'upstream' parts of wetland, or could be transplanted multiple times through commissioning period. - Moss continued to mature in 2016 and does not appear to require additional transplanting.

12. Schedule and action items for 2017

Based on the performance results through 2015 and 2016, an action plan for CWTS optimization and testing for 2017 has been developed (Table 14). An updated multi-year schedule as per the proposed scope of work in the Minto Demonstration Scale Report Document 011_0315_01A (Contango, March 2015) is provided in Appendix C.

Table 14 – Minto 2017 CWTS demonstration-scale action items.

<table>
<tr><th>Who/When</th><th>Task</th><th>Contango Action Required</th><th>Additional Information</th></tr>
<tr><td>Minto Staff, prior to first site visit</td><td>Set flow rates at constant flow</td><td>Develop flow rate based on 2016 tracer study.</td><td>Do not change flow rate throughout year. Evaluate stability of wetland performance over one year, apply adjustments to models for full scale as necessary.</td></tr>
<tr><td rowspan="3">Contango site visit 7 (May/June 2017)</td><td>HRT Tracer study (salt)</td><td>Complete a second tracer study optimized from 2016 findings.</td><td>Coordinate an additional 1 m^3 tank at the CWTS site and a power source for the YSI.</td></tr>
<tr><td>Aphid control (if needed)</td><td colspan="2">Determine the appropriate method for aphid control.</td></tr>
<tr><td>General follow up</td><td colspan="2">Complete seasonal sampling.</td></tr>
<tr><td rowspan="2">Contango site visit 8 (July/August 2017)</td><td>Evapotranspiration study</td><td>Determine length of time and appropriate timeline to conduct the evapotranspiration study</td><td>Ensure the evapotranspiration study will not affect other planned activities at the site.</td></tr>
<tr><td>General follow up</td><td colspan="2">Complete seasonal sampling.</td></tr>
<tr><td>Contango site visit 9 (September 2017)</td><td>General follow up</td><td colspan="2">Complete seasonal sampling.</td></tr>
<tr><td rowspan="2">Contango data monitoring throughout 2017 operations</td><td>Monitor metals leaching from soils</td><td colspan="2">If metals continue to leach in 2017, flows could be stopped temporarily to promote this shift from oxidized to reduced forms. With the additional carbon sources of straw and wood chips now available for the bacteria to use to produce more sulphides for metals treatment</td></tr>
<tr><td>Monitor soil redox</td><td colspan="2">Determine when it consistently reaches targeted range.</td></tr>
<tr><td>December 2017</td><td>Report</td><td colspan="2">2017 Update Report.</td></tr>
</table>

13. 2017 Monitoring plan

A conceptual testing plan was developed for the demonstration-scale CWTS and has been refined and adapted based on performance and scientific findings. The demonstration-scale wetlands are expected to run until at least the end of 2018 in order to assess performance under a wider range of conditions. The conditions that are planned to be tested include both natural/environmental and selected influenced pressures, and can be imposed on the systems to mimic peak flow rates or droughts. In 2016 the systems completed the commissioning-A period and began the commissioning-B period, with plants becoming more established and abundant, microbial communities acclimating to the targeted conditions, and soil redox beginning to achieve targeted ranges. In 2017 the monitoring program will shift focus to testing of operations and performance. A multi-year plan is provided in Appendix C, and includes work performed to date as well as a schedule for 2017 and potential activities for 2018.

14. Closure

We trust the information herein satisfies your present requirements. Should you have any questions, please contact the persons listed below. We appreciate the opportunity to provide the services detailed in this report, and look forward to discussing any comments you may have.

Respectfully submitted,

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Appendix U - 2016 Annual Socio-Economic Monitoring Report

Minto Mine
2016 Annual Socio Economic Monitoring Report

Prepared by:
Minto Explorations Ltd.
Minto Mine
February 2017

Contents

1 Introduction

This report has been prepared by Minto Explorations Ltd., a subsidiary of Capstone Mining Corp., in regards to the Minto Mine property (Minto), located in central Yukon. The following report summarizes the results of the socio economic available data at Minto for 2016, as required by the Socio Economic Monitoring Program framework.

