Minto Mine

Environmental Monitoring, Surveillance and Reporting Plan

Prepared by:
Minto Explorations Ltd.
Minto Mine
June 2014

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List of Acronyms

Acronym	Definition
A2P	Area 2 Pit
AAS-GF	Atomic Absorption Spectroscopy – Graphite Furnace
ABA	Acid-Base Accounting
AP	Acid generating potential
ARD	Acid Rock Drainage
BMP	Best management practices
C(T)	Total copper
CALA	Canadian Association for Laboratory Accreditation
Capstone	Capstone Mining Corporation
CEQG	Canadian Environmental Quality Guidelines
COC	Chain of command
CPUE	Catch per Unit Effort
DOC	Dissolved organic carbon
DPP	Drive point piezometer
DRP	Minto Mine Decommissioning and Reclamation Plan
DSTSF	Dry stack tailings storage facility
EEM	Environmental Effects Monitoring
EMSRP	Environmental Monitoring, Surveillance and Reporting Plan
ICP	Inductively coupled plasma
ICP-MS	Inductively coupled plasma – mass spectrometry
IROD	Ice-rich overburden dump
MCDS	Minto Creek Detention Structure
Minto	Minto Explorations Ltd.
MintoEx	Minto Explorations Ltd.
MMER	Metal Mine Effluent Regulations
MVF	Mill valley fill
MWD	Main waste dump
NP	Neutralizing potential
QA/QC	Quality Assurance/Quality Control
QML	Quartz Mining Licence
RISS	Regulatory Information Submission System
ROD	Reclamation overburden dump
S(T)	Total sulphur
SFN	Selkirk First Nation
SOP	Standard operating procedure
SWD	South West Dump
TSS	Total suspended solids
WSP	Water Storage Pond
WUL	Water Use Licence QZ96-006
YWB	Yukon Water Board

1 Introduction

The Environmental Monitoring, Surveillance and Reporting Plan (EMSRP) is a requirement of Quartz Mining Licence QML-0001 (QML), which requires *"a plan that describes methods and techniques for collecting monitoring information regarding environmental conditions at the Undertaking, as well as quantitative thresholds which trigger the implementation of adaptive management strategies".* The contents of the EMSRP include requirements under the Type A Water Use Licence QZ96-006 (WUL), Part G, such as the water quality surveillance program, the meteorological monitoring program, the physical monitoring program, the annual biological monitoring plan, the acid base accounting test program and the groundwater monitoring program. Additionally, as a metal mine in the Yukon, the Minto Mine is required to comply with the Metal Mine Effluent Regulations (MMER) (Government of Canada, 2002), which regulates the monitoring frequency and reporting of effluent discharged from the Minto Mine. The Environmental Effects Monitoring (EEM) program under Section 7 of the MMER outlines requirements for "*monitoring studies of the potential effects of effluent on the fish population, on fish tissue and on the benthic invertebrate community*" (Government of Canada, 2002), and details of the EEM program are detailed in Schedule 5 of the MMER. These requirements are summarized below, as they pertain to the Minto Mine. Table 1-1 summarizes the regulatory monitoring requirements and key personnel involved with the management of the requirements, as well as the section of the EMSRP which provides details of the monitoring programs. This EMSRP replaces the previous Environmental Management Plan, submitted in June 2011 by Minto Explorations Ltd. and approved in October 2011. The content of this EMSRP is derived from the *Plan Requirement Guidance for Quartz Mining Projects* (Yukon Government, 2013) and has been prepared to meet the requirements of the WUL and the QML. Time to time monitoring plans require updating and will be resubmitted. Minto acknowledges that should adjustments to the EMSRP and associated monitoring be determined during the licensing process for the Phase V/VI, the licence conditions will supersede this document.

Table 1-1: Summary of Regulatory Monitoring Requirements

Regulatory Monitoring Programs	Associated Licence or Regulation	Regulatory Monitoring Programs - Key Managers	EMSPRP Section
Water Monitoring Program			
Surface Water Surveillance Program	WUL 75.; Appendix 3	Environment Manager	2.1
Metal Mine Effluent Monitoring Program	MMER	Environment Manager	2.2
Groundwater Monitoring Program	WUL 96., 97.	Environment Manager	2.3
Seepage Monitoring Program	WUL 76.	Environment Manager	2.4
Minto Creek Detention Structure (MCDS) Seepage Monitoring Program	WUL 84., 85.	Environment Manager	2.5
Geochemical Monitoring Program			
ABA Monitoring Program	WUL 87., Appendix 6	Chief Geologist	3.1
Waste Rock Verification Program	WUL 95.	Chief Engineer	3.2
Meteorological Monitoring Program			

Regulatory Monitoring Programs	Associated Licence or Regulation	Regulatory Monitoring Programs - Key Managers	EMSPRP Section
Climate Monitoring Program	WUL 79.	Environment Manager	4.1
Snow Survey Program	WUL 79.	Environment Manager	4.2
Mine Infrastructure and Workings Monitoring Program			
Physical Monitoring Plan	WUL 80., 81., 82., 90., Appendix 2	Chief Engineer	5
Aquatic Environmental Monitoring			
Biological Monitoring	WUL 86./MMER	Environment Manager	6.1
Environment Effects Monitoring	MMER	Environment Manager	6.2
Terrestrial Environmental Monitoring			
Invasive Species Monitoring Program	QML	Environment Manager	7.1
Wildlife Monitoring Program	QML	Environment Manager	7.2
Erosion and Sediment Control Program	QML	Environment Manager	7.3
Reclamation Effectiveness Monitoring Program	QML	Environment Manager	8

1.1 Project Description

The Minto Mine is a copper-gold mine owned 100% by Minto Explorations Ltd. (Minto), a wholly owned subsidiary of Capstone Mining Corporation (Capstone). The Minto Mine commenced commercial production in October 2007. The Minto Mine is located within Selkirk First Nation (SFN) Category A Settlement Land Parcel R-6A, approximately 240 km northwest of Whitehorse, Yukon and 41 km southwest of Pelly Crossing (Figure 1-1). After crossing the Yukon River, either by summer barge or winter ice bridge, access to the mine-site is via a 27 km access road along the Yukon River and up the Minto Creek drainage (Figure 1-2). Crews and supplies are transported by air during the spring thaw and fall freeze-up.

The Minto Mine is an existing and fully operational copper and gold mine. The Minto Mine is currently an open pit and underground mining operation with conventional crushing, grinding, and flotation to produce copper concentrates with significant gold and silver credits. Concentrates are exported internationally via the Port of Skagway, Alaska for smelting and sale. Minto Mine is currently in Phase IV of development and is currently in assessment and subsequent permitting for Phase V/VI expansion.

Figure 1-1: Minto Mine Location Map

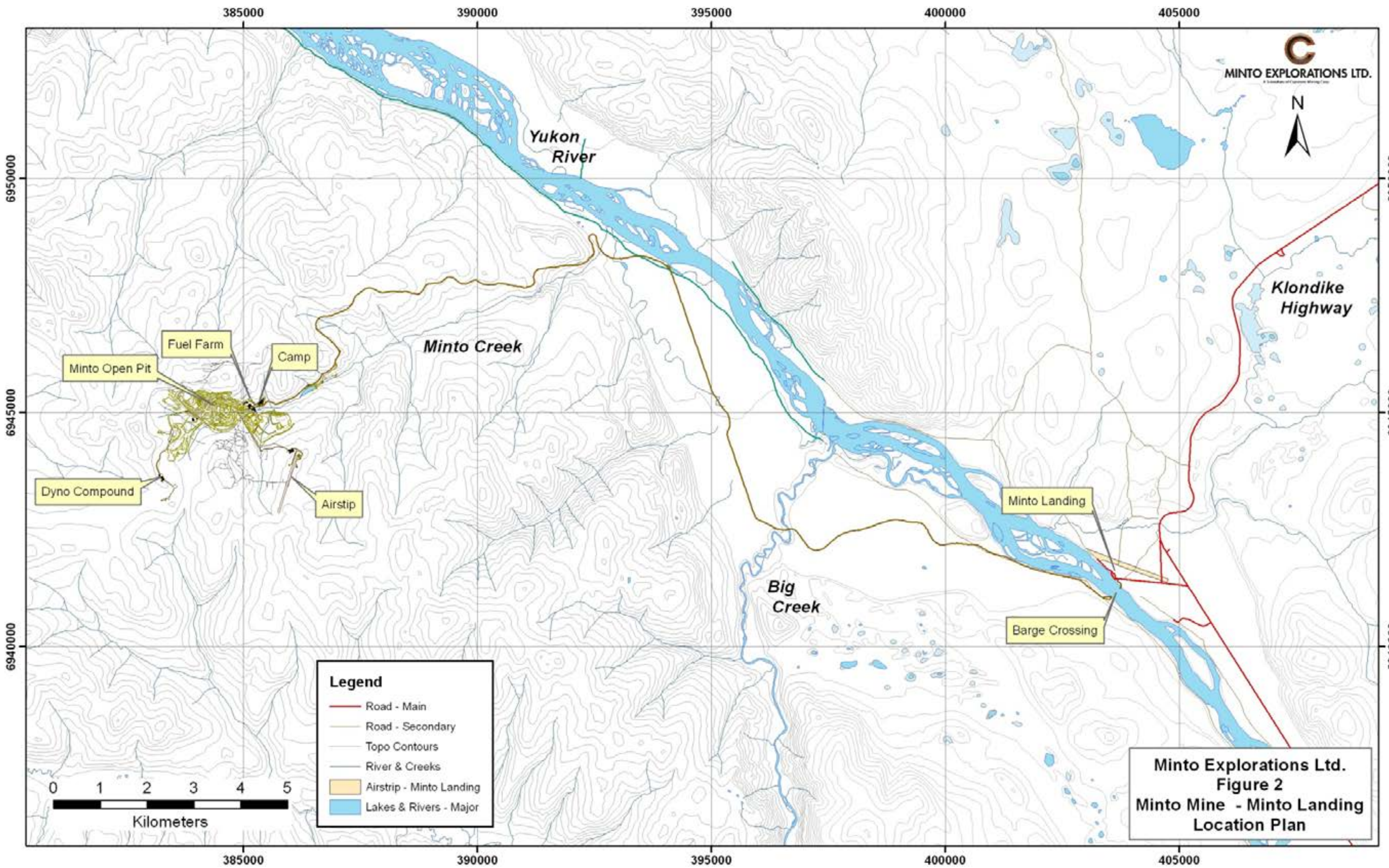


Figure 1-2: Minto Mine Access Location

2 Water Monitoring Program

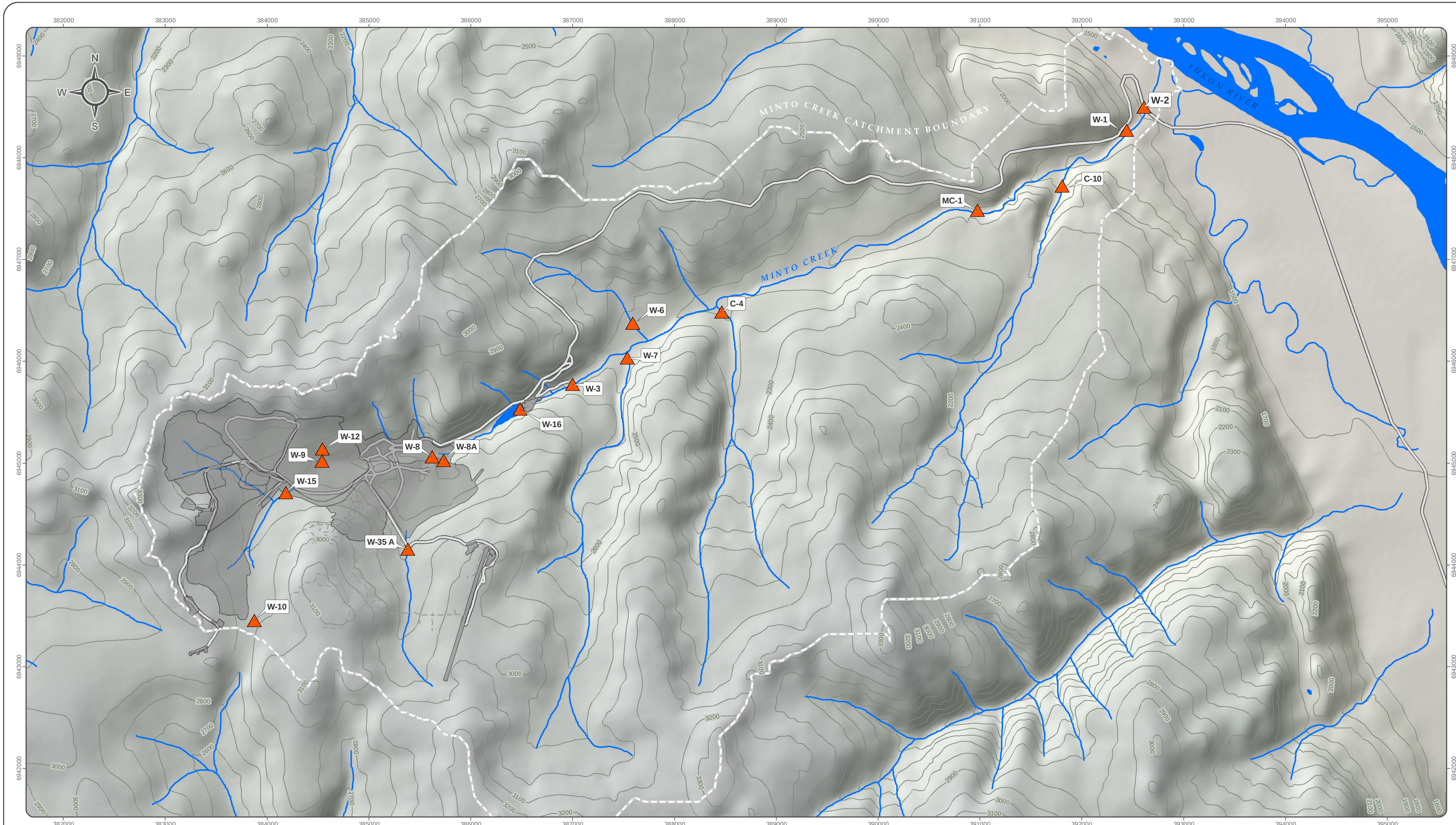
Water quality and hydrology monitoring at the Minto Mine is conducted in accordance with the requirements outlined in WUL QZ96-006 and in the *Metal Mine Effluent Regulations* (MMER). Monitoring programs for water quality and hydrology at the Minto Mine, McGinty Creek, groundwater, seepage, Minto Creek Detention Structure (MCDS) seepage, and under the MMER are detailed below in Sections 2.1 through 2.5. Monitoring stations are described in Table 2-1 and are shown in

Figure 2-1, and Figure 2-2. As the Phase V/VI mine plan incorporates new areas of disturbance, several locations have been identified as appropriate candidates for an expanded monitoring network. The location description, and expected frequency of monitoring are summarized in the tables within this section. It is anticipated that during the water licencing process there may be adjustments to the frequency and locations selected, in which case the monitoring outlined in a revised WUL96-006 will supersede the EMSRP.