The Minto Mine Socio-economic Monitoring Program (Minto Explorations, Yukon Government, Selkirk First Nation, 2014) is a program that has been developed in conjunction with Selkirk First Nation and the Yukon Government to monitor the socio economic effects of Minto Mine on SFN. The primary components of the program include; the mine providing information relating to SFN (e.g. employment data, training information etc.), a community based survey (conducted by SFN and YG), and information from SFN and YG relating to Pelly Crossing or SFN. The information from all of those components is then used in the preparation of an annual report produced by a third party consultant.

Not all of the data that has been requested from historical records is available. Going forward Minto will collect the required and necessary data in order to provide more accurate information for the bi-annual reports. Minto has given best efforts to collect and obtain historical data and going forward accuracy of information and data collection will continue to be further refined.

1.1 Factors at Minto that may have a socio-economic impact

The Minto Mine is an open pit and underground copper mine located 240 kilometres north of Whitehorse in central Yukon, Canada. Minto is located on Selkirk First Nation Category "A" land.

An initial cooperation agreement (CA) between Selkirk First Nation and Minto was agreed upon and signed in 1997, and was later amended in 2009. The agreement serves as a formal document that covers governance, business partnerships, training and employment, and royalties of the Minto Mine on Selkirk First Nations land.

The community of Pelly Crossing is located along the Klondike Highway on the banks of the Pelly River, 282 kilometers northwest of Whitehorse. Pelly Crossing is home to SFN people which includes 336 people (2011 census) 305 which are first nation. The average income of population aged 15 years and over in Pelly Crossing is $26,585 with the average house price being $274,106 (2011 National Household Survey). The median population age of Pelly Crossing is 38 years of age (2011 census).

The city of Whitehorse is the capital of Yukon and is the largest community in the territory with a population of 27,889 (Yukon government website) or 76% of the total population.

The remote location and access to Minto dictates a fly in fly out (FIFO) camp operation. In Yukon, there is a general shortage of available professional and skilled workers. The location also is impacted by low amount of manufacturing of goods locally/ locally sources supply

The advanced and post-secondary education and training available in the Yukon is fairly limited and there are a lack of local candidates possessing mining careers related experience, and educational backgrounds.

Recruitment of local candidates is also impacted by low literacy rates and shortage of candidates possessing a valid driver's license.

Other factors that may have impacted socio-economic items include:

- Implementation of socio-economic monitoring program
- Regulatory delays
- Declining copper prices
- Mine life uncertainty

2 Minto and Contractors Safety Statistics

The below table (Table 2-1) summarises the safety statistics for Minto Employees and site contractors for 2016. The total incidents include minor first aids treated at the site, any property damage, near-misses that could have resulted in an incident, medical aids (where treatment is required off site) and lost-time accidents where a worker would be unable to return to their duties and had to miss work. In 2016 there was 1 lost time accident, which involved a contractor on site.

2016 Total incidents	Minto	Contractors
87	63	24

3 Employment

Minto utilizes a preferential hiring recruitment approach as outlined in the Cooperation Agreement. Our preferential hiring involves the following: Positions are first advertised and offered in the following order of priority: SFN, NTC (Northern Tutchone) Pelly Crossing Resident, OFN, Yukon, and Western Canada.

3.1 Employment Income and Distribution

The following sections outline information and figures that demonstrate salaries are higher for those who are in major centres and/or employed outside of Yukon. Potential reasons for this for Minto include:

- 7 out of 10 managerial staff live outside Yukon
- The majority of professional, supervisory and designated staff are residents of the rest of Canada(Non-Yukon residents)

Other factors for this could potentially be linked to a lack of potential candidate pool in Yukon of professional and managerial experienced staff. Further the post-secondary education requirements for these roles cannot be obtained in Yukon.