Table 2-1: Minto Mine Monitoring Station Descriptions and Coordinates

Station	Description	UTM Coordinates – Zone 8	
		Easting	Northing
W1	Lower Reach of Minto Creek	392445	6948251
W2	Minto Creek, upstream of the Minto Creek/Yukon River confluence where the access road crosses Minto Creek	392584	6948402
W3	Minto Creek, at the federal MMER compliance point	387000	6945778
W4	Yukon River, upstream of the confluence with Minto Creek	394070	6948203
W5	Yukon River, downstream of the confluence with Minto Creek	392583	6949119
W7	Tributary on the south side of Minto Creek, approximately 0.8 km downstream of W3	387546	6946034
W8	Western collection sump from the DSTSF	385629	6945076
W8A	Eastern collection sump from the DSTSF	385716	6945012
W10	Headwaters of Minto Creek (south-west fork at headwaters)	383855	6943364
W12	Main pit and Main Pit Tailings Management Facility	384544	6945137
W14	Tailings thickener overflow	385223	6945089
W15	Upper Minto Creek storm water collection sump, downstream of the overburden dump, just upstream of Main pit	384181	6944708
W16	Water Storage Pond	386402	6945559
W16A	Discharge from the Water Storage Pond	386679	6945664
W17	Water Storage Pond dam seepage	386679	6945664
W30	Headwaters Minto Creek (north-west fork)	383693	6945026
W33	Upgradiant of South Diversion Ditch	385351	6944072
W35	South Diversion Ditch	385223	6944427

Station	Description	UTM Coordinates – Zone 8	
		Easting	Northing
W36	Minto Creek detention structure (MCDS)	385892	6945191
W37	100 m downstream of MCDS (W37 collection sump) and upstream of Water Storage Pond	386180	6945294
W45	Area 2 Pit and Area 2 Pit Tailings Management Facility	384912	6944068
W46	Minto Creek, downstream of W7 and W6 tributaries	387873	6946301
W47	Area 118 Pit water		
W50	Minto Creek, approximately 50 m downstream of the toe of the Water Storage Pond Dam and downstream of the inflow of the treated water.	386747	6945682
MC-1	Minto Creek upstream of Canyon	390967	6947528
WTP	Treated water from water treatment plant	385126	6945154
W51	Area 2 Stage 3 Pit		
W52	Ridgetop North Pit and Ridgetop North Pit Tailings Management Facility		
W53	Ridgetop South Pit		
W54	Main Dam seepage		
W55	Tailings Diversion Ditch		
C4	Tributary on the south side of Minto Creek, downstream of W3		
C10	Tributary on the south side of Minto Creek, downstream of W3		
MN	Minto North pit water		
MN-0.2	Upper west arm of McGinty Creek (Reference Station)		
MN-0.5	West arm of McGinty Creek just upstream of the confluence with the east arm		
MN-1.5	Upper east arm of McGinty Creek downstream of the Minto North deposit		
MN-2.5	East arm of McGinty Creek just upstream of confluence with the west arm		
MN-4.5	Lower mainstream McGinty Creek near confluence with Yukon River		
UG 1	Minto South underground mine dewatering		
UG 2	Wildfire underground mine dewatering		
UG 3	Copper Keel underground mine dewatering		
UG 4	Minto East underground mine dewatering		



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Datum: NAD 83; Map Projection: UTM Zone 8N

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Surface Water Quality Station

Current Mine Footprint (August 2012)

Minto Creek Catchment

Contours (100 ft)

1:35,000 (when printed on 11 x17 inch paper)

0 0.5 1 2 Kilometres

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ACCESS

MINTO CREEK WATER QUALITY CHARACTERIZATION

FIGURE 2-1
MINTO CREEK MONITORING STATION LOCATIONS

JUNE 2013

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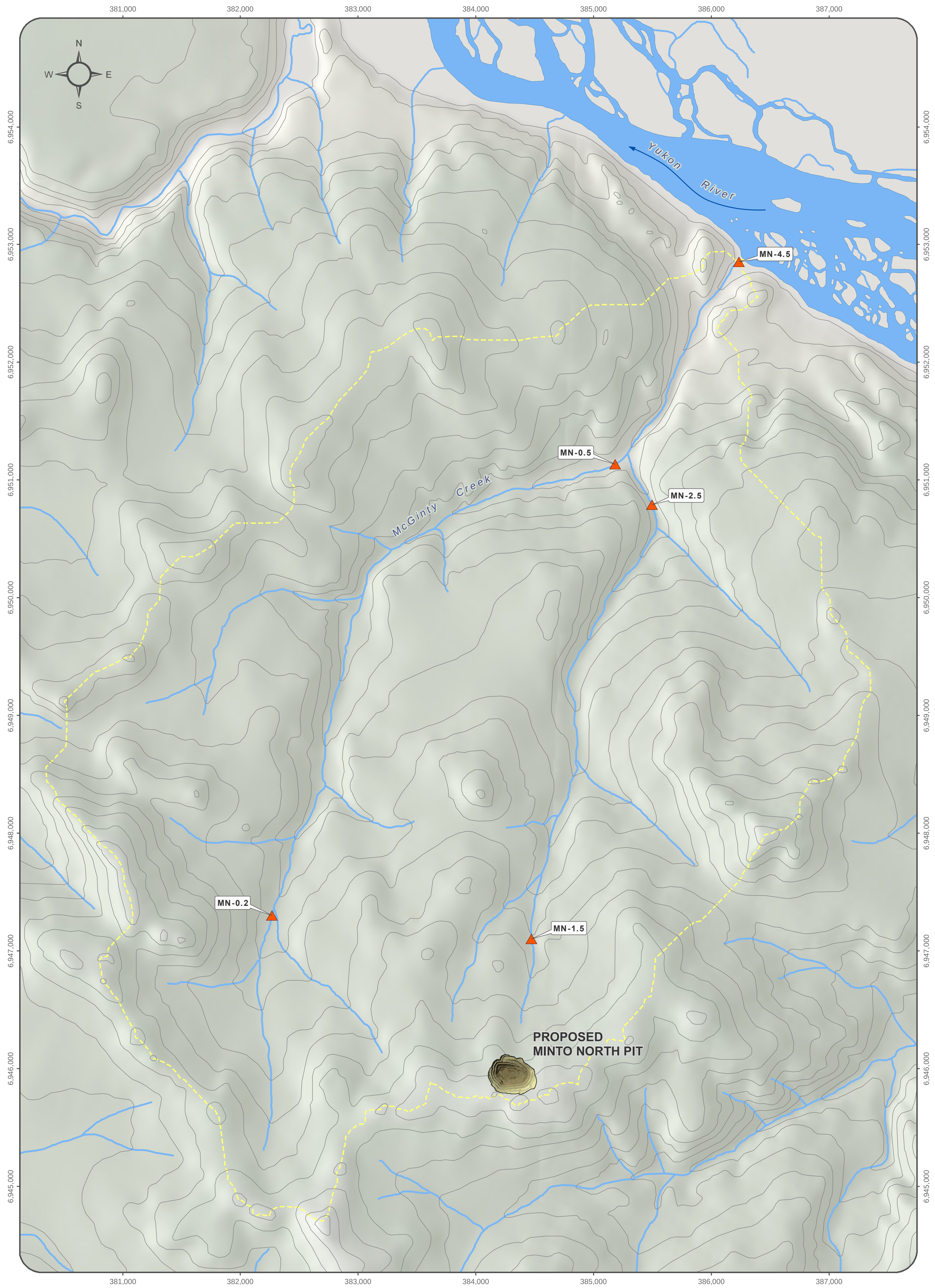

0 500 1,000 1,500 Meters

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- Monitoring Station
- MineFeatureArea
- Contour (100 ft interval)
- McGinty Creek Catchment
- Waterbody

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ACCESS

MCGINTY CREEK WATER QUALITY CHARACTERIZATION
MAY 2009 – JULY 2012

FIGURE 2-1
MCGINTY CREEK
MONITORING STATION LOCATIONS

JUNE 2013

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2.1 Surface Water Surveillance Program

The objective of the Surface Water Surveillance Program is to monitor surface water quality and hydrological conditions at stations within the operational mine area, downstream stations which are influenced by mine effluent discharge, and downstream reference stations which are not exposed to effluent. Water quality and hydrology monitoring is conducted in accordance with the requirements outlined in the WUL QZ96-006, with monitoring variations associated Phase V/VI facilities and activities as reflected in Table 2-2. Monitoring areas can generally be characterized as sites at or near the active mine site and associated facilities, and on Minto Creek, the Yukon River, McGinty Creek and non-impacted drainages. Sampling locations and coordinates are updated annually as part of the WUL QZ96-006 Annual Report.

The Surface Water Surveillance Program monitoring schedule contains weekly and monthly water quality monitoring requirements, and continuous, weekly and monthly monitoring requirements for surface water hydrology and water conveyance flows (Table 2-2). Analytical requirements include in-situ field parameters, physical parameters, nutrients, total and dissolved metals, dissolved organic carbon, and bioassays. Water quality analysis is performed by an external laboratory (for physical parameters, nutrients, total and dissolved metals and DOC) and the Minto Mine internal laboratory (for copper, aluminum, cadmium, selenium, ammonia, nitrite, nitrate and total suspended solids). A combination of continuous water level indicators and inline flow metering systems are used for sites that require continuous monitoring. Calculated flow measurements, determined using the mid-section method with a current meter, are used for sites that require weekly and monthly monitoring.

Monitoring procedures for the water quality monitoring are guided by the *Minto Mine Surface Water Quality Monitoring Standard Operating Procedures* (Appendix 1). The water quality SOPs were developed in accordance with the best management practices (BMP) found in the *Protocols Manual for Water Quality Sampling in Canada* (CCME, 2011), *Guidance Document for the Sampling and Analysis of Metal Mining Effluents* (Environment Canada, 2001) and *Ambient Freshwater and Effluent Sampling Manual* (Clark, 2003).

Monitoring procedures for the hydrological monitoring are guided by the *Minto Mine Surface Water Hydrology Standard Operating Procedure* (Appendix 2). The hydrology SOPs were developed in accordance with the BMPs found in the *Guidance Document for Flow Measurement of Metal Mining Effluents* (Environment Canada, 2001) and in the *Manual of British Columbia Hydrometric Standards* (Ministry of Environment, 2009).

Table 2-2: Water Quality and Hydrology Monitoring Program Requirements

Station	Flow	Water Level	Field Parameters Frequency	External Analytical Suite		Internal Suite	96-Hr LT50	48-Hr LT50	7-day Chronic Toxicity
				Frequency	Analytical Suite	Frequency			
W1	C	-	-	-	-	-	-	-	-
W2	-	-	M/Wd	M/Wd	A,N,DOC	Wd	-	-	Md
W3	C	-	M/Wd	M/Wd	A,N,DOC	Wd	Md	Md	-
W4	-	-	Q	Q	A,N	-	-	-	-
W5	-	-	Q	Q	A,N	-	-	-	-
W7	C	-	M	M	A,N,DOC	-	-	-	-
W8	-	-	M	M	A,N		-	-	-
W8A	-	-	M	M	A,N		-	-	-
W10	-	-	M	M	A,N	-	-	-	-
W12	-	W-WL,TV	M	M	A,N	-	-	-	-
W14	-	-	M	M	A, N	-	-	-	-
W15	C	-	M	M	A,N	Wd	-	-	-
W16	-	W-WL	Mnf/Wd	Mnf/Wd	A,N	Wd	-	-	-
W16A	Cd	-	Wd	Wd	A,N,DOC	Wd	Md	Md	-
W17	C	-	M/Wd	M/Wd	A,N	Wd	-	-	-
W30	M	-	M	M	A,N	-	-	-	-
W33	M	-	M	M	A,N	-	-	-	-
W35	C	-	M	M	A,N	Wd			
W36	C	-	M	M	A,N	-	-	-	-
W37	M	-	M	M	A,N	-	-	-	-
W45	Cdw	W-WL,TV	M	M	A,N	-	-	-	-
W46	M	-	M	M	A,N,DOC	-	-	-	-
W47	Cdw	W-WL	M	M	A,N	-	-	-	-
W50	-	-	M/Wd	M/Wd	A,N,DOC	Wd	M	M	M
MC-1	C	-	M/Wd	M/Wd	A,N,DOC	-	-	-	-
WTP	C	-	Wd	Wd	A,N,DOC	Wd	-	-	-
W51	Cdw	W-WL	M	M	A,N	-	-	-	-
W52	Cdw	W-WL,TV	M	M	A,N	-	-	-	-
W53	Cdw	W-WL	M	M	A,N	-	-	-	-
W54	C		M	M	A,N				
W55	M	-	M	M	A,N	-	-	-	-
C4	M	-	M	M	A,N,DOC	-	-	-	-

Station	Flow	Water Level	Field Parameters	External Analytical Suite		Internal Suite	96-Hr LT50	48-Hr LT50	7-day Chronic
C10	M	-	M	M	A,N,DOC	-	-	-	-
MN	Cdw	W-WL	M	M	A,N	-	-	-	-
MN-0.2	M	-	M	M	A,N	-	-	-	-
MN-0.5	M	-	M	M	A,N	-	-	-	-
MN-1.5	C	-	M	M	A,N	-	-	-	-
MN-2.5	C	-	M	M	A,N	-	-	-	-
MN-4.5	C	-	M	M	A,N	-	-	-	-
UG 1	Cdw	-	M	M	A,N	-	-	-	-
UG 2	Cdw	-	M	M	A,N	-	-	-	-
UG 3	Cdw	-	M	M	A,N	-	-	-	-
UG 4	Cdw	-	M	M	A,N	-	-	-	-

C: Continuously **W:** Weekly	**A**: Physical parameters, conductivity, total suspended solids, total dissolved solids, hardness, alkalinity, sulphate, ICP scan- total metals, ICP – dissolved metals
Wd: Weekly while discharging	**N**: Nutrients: Ammonia-N, Nitrate-N, Nitrite-N
M: Monthly	Field parameters: in-situ pH, conductivity, temperature, Dissolved Oxygen
Mnf: Monthly, when not frozen	Internal lab parameters: copper, aluminum, cadmium, selenium, ammonia, nitrite, nitrate and total suspended solids
Md: Monthly while discharging	**DOC**: Dissolved organic carbon
Cdw: Continuous when dewatering	**96 hr LT50**: LT50 Rainbow trout static bioassay, 96 hrs at 100%, pH non-adjusted
WL: surface water level elevation	**48 hr LT50**: LT50 *Daphnia magna* static bioassay, 96 hrs at 100%, pH non-adjusted
TV: Track tailings volume	**CD-7d**: chronic toxicity – *Ceriodaphnia dubi*a 7 day test

2.2 Metal Mine Effluent Monitoring Program

The Metal Mine Effluent Regulations (MMER) (Government of Canada, 2002) outline requirements for monitoring and reporting of discharged effluent volume and quality under the MMER to Environment Canada. The Metal Mine Effluent Program aims to maintain compliance with the MMER and the program will be revised should regulation amendments occur. Specifically, the Metal Mine Effluent Program requires sampling at station W3, downstream of the end of pipe discharge (Figure 2-1), with monitoring requirements outlined in Table 2-3. Effluent water quality samples are collected weekly during discharge, and the sub-lethal toxicity sample is collected quarterly, or monthly during discharge. Water quality samples are analyzed for hardness, alkalinity, conductivity, temperature and for the concentrations of aluminum, cadmium, iron, mercury, molybdenum, selenium, ammonia and nitrate. Mercury analysis can be discontinued if the concentrations are less than 0.10 µg/L in 12 consecutive samples.

Acute lethality testing on Rainbow Trout and *Daphnia magna* is conducted at least once per month during effluent discharges, with samples taken greater than 15 days apart (Government of Canada, 2002). Acute lethality testing is also required immediately if a deposit occurs outside the normal course of events, and twice per month if a sample of effluent is determined to be acutely lethal. Conversely, if 12 acute lethality tests conducted on effluent are determined to be not acutely lethal, the testing frequency can be reduced to once per quarter (Government of Canada, 2002). Reporting of the water quality results, and discharge volumes is required quarterly and annually to Environment Canada, under the Regulatory Information Submission System (RISS).

Table 2-3: Metal Mine Effluent Monitoring Program Requirements and Frequency

Water Quality Monitoring Stations	Monitoring Frequency	Analytical Parameters
W3 – Compliance Point	Weekly	1. Effluent Volume 2. Water Quality: in-situ field parameters, physical parameters, nutrients, and total and dissolved metals
	Quarterly/Monthly during discharge	3. Water Quality: Radium 226 and acute toxicity tests on both Daphnia magna and Rainbow trout (*Oncorhynchus mykiss*).

2.3 Groundwater Monitoring Program

The objective of the Groundwater Monitoring Program is to monitor potential impacts on groundwater from the mine project components. Groundwater-related monitoring at Minto is accomplished through monitoring groundwater wells, vibrating wire piezometers and thermistors. Monitoring areas include, but are not limited to, the dry stack tailings storage facility (DSTSF), mill area, Main Pit, Area 2 Pit, waste rock dumps, water storage pond (WSP), and areas where future mine components are planned. An additional objective of this groundwater monitoring plan is to provide for the development of baseline hydrogeological conditions in areas where future mine components are being planned, such as: Minto North Pit, Ridgetop North Pit, and Ridgetop South Pit. Groundwater monitoring instrumentation locations are shown on Figure 2-3.

Groundwater wells are sampled for water quality monitoring, as per the procedures summarized in the *Standard Guide for Sampling Ground-Water Monitoring Wells* (ASTM, 2013).

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. Thermistors are read using a basic ohmmeter and RST thermistors are read using the RST TH2016B readout unit.

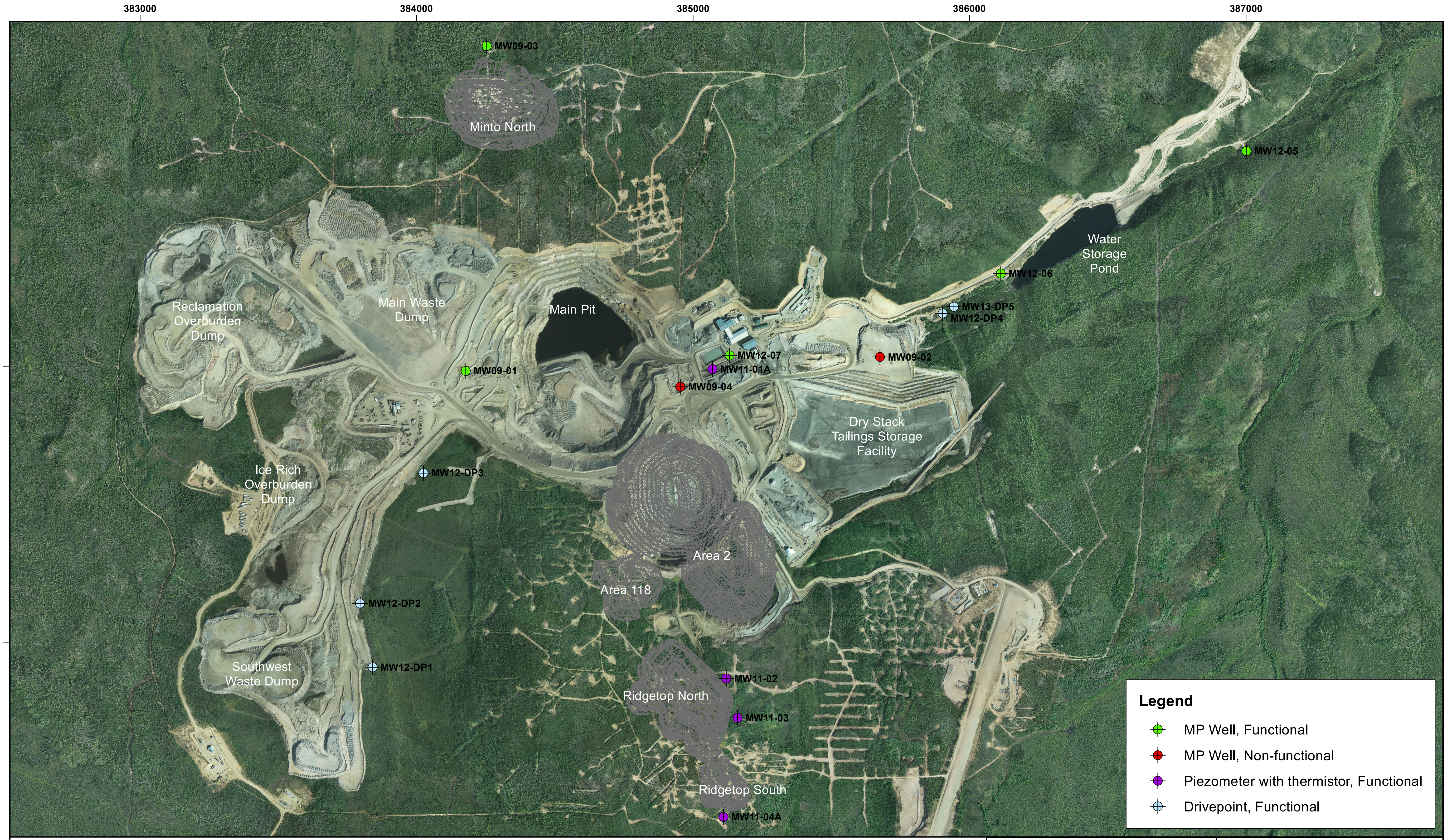
Vibrating wire piezometer strings are used to measure pore water pressure profiles in boreholes. They consist of multiple vibrating wire sensors installed on PVC pipe in grouted boreholes. RST vibrating wire piezometers are installed on site and data is collected with the RST VW2106 readout unit. The groundwater monitoring station locations, water quality analysis and monitoring frequencies are provided in Table 2-4: Operational Groundwater Monitoring Table 2-4 for operational monitoring and in Table 2-5 for baseline groundwater monitoring. The Minto Mine Groundwater Monitoring Program has been included as Appendix 3.

Table 2-4: Operational Groundwater Monitoring

Mine Project Component	Monitoring Installation	Monitoring Required	Monitoring Frequency
Main Waste Dump	MW09-01	1. Water Level 2. Water Quality Analysis: Physical parameters, Conductivity, Total Dissolved Solids, Alkalinity, sulphate, ICP Scan- Dissolved Metals Ammonia-N, Nitrate-N, Nitrite-N and Phosphorous In-situ parameters- pH, Conductivity and Temperature	Twice yearly; once in spring and once in fall
Southwest Waste Dump	MW12-DP1 MW12-DP2 MW12-DP3		
Dry Stack Tailings Storage Facility and Mill Valley Fill Expansion	MW12-DP4 MW12-06		
Main Pit	MW12-07		
Water Storage Pond	MW12-05		

Table 2-5: Baseline Groundwater Monitoring

Baseline Monitoring location	Monitoring Installation	Monitoring Required	Monitoring Frequency
North of Proposed Minto North Pit	MW09-03	1. Water Level 2. Water Quality	Twice yearly; once in spring and once in fall
East of Proposed Ridgetop North Pit	MW11-02 MW11-03		
South of Proposed Ridgetop South Pit	MW11-04		



N

500 250 0 500 Meters

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Notes:
1. Data presented in NAD 1983 UTM Zone 8N.
2. Base airphoto flown August 2012.
3. Future pit designs from October 2012.

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Site Map Showing Well Locations

Date: January 2014 Figure: 1

2.4 Seepage Monitoring Program

The objective of the Seepage Monitoring Program is to assess and monitor potential acid rock drainage and metal leaching conditions at the Minto Mine. The program includes a survey for seepage of all project components including the ore stockpile area; overburden dump; waste rock dumps including low grade, medium grade and high grade waste storage area; dry stack tailing storage facility (DSTSF); mill valley fill (MVF) area; mill area; and other known seepage locations. The monitoring locations and monitoring frequency are summarized in Table 2-6, and the analytical parameters required for water quality samples taken are also detailed in Table 2-6. Seepage survey locations and routes are shown on Figure 2-4.

Table 2-6: Seepage Monitoring Station Locations and Sampling Frequency

Survey Locations	Relevant Water Quality Monitoring Stations	Monitoring Frequency	Analytical Parameters
Ore stockpile areas	W8, W8A, W36, W37	Twice yearly; once in spring runoff conditions (early to mid-May) and once in early fall conditions (late September/early October)	Physical parameters, Conductivity, Total Dissolved Solids, Alkalinity, Sulphate, ICP Scan- Dissolved Metals Ammonia-N, Nitrate-N, Nitrite-N and Phosphorous In-situ parameters- pH, Conductivity and Temperature
Overburden dumps	W32, W38, W39, W40		
Waste rock dumps	W32, W38, W39, W40		
Drystack tailings storage facility	W8, W8A, W36, W37		
Mill Area	W8, W8A, W36, W37		
Mill Valley Fill	W8, W8A, W36, W37		
Dam Seepage	W17		

Seepage surveys are carried out along the toe of each location shown on Figure 2-4. For each seepage monitoring event, survey routes are recorded using the tracking function of a GPS. Where actively flowing seepage is encountered, a sample is collected according to the following protocols:

1. Record sample location using GPS.
2. Take three photos at each station: one close-up photograph, showing the substrate the seepage is interacting with; one upgradient photograph, showing the area from which the seepage is flowing; and one downgradient photograph, showing the seepage flow path and area that the seepage reports to.
3. Take water quality sampling using standard sampling techniques.

For each sample, field data and observations are recorded on a purpose-designed form. This form includes fields for the following information:

- Date and time of sample collection;
- Coordinates of station location;
- Weather at time of sample collection;

- Reference numbers of photographs taken;
- Field measurements of pH, conductivity, temperature;
- Sketch of the sampling location, showing any relevant features (e.g. location of toe, pools of water, trace of surface water flow, site features such as roads, ditches, sumps);
- Water colour, turbidity, and presence of any precipitates or mineral staining; and
- Colour of sediment on filter and number of filters used.

Where the location of the downgradient toe of the monitoring location changes over time, the route surveyed will change such that, for any given monitoring event, monitoring will be carried out along the downgradient toe.