The Company operates a fly in fly out (FIFO) camp model which is attractive to employees who can stay in their current hometowns and not have to move to Yukon. This approach has become somewhat of a standard practice for the mining industry in Western Canada, our peer group, and Minto operates in a fashion to be competitive in this market. Employees expect a FIFO in a remote mining location.

Major centres of Whitehorse and Rest of Canada have the highest income. Reasons for this could include a larger qualified candidate pool. Outlying areas including Pelly Crossing and Rest of Yukon have less availability of qualified candidates for skilled, professional and managerial positions.

3.1.1 Minto - Average employment income by Residency

	Pelly	Whitehorse	Yukon	Rest of Canada
Minto	$30.74	$32.71	$30.67	$37.53

3.1.2 Contractors - Average employment income by Residency

	Pelly	Whitehorse	Yukon	Rest of Canada
Pelly	$27.30	$28.68	$27.93	$29.89
Dumas	-	$20.67	$20.75	$21.82
Sodexo	$16.27	$17.83	$16.09	$16.43

Potential contributing factors include:

- Dumas Contracting is located in eastern Canada indicating hiring from a preferred talent pool in this location
- Pelly Construction is located in Whitehorse, YT and a majority of staff are located in Whitehorse. Pelly Construction underwent 1 major layoff in 2016 (End of Minto North) and laid off the majority of their employees when Minto North was finished.
- The majority of Sodexo employees are entry-level non-skilled workers. Sodexo, like many Remote Site Service providers, has a high turnover rate. However this number was higher in 2016 again, likely due to the uncertain mine plans. Voluntary turnover at Minto for 2016 Sodexo was 79%.

3.1.3 Minto and Contractors – Annual and cumulative total employee income by Group

	Pelly Crossing	Whitehorse	Yukon	Rest of Canada
Minto	$512,458.5	$4,257,665.43	$1,468,130.90	$9,285,929.74
Pelly	$403,310.08	$2,771,763.42	$467,939.54	$1,587,027.14
Dumas	-	$149,558	$157,267	$6,131,670
Sodexo	$121,708.92	$608,544.60	$81,139.28	$243,417.84

3.1.4 Minto – Northern Employment by Group

	SFN	Yukon FN	OFN	Other Yukon	Other Canadians	Total
Minto	11	17	2	36	66	132

3.1.5 Minto - Employment by Residency

	Pelly Crossing	Whitehorse	Other Yukon	Canada	Total
Minto	6	45	13	68	132

3.1.6 Contractor - Employment by Residency

	Pelly Crossing	Yukon	Canada	Total
Pelly	8	58	24	90
Dumas	0	4	42	46
Sodexo	5	16	5	26

3.1.7 Minto – 2016 New Hires by Group

	SFN	Yukon FN	OFN	Other Yukon	Other Canadians	Total
Minto	3	4	0	10	15	32

3.1.8 Minto - Employment by Job Categories and Group

	SFN	Yukon FN	Other Yukon	OFN	Other Canadians	Total
Management	0	0	2	0	10	12
Professional	2	1	13	0	24	40
Skilled	2	6	8	1	24	41
Semi-skilled	4	9	13	1	8	35
Entry Level	3	1	0	0	0	4
TOTAL	11	17	36	2	66	132

3.1.9 Minto and Contractors – Annual and cumulative total employees by group

	Aboriginal	Yukon (Non-FN)	Total Yukon	Other Canadian	Total
Minto	30	36	66	66	132
Pelly	27	40	67	23	90
Dumas	4	2	6	40	46
Sodexo	8	12	20	5	25

3.2 Results of voluntary exit surveys

In 2016 Minto had a very slight increase in our voluntary turnover rate. A total of 33 employees voluntarily left Minto, which represents a voluntary turnover rate of 21.7%.

The results of voluntary exit surveys indicate the following main reasons for resignations:

- Lack of certainty with upcoming Mine plans, and end of Minto North.
- Enhanced opportunity at other Mines, as Copper prices picked up.

4 Business

As part of Minto and SFN's cooperation agreement there is a requirement for the company to provide preferred opportunity notification to SFN to negotiate and potentially be awarded a contract to supply the requirement. SFN has developed partnerships with a number of Minto's vendors for which the details of financial benefit Minto is not privy to. As such, this section summarizes expenditures by the company that is the primary vendor and does not account for any SFN proportional expenditures as a result of those partnerships.

In 2015, Minto and SFN worked jointly to establish new or maintained contracts to ensure involvement from SFN and support our First Nations partners. The contractual arrangements highlighted below represent the majority of the opportunities that SFN and Minto share with service providers. As well as financial gain, SFN also does benefit from employment opportunities on some contracts.

- Borealis Shuttle – Pelly Crossing Shuttle Service-SFN Summer Students
- Capital Helicopters- Helicopter Support
- Driftwood Drilling- Exploration Drilling
- Dumas- UG Mining
- Dyno Nobel Canada- Blasting supplies and services
- Glacier Water Services- Water Hauling
- Manitoulin Transport- Freight Hauling
- Northern Vacuum Services- Vacuum Truck Rental
- Nuway Crushing- Crushing Services
- Parkland Fuel- Fuel Supply
- Pelly Construction- 988 loader rental
- Pelly Construction- Mining Services
- Selkirk Development Corp- Office Lease
- Sodexo- Catering Services
- Standard Bus- Bussing of Staff/Contractors
- Tintina Air- Secondary Air Support
- Yukon Inn- Employee lodging

The six rights of procurement must be met in selection of such vendor relationships.

- Right Materials (to fill need)
- Right Place (Yukon preference)
- Right Quantity and Quality (High quality and ability to supply)
- Right Supplier (Service, technical and aftermarket support, value added service)
- Right moment (product available when needed)
- Right price (competitive commercial price)

In total Minto spent $64,729,636 on Yukon vendors in 2016. This represents 59% of total spend that stayed in the Yukon, supporting local business and developing partnerships for long term mutual benefit. Minto selects the appropriate local vendors based on vendors that meet selection criteria that support Minto's corporate social responsibility. Such partnerships are built on transparency, human rights and labor compliance, supplier status, financial, geographical, and environmental compliancy. The framework for successful local suppliers is based on common shared goals, continuous improvement, and vendors that support Minto's policies and procedures.

In addition to support of our First Nations partners, Minto also strives to support Yukon based companies and service providers based on ability to service our needs and meets commercial acceptance criteria. In analyzing a business for suitability Minto follows best practice guidelines and the six rights of procurement in selecting potential suppliers.

Minto will continue to maintain and increase its spend with local suppliers as they invest in supporting the mining industry and Minto is committed to sustainability in developing the relationships for long term mutual benefit.

4.1 Mine Capital and Operating Expenditures

Indicator #33: Minto Explorations operations & capital expenditures by group					
		Pelly Crossing	Other Yukon	Canada	Total
2016	Capital expenditures		$ 5,431,010.25	$ 1,077,837.72	$ 6,508,847.97
2016	Operating expenditures	$ 5,018,911.53	$ 54,279,714.13	$ 34,746,723.04	$ 94,045,348.70

4.2 Yukon business names by group

See attached **Appendix "A"** noting all Yukon Business Names by group. Note that not all business are captured due to some expenditure by employees and reimbursed through expenses and all contractor purchased items.