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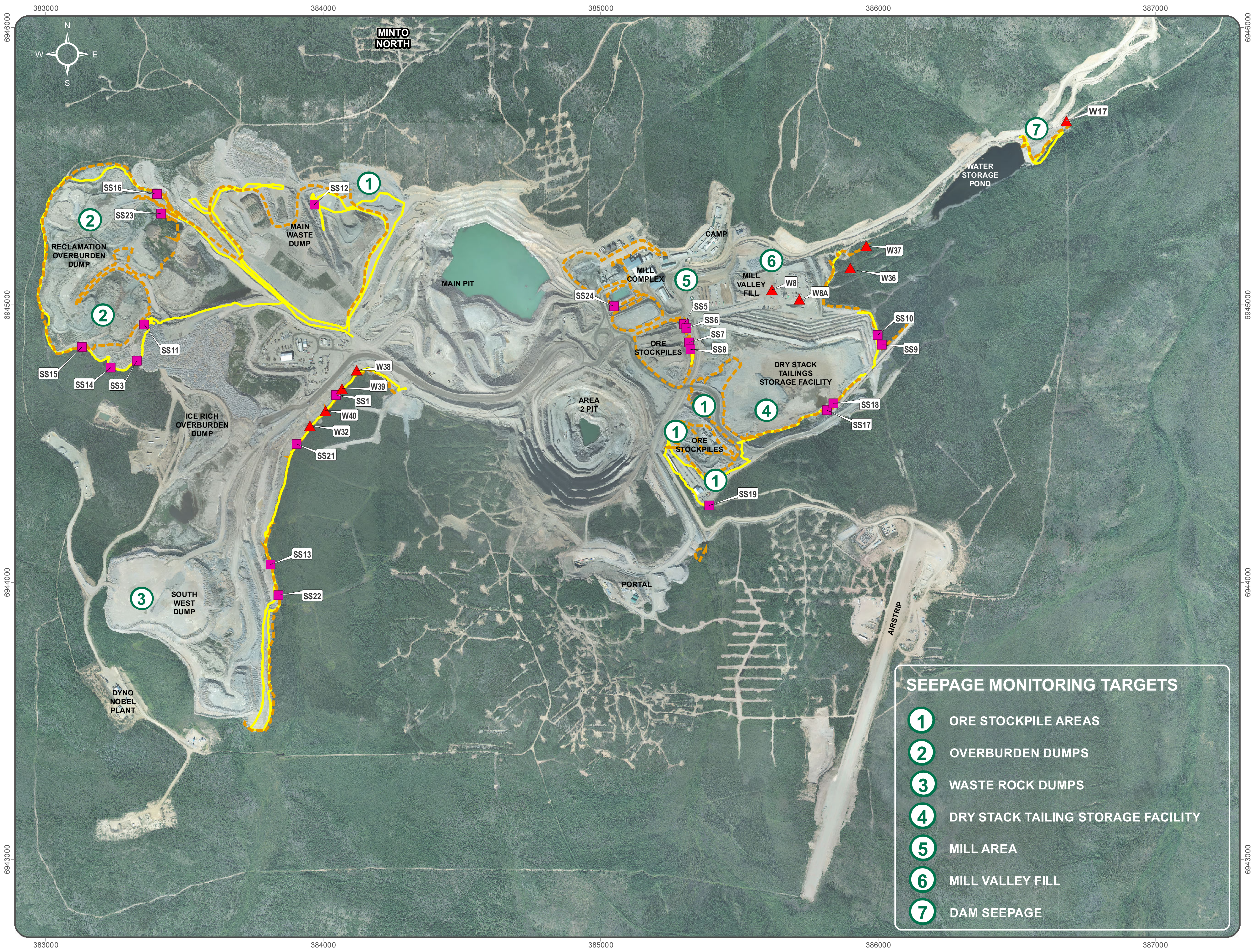
SEEPAGE MONITORING PROGRAM

JANUARY 2014



MONITORING STATIONS

- Seepage Point
- WUL Seepage Water Quality Station

SURVEY TRACKS

- Summer Seep Monitoring Survey
- Fall Seep Monitoring Survey

1:13,000

when printed on 11 x 17 inch paper

0 100 200 300 400 500

Meters

ACCESS

Aerial imagery obtained from Challenger Geomatics. Imagery acquired August 11th 2013.

Datum: NAD 83 Projection: UTM Zone 8N

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2.5 Minto Creek Detention Structure (MCDS) Seepage Monitoring Program

The Minto Creek Detention Structure (MCDS) is located to the northeast and downstream of the DSTSF (Figure 2-5). The MCDS is proposed to be decommissioned following regulatory approval of the Phase V/VI mine expansion. Generally, the objective of the MCDS Seepage Monitoring Program is to monitor the physical condition and performance of the MCDS. The MCDS seepage monitoring program includes regular physical monitoring, MCDS pond water level recording, installation and monitoring of ground temperature cables and assessment of foundation thawing, contaminant monitoring and transport assessment, and the establishment of appropriate triggers and adaptive responses. Monitoring at the MCDS is summarized in Table 2-7. When the MCDS is decommissioned, a new facility of some kind will be constructed at the toe of the expanded Mill Valley Fill extension. Appropriate monitoring for a new facility will be incorporated into the monitoring programs in the EMSRP.

Table 2-7: MCDS Seepage Monitoring Program

Component	Requirement	Frequency
Physical Monitoring	Annual physical inspection	1. After the spring thaw period in May/June 2. Prior to the on-set of winter in September*
	Monthly inspection	Monthly during non-winter months
Groundwater sampling	Water quality analysis for: in-situ field parameters, physical parameters, nutrients, and dissolved metals	Semi-annual (spring & fall)

***As part of the Phase V/Vi licencing, Minto suggests that bi-annual inspections be reduced to once per year and to be completed after the spring thaw period.**

2.5.1 Physical Monitoring

Physical monitoring and reporting on the MCDS is performed on a bi-annual basis as part of the annual physical inspections. The annual physical inspection is completed after the spring thaw period in May/June of each year and again prior to the on-set of winter in September and is done by a qualified professional engineer licensed to practice in the Yukon.

In conjunction with the annual physical inspections, Minto performs a monthly inspection (during non-winter months) based on the inspection checklist provided in Figure 2-6. The purpose of the inspection is to identify early signs of settlement, erosion, and piping as well ensuring the spillway remains clear of debris. Any signs of physical degradation of the MCDS will be passed onto a qualified engineer for further inspection and remedial recommendations, with follow-up actions conducted as recommended.

2.5.2 Instrumentation

The current MCDS is a temporary installation, pending the approval and construction of the extended Mill Valley Fill Extension, the MCDS will be decommissioned. The planned location of a ground temperature cable was at station GTC-1 on Figure 2-5. To date, the installation of the ground temperature cable has not be completed, due to the temporary nature of the current MCDS. A ground temperature cable (if required by the final design), will be installed at the proposed new location and structure.

2.5.3 Groundwater Quality Monitoring

Drive point piezometers (DPP) were installed in 2012 and 2013 at stations DP-1 and DP-2, respectively, on Figure 2-5. The purpose of groundwater sampling downstream of the MCDS is to compare downstream groundwater quality to other groundwater sampling sites and to surface water quality in the MCDS. Water quality data gathered from groundwater well MW12-06 (Table 2-4) located downstream of the MCDS will be analyzed in conjunction with the data collected from the drive point piezometers, surface water downgradient of the MCDS (W37 station) and the MCDS pond (W36 station).

2.5.4 Triggers and Responses

WUL QZ96-006 requires appropriate triggers and responses for the MCDS. The monitoring requirement, triggers and corresponding potential responses are summarized in Table 2-8.

Table 2-8: MCDS Triggers and Responses

Monitoring	Triggers	Response
Physical Monitoring	Observations by Engineer	Engineer to develop a remedial action plan to manage the observed deficiencies.
Pond Levels	Lack of freeboard to manage large storm events or freshet	Water to be pumped to the Area 1 Pit if the Water Storage Pond levels reach the point where freeboard is limited.
Groundwater Quality	Groundwater Quality trends towards that contained in the MCDS	Reassess functionality of MCDS in terms of its water retention capabilities.

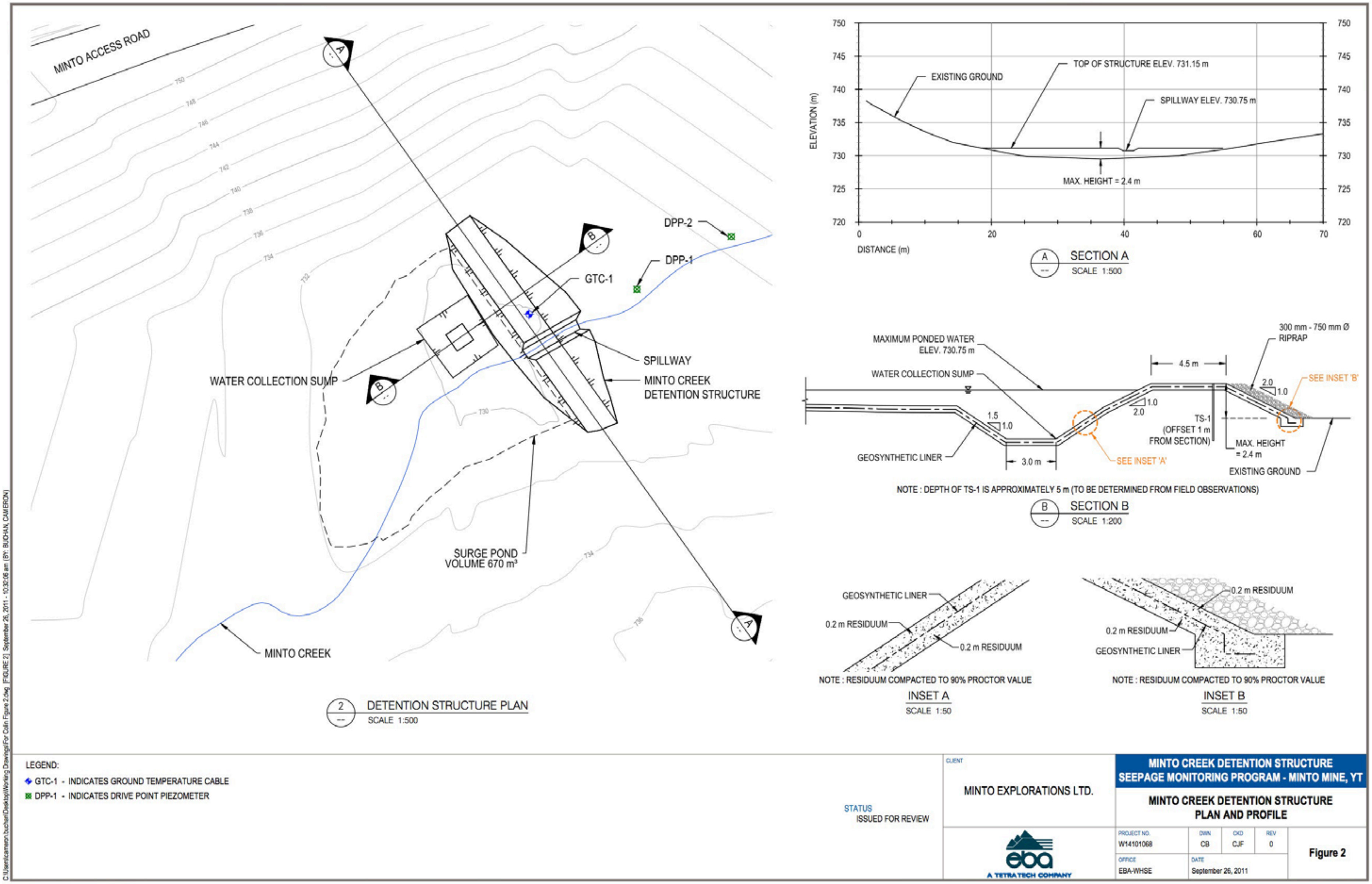


Figure 2-5: Minto Creek Detention Structure Plan and Profile

MCDS INSPECTION TRACKING				
Date				
Inspector				
Slope/Berm Conditions				
Settlement, sink holes, bulges, sloughing				
Cracking				
Erosion rills/gullies				
Rip Rap Movement				
Seeps				
Pond Conditions				
Water Level				
Foreign materials/obstructions				
Settlement/Cracks at the bottom of the pond				
Abnormal and continuous water bubbles				
Inlet and Outlet Conditions				
Proper water flows in inlet				
Water in Outlet/Down Stream				
Obstruction/Vegetation clog outlet/inlet				
Cracks/Settlement/Soil Collapse on outlet/inlet slopes				
Pump and Pipe Conditions				
Proper pump operation				
Foreign materials/obstructions				
Damage/Leakage on Pipelines				
Notes				

Figure 2-6: MCDS Inspection Form

3 Geochemical Monitoring Program

Geochemical monitoring is required under the existing version of WUL QZ96-006 (in particular, in Appendix 6- ABA Test Program), and the Geochemical Monitoring Program described here is intended to replace the monitoring described in the existing Amendment 8 licence.

The Geochemical Monitoring Program is comprised of two main components:

- The Acid Base Accounting (ABA) Program, which provides for monitoring of overburden and waste rock derived from the underground and open pit mining operations, and tailings from milling; and
- The Waste Rock Management Verification Program.

These programs are detailed in sections 3.1 and 3.2. Details relating to the waste rock sampling and analysis is provided in the *Minto Mine Phase V/VI Expansion Waste Rock and Overburden Management Plan* (WROMP) (Minto Explorations Ltd., 2014).

3.1 Acid Base Accounting (ABA) Monitoring Program

3.1.1 Internal (On-site) Monitoring

On-site ABA monitoring will be carried out on drill cuttings from every blast hole, as is currently the practice for Phase IV operations. Samples are collected for grade control purposes, and a portion of each sample is sent for total sulphur (S(T)) and total carbon (C(T)) analyses at the on-site laboratory.

Following analysis, S(T) and C(T) results are converted into equivalent acid potential (AP-S(T)) and neutralization potential (NP-C(T)) values, and NP-C(T):AP-S(T) ratios are calculated for each sample. The NP-C(T):AP-S(T) values are plotted for each drill hole in a given blast pattern (along with other assay results), and mine geologists use the mine's grade control software to define polygons outlining contiguous zones of waste rock types- either bulk waste or waste with an NP-C(T):AP-S(T) ratio less than 3.0. Additional details about on-site monitoring and waste handling procedures can be found in the WROMP (Minto Explorations Ltd., 2014).

3.1.2 External (Off-site) Verification

Composite samples from each waste class for each blast are formed from the individual samples that are subject to on-site monitoring for S(T) and C(T). These composite samples are both tested on-site and sent off-site to a commercial laboratory to provide external verification for quality control purposes. The external verification samples will be analysed for a broader range of parameters, including paste pH, total sulphur, sulphate sulphur, total inorganic carbon, modified neutralization potential (Modified NP) and metals by aqua regia digestion with ICP finish. Modified NP will be analysed using the MEND (1991) method to allow direct comparison with pre-production characterization (MEND, 1991).

3.1.3 Summary of Sampling and Analytical Frequency

A summary of the ABA sampling methods that are used by the mine for collection of overburden, waste rock, tailings solids, and construction materials are summarized in sections 3.1.5, 3.1.6, and 3.1.7 respectively. ABA sample frequency, sample type and analysis requirements are summarized in Table 3-1.

Table 3-1: Acid Base Accounting Monitoring Program Requirements

Material	Sample Frequency	Sampling Type	Analytical Requirement
Overburden	Sampled when overburden is mined	Representative sampling whenever overburden is mined	1. Internal Laboratory: S(T) and C(T) 2. External Laboratory: ABA and trace element analyses
Open Pit Waste Rock	Each blast hole	Split of grade control sample (single hole composite of blast hole cuttings)	1. Internal Laboratory: S(T) and C(T)
	One composite sample per waste class per blast containing >25% waste	One composite sample per waste type comprised of 4-5 individual samples that are collected at a rate of approximately 1 sample for every 7 holes drilled	2. External Laboratory: ABA and trace element analyses
Underground Waste Rock	One sample for every 50m of development (represents ~ 3300 tonnes of waste rock)	Representative composite grab sample from transfer pad pile	1. Internal Laboratory: S(T) and C(T)
Tailings Solids	Monthly	One composite sample per month comprised of weekly final tailings sample	1. External Laboratory: ABA and trace element analyses

3.1.4 ABA Program Reporting

Analytical results are added to the existing mine ABA database and will be reported on an annual basis as part of the WUL Annual Report. The report will include:

- a comparison between new and historical data (including discussion),
- a comparison of NP/AP and sulphide sulphur (log NP/AP versus log percent sulphide sulphur graph).

3.1.5 Overburden and Waste Rock

The objective of the overburden and waste rock ABA test program is to classify all overburden, waste rock and low grade, partially oxidized material mined at the Minto Mine and disposed of on surface. Classification is done through a combination of logging of lithology and related characteristics by the mine geologist during sample collection, and subsequent chemical analysis (determination of copper, sulphur and carbon content). Further details of the segregation of waste rock at Minto Mine is detailed in the *Minto Mine Phase V/VI Expansion Waste Rock and Overburden Management Plan* (submitted as part of Phase V/VI Project Proposal). SOPs support the execution of the program and ensure that consistent field observations and sampling protocols are followed. Brief summaries of sampling procedures for open pit and underground waste rock are included in the following two subsections for reference.

3.1.5.1 Open Pit Waste Rock

The sampling procedure for sampling for open pit development waste is summarized in Figure 3-1.

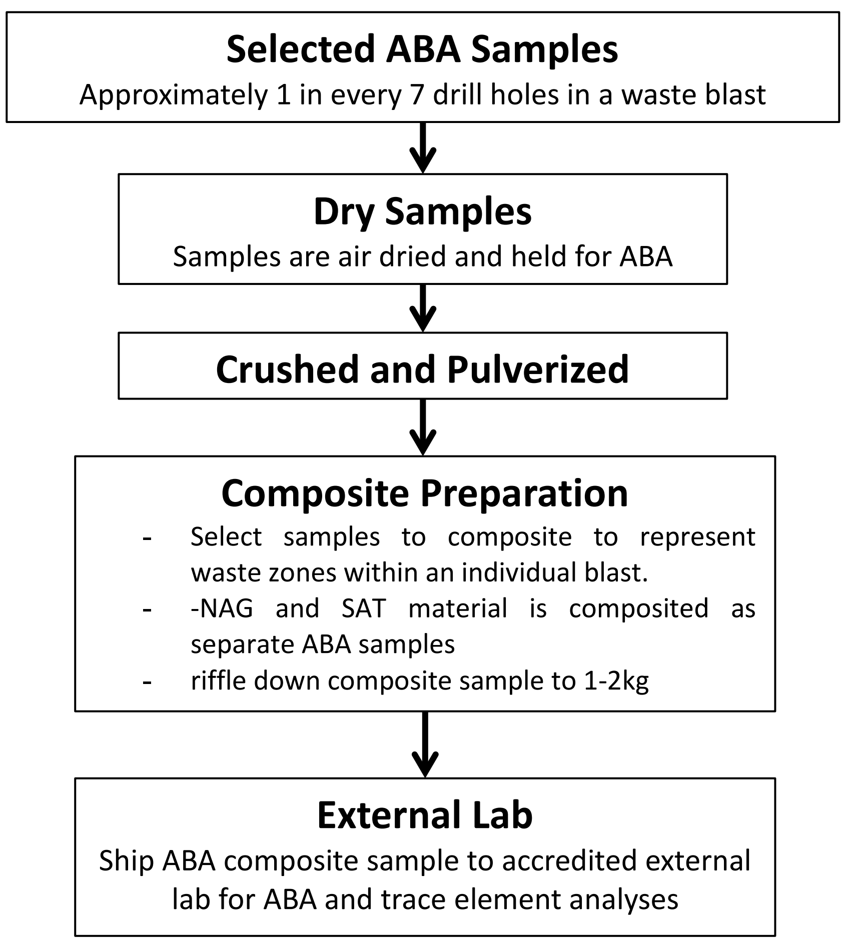


Figure 3-1: Open Pit Drill Hole ABA Sampling Flow Chart

3.1.5.2 Underground Development Waste

The sampling procedure for sampling for underground development waste is summarized in Figure 3-2, and is detailed below.

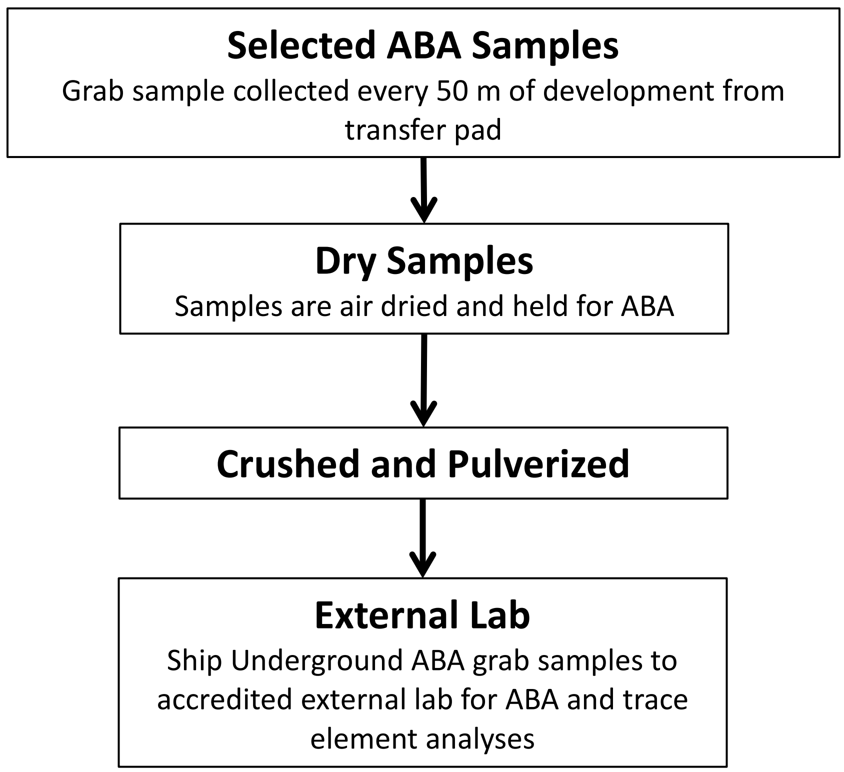


Figure 3-2: Underground Waste Rock ABA Sampling Flow Chart

3.1.6 Tailings Solids

The objective of the tailings solids monitoring program is to maintain an inventory of the geochemical properties of the tailings produced during the project life. This is achieved through analysis of monthly composite tailings samples that are formed by combining weekly grab samples. Each week, a grab sample is collected which contributes the monthly composite sample. The monthly composite is air dried and sent to an accredited laboratory for ABA and trace element analysis. Analytical results are added to the existing mine database and reported on an annual basis as part of the WUL Annual Report..

3.1.7 Construction Materials

ABA test work must be conducted on all mined materials proposed for use in construction. Testing of potential construction material will occur during routine pit operations as described in Section 3.1.5, and will be carried out on-site. Construction material must meet the following requirements to be used for construction:

- NP-C(T):AP-S(T) > 3;
- Total sulphur content < 0.3%.

3.2 Waste Rock Management Verification Program

The Waste Rock Management Verification Program supports the waste rock management procedures at the mine. The program was developed to address clause 95 of WUL96-006 Amendment 8, and results of this program will be detailed in the annual report.

The program includes detailed record-keeping on the types and quantity of waste rock placed at each location, and monitoring and verification of the characteristics of the waste rock stored at each location as per the *Waste Rock and Overburden Management Plan*.

Minto tracks all material dispatched between sources and destinations generated using the mine's production tracking database system. This data is based on load count sheets compiled by the mining contractor.

Monthly dump sampling program has also been initiated. The procedure is as follows:

1. At monthly intervals, mine personnel will visit every dump crest that was active over the preceding month, as determined by an analysis of the production tracking database system.
2. At 25 m intervals along each active dump crest, the waste rock will be manually sampled.
3. For each sample, one shovel-full of material will be collected and labelled. Particles greater than fist size will be manually rejected at the time of sampling.
4. The resulting samples will be crushed, pulverized, and split in Minto's assay lab such that a representative sample is obtained.
5. Each sample will be analyzed at site for copper, total sulphur (S(T)), and total carbon (C(T)) content using an Eltra CS-800 induction furnace with infrared detectors.
6. S(T) and C(T) values are converted into equivalent acid potential (AP-S(T)) and neutralization potential (NP-C(T)) values, and NP-C(T):AP-S(T) ratios are calculated for each sample.
7. Resulting NP-C(T):AP-S(T) ratio values are compared to the segregation criteria and assigned 'Pass' or 'Fail' verification designations.

The results of both the inventory update and the as-built monitoring and verification will be presented in Minto's annual report to the Yukon Water Board.

Isolated failures will be accepted with no further action.

If two or more adjacent failures occur, the crest will be resampled at 5 m intervals over each 25 m crest section represented by the failed samples. Sampling and analysis will follow steps 3 through 6 in the procedure described above. The average copper grade and NP-C(T) and AP-S(T) for the suspect zone will be calculated, and then the (Average NP-C(T)) : (Average AP-S(T)) ratio value for the zone will be calculated.

If the calculated bulk zone NP-C(T):AP-S(T) ratio is below the segregation criteria for the dump, further sampling will be carried out to define the limits of the zone in three dimensions. The non-conforming material will be excavated and relocated to one of the waste rock dump locations that will ultimately be saturated; no relocation will occur if the non-conforming waste rock is already located where saturated conditions will exist in the long term (i.e. in an in-pit dump below the expected final water table elevation).

4 Meteorological Monitoring Program

Meteorological Monitoring at the Minto Mine consists of meteorological monitoring and data collecting, including data on rainfall, snowfall, temperature, evaporation, wind speed and direction, and total sunshine hours. The Meteorological Monitoring Program is comprised of the Climate Monitoring Program (section 4.1) and the Snow Survey Program (section 4.2).

Data collected under the Meteorological Monitoring Program, along with baseline climatic data, provides input for the following mine projects:

- Site water management;
- Prediction for yearly water events (e.g. freshet);
- Design of water storage, conveyance and discharge systems; and
- Design of flood control structures on the road network.

4.1 Climate Monitoring Program

The objective of the Climate Monitoring Program is to collect climatic data specifically for the Minto Mine site. The monitoring areas consist of a meteorology station located north east of the Minto Mine airstrip. The meteorological station logs parameters at hourly intervals. The loggers are downloaded twice per month. During the download process, staff inspect the meteorological station for inoperative equipment.

The meteorology station is a research grade Campbell Scientific station that records the following parameters: maximum wind speed, minimum wind speed, average wind speed, wind direction, precipitation (rain and snow), temperature, relative humidity, barometric pressure, solar radiation and calculated evapotranspiration.

Data is downloaded, compiled and reported in monthly and annual water use licence reporting.

4.2 Snow Survey Program

The objective of the Snow Survey Program is to collect snow data used for calculating the snow water equivalent specifically at the Minto Mine. Snow water equivalents are inputs to the Minto Mine Site Water Balance models. Three courses are surveyed during the first week of February, March & April each year. These courses are East-facing (near the Dyno compound), North-facing (near the airstrip) and South-facing (above the Tank Farm), detailed in Table 4-1. Along each course, ten stations are sampled using a machined core tube with cutting end and scale with assembly. The parameters collected during the surveys include snow depth, core length, core weight, snow density, weather, site conditions, snow conditions, crust layers, and snow temperature.

Table 4-1: Snow Survey Course Locations

Course Location	Description	Aspect	UTM	
			Easting	Northing
Dyno	East of the Dyno compound on an east facing slope along a cut line surrounded by moderately densely tree area.	East Facing	8V 383 594	694 3377
Fuel Farm	North of the Minto Mine fuel farm on a south facing slope in a sparse to moderately densely treed area.	South Facing	8V 385 061	694 5318
Airstrip	Northeast of the Minto Mine airstrip on a north facing slope in a sparsely treed area.	North Facing	8V 386 255	694 4284

Snow sampling procedures are conducted following a standard operating procedure, developed in accordance with the BC Ministry of Environment's *Snow Survey Sampling Guide* (Ministry of Environment, 1981). A sample field data sheet is provided in Figure 4-1.

Surveyors:	
Driving wrench used? (Y/N)	

Station No.	Snow depth (cm) With dirt plug	Snow depth (cm) Without dirt plug	Core Length (cm)	Weight: Tube & Core	Weight: Tube only before sampling	Snow Water Equivalent (cm)	Density (%)
1	64	62	54	39	24	15	24.2
2	63	61	48	36	24	12	19.7
3	69	67	56	39	24	15	22.4
4	67	65	49	38	24	14	21.5
5	67	65	52	39	24	15	23.1
6	69	67	53	38	24	14	20.9
7	71	69	53	39	24	15	21.7
8	72	70	61	41	24	17	24.3
~~9~~	~~73~~	~~71~~	~~63~~	~~42~~	~~24~~	~~18~~	~~25.4~~
10	76	74	63	42	24	18	24.3
11	76	74	60	40	24	16	21.6
12	70	67	56	39	24	15	22.4
Total	694	674	549	391	240	151	246.1
Average	69.4	67.4	54.9	39.1	24	15.1	22.4

Checked by (initials & date):

Field Notes:

			Snow Temp:	-6°C
Weather: Clear & sunny			Remarks: Density range: 19.7 to 24.3% = 4.6% Av core to snow depth = 81% Station 9 discarded (outlier).	
Surface snow conditions:				
Wet	Soft			
Dry X	Crusted X			
Flat	Drifted			
Freeze	Thaw			
Sampling conditions:				
Easy	Moderate	Difficult		

Figure 4-1: Sample Snow Survey Field Form

5 Physical Monitoring Program

The objective of the Mine Infrastructure and Workings (Physical) Monitoring Program is to monitor the performance of key mine infrastructure and workings. Mine infrastructure that requires monitoring under the Mine Infrastructure and Workings Monitoring Program, the infrastructure descriptions and instrumentation in place are outlined in Table 5-1. The program consists of two main components: instrumentation to measure ground conditions and deformation; and, regular geotechnical inspections. The roles and responsibilities for each component of the program are summarized in Table 5-2. More details regarding the components of the program can be found in Appendix 4, the *Minto Mine Physical Monitoring Plan.*