4.3 Minto Royalty Payments

Indicator #36: Minto royalty payments				
		SFN	Yukon	Total
Minto Royalties Paid 2016		$	$	$
Gravel Royalties		1,308.00		1,308.00
Net Smelter Royalties		1,214,278.46		1,214,278.46
Quartz Mining Act Royalties		3,399,118.00		3,399,118.00
Total		*$ 4,614,704.46*	*$ -*	*$ 4,614,704.46*

4.4 Minto property tax payments and other fees

Indicator #37: Minto property tax payments and other fees					
	SFN	Yukon	Other Canada	Other	Total
Minto Fees & taxes Paid 2016	$	$	$	$	$
Land Leases	$ 86,826.60				$ 86,826.60
Property Taxes		$ 292,839.31			$ 292,839.31
Landing Fees	$ 25,000.00				$ 25,000.00
Trappers' Compensation	$ 10,000.00				$ 10,000.00
Skagway Municipal Taxes				$ 39,473.28	$ 39,473.28
Total	*$121,826.60*	*$ 292,839.31*	*$ -*	*$ 39,473.28*	*$ 454,139.19*

5 Capacity, Training and Education

Minto, working with our major contractor partners, supported many different capacity building, training and educational initiatives in 2016. Through a combination of "on-the- job" training and mentoring, combined with sponsoring apprenticeships, pre-apprenticeships and other educational initiatives, we continued to build upon work done in 2015 – to create a workplace that enhances our current employees skills and also supports the ongoing development towards a more advanced local labour force.

5.1.1 Selkirk First Nation and Other First Nation specific training in 2016

Mill Competency Program

- Minto initiated a Mill Operator Competency Program in 2016 that targets the entry-level Mill Operators to allow them to "train up" in the Mill through a combination of on-the-job training, signed off verified hours, and on-line training modules.

Pre-Apprenticeship training

- Minto continued work with sponsoring One SFN student in completing pre-apprenticeship study requirements in partnership with Yukon College (LD Mechanic)

Apprenticeship training

- Minto continued sponsoring One SFN student in apprenticeship training (Warehouse Partsperson) however this employee failed the exam levels and is in the process of rewriting his level 2 training within that program of study.
- Additionally Minto is currently sponsoring another OFN within the Millwright Apprenticeship program, and this employee is working on his level 4 Millwright apprenticeship.

6 Cultural Well-being

Minto's approach to community investment is based upon opportunities to further build and maintain our social license, maintain good relationships with our partners and maintain a local presence and good reputation in the communities where we operate and where our employees live and work. The goal of this is to strengthen accountability and working partnerships with stakeholders while providing a foundation to understand and consider the needs, opinions and interests of the community.

Minto employs several methods of community engagement with different levels of involvement from the community and other stakeholders. These methods include formal and informal ways that are best suited for the various stakeholders. While Minto currently employs many different engagement methods, they are largely utilized in an ad hoc way. In the absence of signed, guiding document the current general strategy is that management reviews ways we engage and uses management best efforts and discretion for methods of engagement.

A community engagement plan was prepared and signed off by Minto management in 2015. A method of engagement and frequency table was prepared and presented to Selkirk First Nation Chief and Council.

Examples of community and cultural engagement initiatives include the following:

- Fort Selkirk educational tours with Selkirk citizens and Minto employees and contractors
- Sports Sponsorship
- Christmas Turkey Distribution
- High school Bursaries, and attendance by Senior Minto Management at Graduation ceremonies.
- Selkirk First Nation Elder's workshops held at the Mine site, whereby Minto employees and Contractors get to participate in traditional cultural activities, such as beading workshops, birch bark crafts and traditional sewing.

In 2016 Capstone spending included the following designed to enhance and protect SFN cultural and community wellbeing;

- $500 provided to each of the 4 SFN graduating students in 2016
- $7,911 worth of turkeys, delivered to each home in Pelly Crossing for Christmas
- $1,500 to support Yukon sports
- $2,000 in contributions to SFN events

In 2016 Minto continued to support several sporting and recreation events and organizations including Dog Powered Sports Association and the Selkirk Bears hockey team.

Minto also continued to support the primary industry event in the territory - the 2016 Geoscience Forum and Trade Show which is the territory's largest conference and industry event. We also supported the Yukon Chamber of Commerce. Our largest and most notable donation was the $10,000 contribution to the Yukon Hospital Foundation's Festival of Trees events which raises money to upgrade Whitehorse General Hospital's facilities and equipment.