Table 5-1: Mine Infrastructure and Workings Monitoring Program Requirements

Structure	Description	Instrumentation
Area 1 Pit (Main Pit)	Mining in the Area 1 Pit is complete and the pit is now used as a tailings storage facility. As such, no in-pit deformation monitoring is carried out. 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 construction of a waste rock buttress, known as the **South Wall Buttress**, in the pit along the south wall, completed in 2013. Instrumentation is currently monitored along the south rim of the pit to detect any continued movement of the wall and buttress.	• Survey hubs • Inclinometer
Area 2 Pit	The Area 2 Pit is completed to the extents licensed under Phase IV; the pit will be extended to the south as part of Phase V/VI. As part of Phase IV, a portal was created at the bottom of the pit to access an underground ore zone. Monitoring is therefore ongoing. The highwall crest is monitored via survey hubs to measure large scale stability of the wall. The highwall is monitored by realtime radar-based slope stability measurements, and a program of weekly inspections and prism readings monitors those portions of the wall not actively scanned by the radar.	• Survey hubs • Prisms • Radar
Area 118 Pit	Mining of the Area 118 Pit commenced in January 2014. Survey hubs are monitored along the northeast crest of the pit between Area 118 and Area 2. In-pit monitoring currently consists of regular inspections. Prisms will be installed along catch benches as mining progresses.	• Survey hubs • Prisms
Dry Stack Tailings Storage Facility (DSTSF)	Tailings placement was completed in November 2012; subsequently, a layer of overburden was placed over the stack as part of progressive reclamation activities. The DSTSF began showing deformation in 2009; the movement has been monitored continuously since then via inclinometers, which are typically short-lived due to the rate of deformation, and survey hubs. Ground temperature cables and piezometers have also been installed to better understand foundation conditions and to provide data for analytical work. The deformation is interpreted as primarily horizontal sliding towards the north/northeast on an ice-rich layer in the underlying overburden, several meters above bedrock.	• Survey hubs • Thermistors • Inclinometers • Piezometers
Mill Valley Fill Extension (MFVE)	A waste rock buttress to the north of the DSTSF, constructed from January 2012 to March 2013 in an attempt to prevent or decrease further movement of the DSTSF.	• Survey hubs • Inclinometers

Structure	Description	Instrumentation
Ice-rich Overburden Dump (IROD)	Originally constructed as a free-standing rockfill structure to contain a volume of ice-rich overburden. It is now entirely surrounded by the Southwest Dump rockfill which extends a minimum 210m down-slope. The crest and contents of the IROD are visually inspected once per year. No instrumentation is installed in the IROD.	None
Mill Water Pond (MWP)	The mill water pond is a small water storage pond used for excess process water and recirculation of mill process water.	• Thermistors
Minto Creek Detention Structure (MCDS)	Detains surface water considered impacted from upstream sub-catchment areas and directs it to the Area 1 pit or water treatment plant. Extensive instrumentation related to the MVFE is near the MCDS; however, no instrumentation specific to the MCDS is installed.	None
Reclamation Overburden Dump (ROD)	Received the bulk of the overburden released as part of Phase IV and earlier mining of the Main pit. Due to the nature of the material placed within the dump, small-scale sloughs are expected and have been noted. Annual visual inspections have not noted large tension cracks that could be indicative of differential settlement. The dump is inspected annually, and contains no survey hubs or instrumentation. The material in the ROD is available for use in reclamation of the mine at closure.	None
Southwest Waste Rock Dump (SWD)	The southwest waste rock dump (SWD) is currently the main active waste rock dump at Minto. Design details on the SWD are contained in the report "Waste Rock and Overburden Management Plan" for Phase IV mining.	• Survey hubs • Inclinometers • Thermistors • Piezometers
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
Main Waste Dump (MWD)	This dump stores waste released during the mining of the first three stages of the Main pit. The dump is founded on bedrock. Movement below the toe is monitored by a single inclinometer.	• Inclinometers

Table 5-2: Physical Inspection Roles and Responsibilities

Role	Responsibilities
Geotechnical technicians	• Collect instrumentation data at specified frequencies • Input data into monitoring spreadsheets/databases • Internal reporting of monitoring data • Maintain equipment
Geotechnical Engineer	• QA/QC of data collection • Ensure compliance with license requirements • Monthly, quarterly and annual water use license (WUL) reporting • Visual inspections at specified frequencies • Review and update Physical Monitoring Plan
Chief Engineer	• Review annual WUL/QML report • Ensure compliance with license requirements

6 Aquatic Environmental Monitoring Program

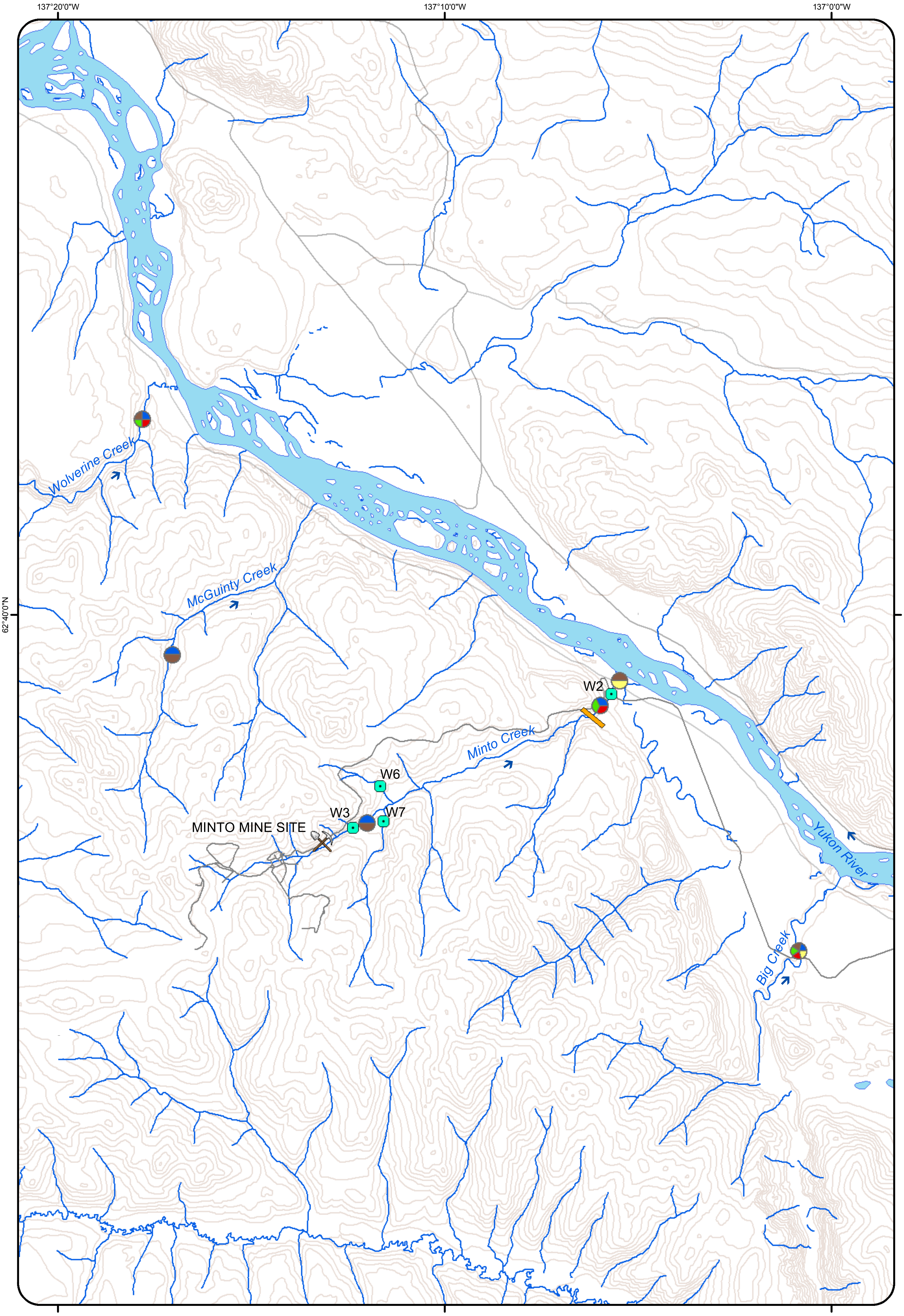
The Aquatic Environmental Monitoring Program at Minto Mine is comprised of a Biological Monitoring Program and an Environmental Effects Monitoring Program. The Biological Monitoring Program is a requirement of WUL clause 86, and outlines the monitoring program for sediment, periphyton, benthic invertebrates and fish and fish habitat. The Environmental Effects Monitoring Program is required under the MMER of the federal Fisheries Act (Government of Canada, 2002). Both programs focus on aquatic effects of mine effluent in Upper Minto Creek (discharge sites), Lower Minto Creek (receiving environment sites) and comparable unaffected areas (reference sites).

6.1 Biological Monitoring Program

The Biological Monitoring Plan includes monitoring for sediment, benthic invertebrates, periphyton and fisheries, and each program is detailed below. Monitoring is conducted during the open water season on the Minto Creek watershed and reference systems (where applicable). Biological monitoring program sampling locations and frequencies are summarized in Table 6-1 and the sample stations are shown on Figure 6-1. Monitoring and measurements are taken according to the *Canadian Aquatic Biomonitoring Network Field Manual* (Environment Canada, 2011).

Table 6-1: Biological Monitoring Program Sample Locations and Frequency

Monitoring Requirement	Locations		Frequency
	Affected Area	Reference Area	
Sediment Monitoring	Upper Minto Creek (near water quality station W3)	Upper McGinty	Annually (late August or early September)
	Lower Minto Creek (downstream of water quality station W2)	Lower Wolverine Creek	
Benthic Invertebrate Community Monitoring	Lower Minto Creek (downstream of water quality station W2)	Lower Wolverine Creek	
Periphyton Monitoring Program	Lower Minto Creek (downstream of water quality station W2)	Lower Wolverine Creek	
Fisheries Monitoring Program	Lower Minto Creek below the canyon	Lower Big Creek	Monthly (during the open water season)



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MAP INFORMATION
Map Projection: NAD 1983
Data Source: Department of Natural Resources Canada. All rights reserved.
Created By: J.Wilson
Creation Date: March 2013
Project No.: 2461

Features

Mine Site

SAMPLES COLLECTED

- Water
- Sediment
- Periphyton
- Benthos
- Fish

- Water Quality Station
- Fish Barrier
- Water Flow
- Contours (30m interval)
- Roads

Figure 2.1: Monitoring Areas for the Minto Creek Sediment, Periphyton, and Benthic Invertebrate Community Assessment – 2012

Created by:
minnow environmental inc.

6.1.1 Sediment Monitoring Program

The objective of the Sediment Monitoring Program is to monitor the sediment quality of Minto Creek and to provide data to allow interpretation of the potential influence of the Minto Mine on sediment quality. Sediment data analysis is performed using temporal comparisons, spatial comparisons (control-impact design) and comparisons to the *Canadian Environmental Quality Guidelines* (CEQG) for sediment (CCME, 2014).

Specific monitoring areas include upper Minto Creek (near water quality monitoring station W3), lower Minto Creek (downstream of water quality station W2) and two reference areas (Upper McGinty Creek and lower Wolverine Creek). Sampling is to target deposits of fine sediments (silt and clay) in quiescent pools and wetted backwater locations (i.e., depositional locations). Each monitoring area is sampled five times, and the five samples are to be separated by at least three creek bankfull widths. Supporting water quality measures are recorded at each monitoring area including in-situ temperature, dissolved oxygen, specific conductance and pH. Samples are submitted to a Canadian Association for Laboratory Accreditation (CALA) accredited analytical laboratory for the analysis of particle size distribution (gravel, sand, silt and clay), total organic carbon, metals and total Kjeldahl nitrogen.

Sampling methodology is detailed as follows:

1. For samples in upper Minto Creek and the matched reference area:
   - Collect sample using a stainless steel or Teflon spoon or scoop with only the top two centimeters of deposited sediment collected.
   - Each sample to be made up of at least 10 scoops per sample.
2. For samples in lower Minto Creek and the matched reference area:
   - Collect sample using a petite ponar (samples for particle size distribution characterization) and a hand corer (samples for chemical characterization).
   - Only the top two centimeters of deposited sediment to be collected to form the sample (using a stainless steel or Teflon spoon or scoop for the samples collected by petite ponar and a core extruder and core knife for the sample collected by coring).
   - Each sample to be comprised of three grabs (particle size) or cores (chemistry).

6.1.2 Benthic Invertebrate Monitoring Program

The objective of the Benthic Invertebrate Monitoring Program is to monitor the condition of the benthic invertebrate community of Minto Creek and to provide data to allow interpretation of the potential influence of the Minto Mine on the benthic invertebrate community using temporal comparisons and spatial comparisons (control-impact design). This monitoring is to be conducted in addition to benthic invertebrate community monitoring required every three years as part of Environmental Effects Monitoring (EEM) under the Metal Mining Effluent Regulation of the federal *Fisheries Act* (Government of Canada, 2002). An effects assessment on benthic invertebrates is also required under the MMER EEM program on the same cycle as the EEM monitoring occurs (section 6.2).

Specific monitoring areas include lower Minto Creek (downstream of water quality station W2) and Lower Wolverine Creek (reference site). Each monitoring area is sampled five times using a Hess sampler. Each sample is a composite of three grabs. Supporting habitat measures and in-situ water quality parameters are recorded at each monitoring area. A water quality sample for physical parameters, nutrients, total metals, dissolved metals and dissolved organic carbon is performed concurrent with periphyton sampling. Taxonomy to be performed to "lowest practical level" and data to be summarized using the endpoints specified in Environment Canada (2011).

Collect supporting habitat and water quality measures:

Habitat measures*	**Supporting water quality measures**
– Substrate characterization (100 pebble count)	– Temperature
– Water velocity	– Dissolved oxygen
– Sample depth	– Specific conductance
– Creek width (wetted and bankfull)	– pH
– Cover description	

*Habitat measures are recorded as per the *Canadian Aquatic Biomonitoring Network Field Manual* (Environment Canada, 2011)

6.1.3 Minto Creek Annual Fisheries Monitoring Program

The objective of the Minto Creek Annual Fisheries Monitoring Program is to monitor, assess and characterize fish usage in Minto Creek and to provide data to allow interpretation of the potential influence of the Minto Mine on the fish community. The Minto Creek Annual Fisheries Monitoring Program focuses on Chinook salmon, however, characterization of other species such as slimy sculpin, arctic grayling and round whitefish also takes place. Usage and characterization is primarily focused on extent and timing of use as well as quantitative use. While the EEM program (Government of Canada, 2002) requires fisheries monitoring every two to three years, the Minto Creek Fisheries Monitoring Program is conducted annually to establish consistent reports on usage and characterization.

Specific monitoring areas include lower Minto Creek below the canyon (Figure 6-1), as it is known that only lower Minto Creek (below the canyon) is used by fish during the open water season. Further, a natural barrier to fish passage was confirmed during a 2010 study at (approximately) 1.2 km up from the Yukon River. Past observations have indicated that the area at the confluence of Minto Creek and the Yukon River is not used by spawning salmon or other species. The annual fisheries program will however, continue to observe for and report on the use of the confluence zone by spawning salmon and other species.

Sampling methodology is as follows:

- Sampling is conducted monthly during the open water season from late June/early July through November.

- Known juvenile habitat is targeted, such as eddies, deep pools, and calmer waters with shady areas and/ or woody debris.
- Gee-type Minnow traps (with ¼" mesh) are placed at monitoring site locations, and left to soak for 24 hours.
- Traps are baited using Yukon River origin Chinook salmon roe.

- Data is collected on the fish caught, including the following parameters:

Captured fish data	Trapping location information	In-situ water quality
– Fish identification	– GPS coordinates	– Temperature
– Number of fish caught	– Physical description	– Dissolved oxygen
– Fork length (mm) or total length (mm)*	– Photo of site	– Conductivity
– Abnormalities	– Weather conditions	– Flow

*Total length measurement is for sculpins or burbot

- Following data collection all fish are released at the same location as where they were trapped.
- Data analysis will be performed to quantify relative use of Minto Creek and will be reported through determination of Catch Per Unit Effort (CPUE). Annual reporting will also include a description of water chemistry in the receiving environment and mine discharge actions during the open water period.

6.1.4 Periphyton Monitoring Program

The objective of the Periphyton Monitoring Program is to monitor the condition of the periphyton community in Minto Creek. 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 algae community. Attached algal communities are representative of the lowest trophic level and are indicators of productivity. Periphyton data analysis is performed using temporal and spatial comparisons (control-impact design).

Periphyton sampling for community assessment is conducted by collecting randomly selected rocks on suitable substrate (cobbles). Periphyton samples are collected from Lower Minto Creek (in the vicinity of water quality station W2), and at a reference area with similar habitat characteristics (i.e., substrate texture, water velocity, water depth). At each station approximately 2 – 5 grams of periphyton sample is collected. C*hlorophyll a* density is measured in periphyton. Supporting habitat measures and in-situ water quality parameters is measured concurrent with benthic invertebrate samples and described above in Section 6.1.2.

Sampling methodology for community assessment is as follows:

- Collect sample from suitable substrate through scraping or brushing.

- Samples from each station are combined till approximately 2 – 5 grams of periphyton sample is collected.
- Repeat sample procedure at the same sample site and target five replicate samples.
- Place scraped sampled into jars, preserve with Lugol's iodine solution, labeled with station name and replicate number.
- Store sample jars in a cool dark place.
- Samples are shipped to a plant taxonomist for identification.
- Laboratory taxonomy is conducted to the "lowest practical level".

Sampling methodology for *Chlorophyll a* is as follows:

- Collect sample from suitable substrate through scraping or brushing.
- Measure the surface area sampled at each station
- Transfer sample material to filter paper
- Place folded filter paper in a labeled opaque centrifuge tube
- Store sample jars in a cool dark place.
- Samples are shipped to the analytical laboratory

6.2 Environmental Effects Monitoring Program

The Environmental Effects Monitoring (EEM) Program was developed in accordance with Schedule 5 of the MMER (Government of Canada, 2002) and its objectives are to characterize the impact of effluent on the receiving environment through water quality and biological monitoring. The EEM Program is comprised of the EEM Water Quality Program (section 6.2.1) and the EEM Biological Monitoring Program (section 6.2.2).

6.2.1 EEM Water Quality Monitoring Program

The EEM Water Quality Monitoring Program is designed to characterize water quality in the exposure area surrounding the point of entry of effluent and compares the results to those in reference (un-impacted) areas. Water quality samples must be collected four times a year, not less than one month apart, while the mine is discharging effluent. Water quality samples are also collected concurrently with the Biological Monitoring Program samples. Samples are collected at receiving environment station W2 and reference station W7.

Water quality measurements and analysis are as follows:

In-situ measurements	Analytical Measurements
– Temperature	– Concentrations of As, Cu, CN, Pb, Ni, Zn, TSS, Ra226
– Dissolved oxygen	– Cyanide analysis is not required if cyanide is not used as a

– pH – Hardness – Alkalinity – Conductivity	process reagent. – Ra226 analysis may be reduced to quarterly if the concentration is <0.037 Bq/L in 10 consecutive tests.

Water quality monitoring results are reported annually through Environment Canada's RISS website.

6.2.2 EEM Biological Monitoring Program

The EEM Biological Monitoring Program outlines fish population, fish tissue and benthic invertebrate tests conducted under Schedule 5, Part 2 of the MMER (Government of Canada, 2002). Minto Mine has submitted the results of the First Study Design and one subsequent study design, and has submitted details of a third study design. This third study will be conducted in the 2014 field season, and the results reported to Environment Canada in early 2015. The study design is currently under review by Environment Canada. The Cycle 3 EEM is an Investigation of Cause (IOC) into the consistent difference in benthic invertebrate community composition in Minto Creek relative to reference creeks as detected by the Bray-Curtis Index of Dissimilarity (Bray-Curtis distance). To determine if differences are due to the comparison of the exposure site to a small number of reference sites or to a slight mine-related water quality effect, a Reference Condition Approach (RCA) and upstream-downstream gradient of sites within Minto Creek will be measured. This will better characterize the regional range of benthic invertebrate community and determine whether water chemistry is a potential cause.

The third study design will include details such as:

- Site characterization including:
  - Effluent mixing details in the exposure area, including an estimate of concentrations 250 m from the final discharge point.
  - A description of the reference and exposure areas.
  - A description of production processes used at Minto Mine and the environmental protection practices in place at the mine.
  - A summary of federal and territorial laws applicable to the mine in respect of effluent and environmental monitoring.
  - A description of other factors that may be expected to contribute to any observed effect.
  - Any additional information relevant to the site characterization.
- A description of the benthic invertebrate study, including a description and the scientific rational for:
  - Sampling areas selected;
  - Sampling season selected;
  - Sample size selected; and
  - Field and laboratory methodologies selected.
- Dates and times that the samples will be collected.
- A description of QA/QC measures.
- A summary of previous biological monitoring studies conducted at the Minto Mine.

7 Terrestrial Environment Monitoring Program

The Terrestrial Environment Monitoring Program is designed to monitor terrestrial features of the Minto Mine and surrounding environment. The objective of the program is to monitor invasive plant species, wildlife and erosion and sedimentation occurring in and around the mine site. These programs are detailed in sections 7.1 through 7.3.

7.1 Invasive Plant Species Monitoring Program

Invasive species largely refer to non-native, foreign, or exotic species, although a few native species, if introduced into new and suitable environments, can become problematic (e.g. Foxtail barley). It is important to note that the term invasive species includes plant, animal, fungus, and bacterium. The main pathways by which invasive species may be introduced to the Minto Mine site include distribution through reclamation efforts, and introduction though vehicle traffic to the mine site.

7.1.1 Invasive Plants Mitigation

7.1.1.1 Site access

The following mitigation measures will be implemented in order to reduce the possibility of propagules spreading across site by means of vehicles and equipment.

- Wherever possible, vehicle use (including ATVs) will be restricted to roads and existing pathways so as to limit additional disturbance to ecosystems and plants;
- Wherever possible, vehicles entering site will be clean (e.g., no large, obvious clods of mud), so as to limit the spread of invasive plant propagules. This will be monitored as part of the walk around inspection done prior to site access.

7.1.1.2 Plant Selection

- Ensure plants for reclamation are not included in the list of Yukon invasive species.
- Ensure any straw used for erosion control or other projects around site is certified to be weed free or at a minimum is locally sourced.
- Use locally gathered seed whenever possible
- Establish woody species early in reclamation. This will give woody species time to establish and grow above the height where they will be affected invasive plants (grasses and non-woody plants).
- Ensure seedlings brought to site were grown in sterile potting mixes (ex. potting soil and perlite) and not from regional sources.

7.1.1.3 Erosion Control

Exposed soil will be managed in such a manner as to discourage the production of fugitive dust and colonization by invasive plant species, e.g., covers, dust suppressants, temporary or permanent planting;

- Reduce the amount of seed that sown on site. If seed is necessary it will be limited to weed free certified seed mix.
- Reduce the amount of areas that require fast growing grasses for erosion control by planning lower angle slopes.
- Plant local colonizing species on exposed slopes.

7.1.1.4 Soil Salvage

Properly segregated topsoil and woody overburden collected during any striping activities will allow for a natural seed bank and reduce the need for imported seed mixes and fertilizers when reclamation is required.

- Stripping activities should be monitored by an environmental employee to ensure that quality material is being stored separately.
- Suitable soils should be placed directly on reclamation slopes whenever possible to reduce re-handling and increase viability of natural seed reserves within the soil matrix.
- Salvaged soils storage should be planned with the Mine Technical department to ensure it is stored in such a manner that do not require temporary seeding vegetated in order to prevent erosion.

7.1.2 Invasive Plants Monitoring

Currently, the extent and location to which invasive plants may exist at the Minto Mine is unknown. Vegetation surveys have been completed since September 2012 on the Main Waste Dump (MWD) and monitoring will be expanded to include areas where there is high visitor traffic, recently exposed areas and areas that have high recently reclaimed. This will allow Minto to better track locations and distribution of any established invasive species. Vegetation surveys will be conducted annually in high risk areas, and frequency will be reduced once areas are no longer considered high risk (e.g. low traffic or some amount of time after reclamation has been completed. Vegetation surveys will identify vegetative cover and species types (within the dry land seed mix) and should invasive species be detected, the following information should be included in the survey:

- Location;
- Species Name;
- Health and size of the plant;
- Pictures (for verification), ensure pictures of taken of the plant as well as reference points so the location can be more easily found in the future; and
- Percent coverage in the area.

The top 19 most problematic species in the Yukon are summarized in Table 7-1. A full list of invasive species found in the Yukon by taxonomy is provided in Appendix 5.

Table 7-1: Common and Scientific Names of Common Yukon Invasive Plant Species

Common Name	Latin Name	Common Name	Latin Name
Common tansy	*Tanacetum vulgare*	Smooth brome	*Bromus inermis*
Creeping thistle	*Cirsium arvense*	Spotted knapweed	*Centaurea stoebe*
Dalmatian toadflax	*Linaria dalmatica*	Scentless chamomile	*Tripleurospermum perforata*
Great butter and eggs	*Linaria vulgaris*	Foxtail barley	*Hordeum jubatum*
Hawkweeds	*Crepis tectorum*	Altai wild rye	*Leymus angustus*
Leafy spurge	*Euphorbia esula*	Crested wheat grass	*Agropyron cristatum*
Oxeye daisy	*Leucanthemum vulgare*	Quackgrass	*Elymus repens*
Perennial sow-thistle	*Sonchus arvensis*	Reed canary grass	*Phalaris arundinacea*
Sweetclover	*Melilotus alba (white) officinale (ellow)*	Bird vetch	*Vicia cracca*
		Lucerne	*Medicago falcata*

7.1.3 Invasive Plants Reporting

Should any invasive plant species listed by the Yukon Invasive Species Council be encountered, Minto will report the findings to Yukon Government by e-mail (invasives@gov.yk.ca) or to the Northern Tutchone Regional Biologist (867-996-2162).

7.2 Wildlife Monitoring Program

The *Minto Mine Wildlife Protection Plan* establishes guidelines for minimizing wildlife disturbance at the Minto Mine site and along the development corridor and has developed a monitoring program to yield information about wildlife use in the area. Monitoring program results will be used in closure planning activities and will help refine closure objectives related to ensuring unobstructed passage through the area by wildlife.

The activities under the Wildlife Monitoring Program are summarized in Table 7-2, including the area monitored and the frequency of monitoring. Wildlife monitoring logs are kept in the Environmental Department office, and stored in an Excel spreadsheet. An example *Wildlife Sighting Log* form is provided in Figure 7-1. Interactions with dangerous wildlife are tracked through completion of a *Nuisance or Potentially Dangerous Animal Observation Form* provided in Figure 7-2. Wildlife Sighting Logs are posted at all main offices and around camp, and all staff are encouraged to record all wildlife observations. These are collected regularly and entered into an Excel spreadsheet.

A review of the data is conducted annually in order to build a picture of wildlife use in the area, to inform wildlife protection activities and to evaluate any effects that the mining operation may be having on wildlife values identified in baseline studies. Further details of the wildlife protection measures are found in the *Minto Mine Wildlife Protection Plan*.

Table 7-2: Wildlife Monitoring Activities

Area Monitored	Monitoring Activities	Frequency
Wildlife Monitoring	• Maintaining a wildlife observation log onsite; reporting wildlife encounters; monitoring measures to ensure birds do not settle on tailings facilities. Environmental personnel on site will monitor project activities and modify operations to address wildlife concerns. • Monitoring of planned areas of disturbance prior to work to ensure nesting birds are not present.	Ongoing
Migratory Birds	• Monitoring to ensure waterfowl and shorebirds do not settle on impacted water bodies, such as the Mill Water Storage Pond or the Main Pit. Environmental personnel on site will monitor project activities and modify operations to address wildlife concerns.	Seasonal during migratory periods
Species at Risk/of Concern	• Any caribou observations will be reported to the Conservation Officer in Carmacks. • Bank swallows have been observed to nest in residuum piles in the summer months, in which case these piles are cordoned off and left undisturbed until after the late summer migration, or resloped prior to nesting season to deter nesting.	As necessary

Date	Time	Type of Animal	# of individuals	Location	Description: Size/Color/Markings and Additional Notes	Reportable Incident Yes
EXAMPLES						
3/31/2013	12:00 PM	Grizzly	3	Km 17 access road.	Cubs- Chocolate (Small) Sow-Dark brown/Tan.	
4/1/2013	4:30 PM	Black bear	1	W37	200 lbs	
4/3/2013	7:10 AM	Fox	2	Laydown on airport road.	1 black and 1 orange fox kits, small.	
4/5/2013	5:40 PM	Moose	2	Portal	Moose and calf, healthy.	
4/10/2013	3:00 PM	Wolf	1	At km 5.	Lone wolf, skinny, eating plants.	