Appendix A – Yukon Businesses used by Minto in 2016

Acklands Grainger	Marcel McGinty
ALBERTA FUEL DISTRIBUTORS INC.	Mercer Contracting
Air North	Mile 918 Driver Development
Ajax Steel Limited (Steel Only)	MIC MAC TOYOTA (YUKON) LTD.
Ajax Steel Limited	Mobile Maintenance Services
Alkan Air Ltd.	Napa Whitehorse (0331) Div of Uap Inc
All-West Glass Whitehorse Limited	Northern Fusion Welding Fabrication
ALX Exploration Services	Northern Industrial Sales (Whitehorse)
Aon Reed Stenhouse Inc.	North 60 Petro Ltd
Aqua Tech Supplies & Services	Northerm Windows & Doors
Arctic Star Printing	NUWAY CRUSHING LTD.
Boring Guy Equipment Repair	Northwestel Inc.
The Brick	Office Supply Centre
Bud's Industrial Installations (Yukon) Ltd.	Pacific Northwest Freight Systems
Carmacks Hotel	Patricia Halladay Graphic Design
Canada Games Centre	Peacock Sales Limited
CHALLENGER GEOMATICS LTD.	Pelly Construction
The Chocolate Claim	PolarCom Certified Personal Computers ML & Associates
City Of Whitehorse	Quality Bearing Supply Ltd
Clean Choices	R.C. Crane and Construction
Clayton Johns	Reactive Design
Cobalt Construction Ltd	Sandvik
Dimok Timber Ltd	Selkirk Development Corporation
Dog Powered Sports Association of the Yukon	39539 Yukon Inc.
Duncan's Limited	Selkirk First Nation
Dynamic Systems	Secure Mobile Shredding
Dyno Nobel	Stephane Gingras
The Edgewater Hotel (2009) Ltd.	Shoppers Drug Mart
Eecol Electric Corp.	Small's Expediting Services
Finning	Larry Smith
Fountain Tire	Staples#251 Whitehorse
General Waste Management	Superior Propane
General Enterprise Ltd.	Territorial Auto Parts
Tom Gill	Tahyah Van Bibber
Government Of The Yukon	The Whitehorse Star Ltd.
GP Distributing	Tintina Air Inc.
Bluewave Energy	Total North Communications Ltd.
GRIFFITHS HEATING & SHEET METAL	Total Fire Protection Services Ltd.
High Country Inn	Totaltrac Yukon Inc.
Hi Tech Fluid Power	TransNorth Helicopters

Home Hardware	True K9 Security Detection Inc.
INTEGRAPHICS LIMITED	Underhill Geomatics Ltd.
Inkspirationz Graphix	Whitehorse Chamber of Commerce
Integraphics Ltd.	Westmark Whitehorse Hotel & Conf. Center
JACOBS INDUSTRIES LIMITED	Whitehorse Beverages
Java Connection	Whitehorse Motors Ltd.
Dywidag Systems	Woodland Heating and Sheetmetal
Kathleen Burke Cleaning Service	Yukon Energy Corporation
Kilrich Industries Ltd	Yukon Hospital Foundation
Kindra Stewart	Yukon Mine Training Association
Klondike Motors	Yukon Chamber of Commerce
Lamarche & Lang	Yukon Chamber Of Mines
Listers Motor Sports	Yukon Government
Locksmith Services Ltd.	Yukon Honda
MacPherson Rentals	Yukon Inn
Mac's Fireweed Books (Maximillians Corporation)	Yukon Pump Limited
Maintenance Enforcement Program	Yukon Radiator Shop
Marsh Lake Tents & Events	Yukon Service Supply Company
Marj Eschak	Yukon College
Research Northwest	YUKON YAMAHA
George McGinty	Yukon Workers' Comp Health & Safety Bd
Kenny McGinty	Yukon Women in Mining Association
Kevin McGinty	