Figure 7-1: Wildlife Monitoring Log Form

ting binder

Figure 7-2: Nuisance or Potentially Dangerous Animal Observation Form

7.3 Erosion and Sedimentation Monitoring Program

Monitoring of surface structures and of the receiving environment for evidence of erosion and sediment accumulation is required by WULQZ96-006, and monitoring activities are summarized in Table 7-3. Initial erosion can be visually inspected by searching for light surface material (litter or soil) movement, while sedimentation resulting from erosion can be found by searching for deposition of soil particles at the bottom of slopes and depressions. Riling, gullying, pedestalling, unusual compaction, hoof shearing and trailing are also indicators of erosion problems.

Ditches will be examined during heavy runoff events and the outlets of culverts and pipes visually inspected regularly to ensure that roads and other permanent structures are not being compromised and sediment loads are not becoming excessive. Movement of the lighter and finer top soils before vegetation has taken root on reclamation plots will be monitored closely and mitigation efforts employed to prevent compromising the seed and soil. Further details of the erosion and sedimentation control methods and areas of concern at the Minto Mine are provided in the *Minto Mine Sediment and Erosion Control Plan.*

Table 7-3: Erosion and Sediment Monitoring Schedule

Activity	Location	Frequency
Visual inspections	Bottoms of slopes and depressions of large structures.	As needed following heavy rain events, and during freshet.
	Road routes: ditches and outlets of culverts and pipes.	As needed following heavy rain events, and during freshet.
Water quality monitoring for total suspended solids (TSS) [1.]	Water quality monitoring stations W2, W50 and W17	Weekly and during heavy runoff periods.
Physical inspection of surface facilities by a Yukon registered Engineer.	Water Storage Pond Dam, Mill Water Pond, all waste rock and overburden dumps, all water diversion and conveyance structures and the dry stack tailings storage facility.	After the spring thaw period in May/June of each year.

1. Monitoring locations and frequency dictated by Water Use Licence QZ96-006

8 Progressive Reclamation Effectiveness Monitoring Program

The Progressive Reclamation Effectiveness Monitoring Program is a requirement of the EMSRP Plan, and is required to *"monitor the effectiveness of progressive reclamation and post closure reclamation*" at the Minto Mine. Additionally, WUL QZ96-006 requires a *Reclamation Research Plan* and progressive reclamation activities that are detailed in the *Minto Mine Reclamation and Closure Plan* (RCP). The Progressive Reclamation Effectiveness Monitoring Program is used to support the progressive reclamation activities that occur during mine operation and post-closure monitoring is described in the RCP. The objective of the Progressive Reclamation Effectiveness Monitoring Program is to identify and evaluate reclamation and remediation technologies that are considered both promising and feasible for incorporation into the evolving mine DRP.

Reclamation research at the Minto Mine has focused primarily on key closure methods proposed for the site including soil covers, vegetation, and semi-passive treatment. 2013 monitoring areas included the Main Waste Dump (MWD) vegetation study plots. The first phase (i.e. information gathering) of a constructed wetland treatment system study took place in 2013; future phases will include the construction of pilot-scale testing at a laboratory and eventually pilot-scale testing on site.

The processes for identifying optimal reclamation design is based on the BMPs discussed in guidance documents such as the *Mining Waste Treatment Technology Selection Website* (Interstate Technology Regulatory Council, 2010) and the *Yukon Revegetation Manual: Practical Approaches and Methods* (Mathues & Omtzigt, 2013).Further information on reclamation research can be found in the *Minto Mine Reclamation and Closure Plan.*

9 Quality Assurance and Quality Control

A primary objective of quality assurance and quality control (QA/QC) programs is to ensure that data collected, analyzed and evaluated through environmental monitoring programs at Minto Mine is representative and of high quality and to provide confidence in the data collected for all environmental monitoring and sampling programs. QA/QC procedures at Minto Mine have been designed after generally recognized QA/QC protocols. This section summarizes the use of duplicate, field and trip blanks, on-site laboratory and field equipment calibration, external and on-site laboratory QA/QC, on-site laboratory verification, and a description of QA/QC protocols for other site monitoring activities including meteorology, hydrology, and hydrogeology with respect to the Minto Mine.

9.1 Quality Assurance

Quality assurance protocols help ensure that the Minto Monitoring Programs are quantifiable and able to produce quality data. Minto Mine is continuously involved in consultation with professionals and technical experts regarding program design, standard operating procedures, and data review. Ongoing staff training and job observations of staff (new hires and experienced employees) performing monitoring activities ensure that data collection and results are consistent, representative and of high quality.

The steady improvement of quality assurance protocols involves developing more detailed and program specific verification processes and automated checks, as well as peer reviews and audits by external professionals on a regular basis. Effective quality assurance will identify potential problem areas and necessary corrections to procedures and data management, and facilitates evaluation and improvement of the monitoring program.

Examination and evaluation of field data and data entry is an integral part of quality assurance. While it is not possible to check all aspects of input data, calculations, and interpretations, checks can be performed on selected sets of data at appropriate intervals. A review of work procedures and data collection methods will identify potential sources of error.

Reported data is reviewed and evaluated by Minto Mine staff on a monthly and annual basis by cross checking the database with the sample tracking and log spreadsheet. The database is frequently audited by Minto Mine personnel and a professional consultant on an annual basis. If inconsistences are found, further investigation is performed using field notes, COCs, and lab result files depending on the nature of the error.

9.2 Quality Control

Quality control protocols are the set of routine procedures and methods designed to achieve and maintain a recognized level of quality. Some of the most common quality-related problems introduced in surface water quality sampling include the mislabeling or switching of bottles, failure to add proper preservatives, improper storage conditions, and sample contamination from sampling equipment or other sources. Quality control samples are collected and analyzed to verify the integrity of water samples and detect errors introduced during sampling. Quality control samples represent 10% of the total number of samples collected and consist of a random combination of the types provided in Table 9-1. Field staff are responsible for documenting when and where quality control samples are prepared on the field forms and in the Minto Water Quality Database.

Table 9-1: Quality Control Sample Descriptions

Type	Description and Sample Purpose
Trip Blank (TB)	A sealed container of deionized water sent from the laboratory used to detect any widespread contamination during transport and storage. The trip blank is transported with the sample bottles for the entire duration of the sampling event. Trip blanks indicate contamination within the bottle or from volatile compounds.
Field Blank (FB)	A sample of deionized water that is prepared in the field using the same procedures as for collecting the field sample. Preservative, if required, is added after the sample is collected. Field blanks measure contamination from bottles, collection methods, the sampling environment, and preservatives.
Duplicate (DUP)	Duplicate samples are independent samples collected from the same place and time to determine the precision of environment and laboratory heterogeneity. Duplicate samples measure the reproducibility of the sampling and analysis.
Field Spilt (FS)	Aliquots taken from the same sample container and assumed to be identical. Split samples can be sent to separate laboratories for analysis and the results can be used to determine inter-lab variability. Care must be taken to ensure that the samples are split homogeneously.

9.3 Environmental Monitoring Programs QA/QC

9.3.1 Hydrology QA/QC

The primary objective of hydrology data collection under the WUL is to monitor the quantity of water moving around Minto Mine as well as the quantity moving down the Minto Canyon watershed. Minto Mine current uses a variety of techniques and instrumentation for the collection of hydrology data, including; continuous measurements using Solinst level loggers, continuous measurements using inline flow meters, measurements using a calibrated flume as well as volumetric measurements and manual measurements using a Hach FH950 Electromagnetic Velocity Meter.

For current meter measurements, errors in the measurement of width, depth, and velocity as well as the lack of care in choosing the number of vertical measurements and observations in a vertical measurement, all combine to reduce the overall accuracy of water quantity data. To a large extent, human errors can be avoided by careful attention to detail and by adhering to established and proven techniques and routines. Systematic errors can be reduced significantly by proper maintenance and calibration of instruments and equipment, and by adequate training. However, random errors will always occur. A significant reduction in these errors can be achieved if field staff performing the measurement can recognize the potential problem areas and can take the appropriate precautionary measures to avoid or minimize them. SOPs used as field guides have been prepared to minimize human error, and manual measurements are conducted at the same location to minimize variability.

Standardized management of data collected in the field is important in hydrological monitoring programs. Standard protocols and systems are in place to ensure ease of data processing and less likely prone to error. Processing of data can involve returning to the original field notes to cross check suspicious values or to analyze site conditions that might have been responsible for anomalies in the logger records. Therefore, supportive values and observations are well documented by field staff.

All water quantity data including field notes, photographs and datalogger download files are carefully handled, organized and stored to ensure the information can be located for future use

9.3.2 Meteorology Monitoring Program QA/QC

Monitoring of meteorological parameters is done with a research-grade weather station, containing Campbell Scientific meteorology instrumentation, a data logger and a 10-m tower. The station is located approximately 100m northeast of the airstrip and has been operating since 2005. Data from the station has been collected regularly and is used for prediction and operational planning purposes.

QA/QC of data by Minto staff includes validation of equipment by comparing trends in the data sets for the meteorological station. Furthermore, a monthly review of the data takes place as a result of monthly reporting activities. Along with the QA/QC performed by Minto staff, the compiled data is frequently sent to external consultants for further QA/QC to ensure the data is representative of the meteorological condition that occur at Minto Mine.

9.3.3 Hydrogeology Monitoring Program QA/QC

QA/QC for groundwater well monitoring includes field duplicate samples that are collected at a frequency of one field duplicate sample per ten groundwater monitoring samples (10%).

One field blank sample is collected during each Spring/Fall groundwater monitoring event. Field blank samples are collected from deionized water supplied by the analytical laboratory, using the methods as similar as possible employed to collect groundwater monitoring samples (including field filtration and preservation of the dissolved metals field blank).

9.4 External Laboratory QA/QC

Every sample report received from an external lab is accompanied by a Quality Assurance Report, which includes a calculated percent recovery for all applicable parameters, as well as QC limits. The QC tests include: matrix spike (within 80-120% recovery), spiked blank (80-120% recovery), method blank value, and Relative Percent Difference for duplicates (less than 20%). Each report also details any deviations from procedure, including exceeding standard holding time. A QC batch number is assigned to each sample for traceability.

9.5 On-site Laboratory QA/QC

In the on-site laboratory, metals are analyzed using an atomic absorption spectrometer; specifically a Varian 240 G is used. Copper, aluminum and cadmium are analyzed using a graphite tube atomizer. Selenium is analyzed using a Hydride vapour gas accessory.

Ammonia, nitrite and nitrates are analyzed using a Hach DR2800 spectrophotometer. Total solids are determined gravimetrically.

The parameter specific methods used to establish the above criteria are as follows:

- **Ammonia -** Hach Method 8155 Nitrogen Ammonia Salicylate Method
- **Nitrites -** Hach Method 8507 USEPA Diazotization Method.
- **Nitrates -** Hach Method 8039 Nitrogen Nitrates, Cadmium Reduction Method
- **TSS -** Method Derived from Standard Methods for Water and Wastewater Treatment
- **Copper -** Graphite Furnace Atomic Absorption Spectrometer: Operation and Maintenance
- **Aluminum -** Graphite Furnace Atomic Absorption Spectrometer: Operation and Maintenance
- **Cadmium -** Graphite Furnace Atomic Absorption Spectrometer: Operation and Maintenance
- **Selenium -** VGA-77 gas generator for Hydride Generation using Varian Atomic Absorption Spectrophotometers

The on-site lab and field instrumentation calibrations are performed using the manufacturers' specifications. Laboratory atomic absorption spectrometry and spectrophotometer equipment require calibration, which is conducted by on-site lab personnel that are trained in the use of the equipment. Field instrumentation, the two YSI in-situ multi parameter meters and a Eutech (Oakton) PCTestr 35 handheld meter also require calibration, which is conducted by field staff according to manufacturers' specifications.

The on-site lab commenced testing samples in March 2012, and began establishing Standard Operating Procedures (SOPs) and a QA/QC program. The SOPs that formed the basis of the lab QA/QC program are:

- *Lab QA/QC Guidelines SOP;*
- *AAS-GF Set-up and Operation SOP;*
- *Replacing and/or Aligning a Hallow Cathode or D2 Lamp SOP;*
- *Replacing a Graphite Tube and Aligning the graphite furnace SOP;*
- *Alignment of the PSD -120 SOP, Dilutions and Standards SOP;*
- *Preparation of Dissolved and Total Metals (Cu, Al, Cd) SOP; and*
- *Preparation of Dissolved and Total Selenium SOP, and Total Suspended Solids SOP.*

All of the aforementioned SOPs are stored in the on-site lab for immediate reference. The SOPs are updated as required to maintain consistency with manufacturers' specifications.

9.5.1 On-site Lab Verification

The intent of on-site lab verification is to demonstrate the ability of the Minto Mine on-site water quality laboratory to produce results from water analysis that are reasonably comparable to those results obtained at an accredited external lab, and verify that on-site results are reliably reported at or below WUL discharge criteria for most metals. The verification of the on-site laboratory was initiated in March 2012 to demonstrate compatibility between the results obtained at the Minto Mine on-site laboratory and accredited external labs. Two external, CALA certified laboratories were used: Maxxam Analytics and ALS Environmental. It is to be noted there is, as expected, variation in the results due to method and instrumentation differences. The detection limits reported by the external labs using Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS) can be as much as an order of magnitude lower than an Atomic Absorption Spectroscopy-Graphite Furnace (AAS-GF).

Table 9-2 demonstrates the ability of Minto Mine Laboratory to reasonably correlate with an external accredited lab (Maxxam Analytics) for metal analysis with the exception of cadmium. It is important to note that the poor correlation with cadmium is due to the difference in instrumentation (AAS-GF and ICP-MS). Unfortunately this correlation cannot be resolved to a greater degree, as the majority of the variance comes from the superior capability of an ICP-MS to discern trace amounts of cadmium.

Table 9-2: Coefficient of Correlation between Minto Mine On-site Laboratory and Maxxam for Total Metals.

Metal	Coefficient of Correlation
Cu Dissolved	0.8
Cu Total	0.9
Al Dissolved	0.8
Al Total	0.6
Cd Dissolved	0.04
Cd total	0.2
Se dissolved	0.9
Se total	0.9

Nutrient and TSS coefficients of correlation between on-site and external laboratories are provided in Table 9-3. Nitrate and TSS correlations are reasonable, indicating that the labs resolve these in a similar fashion. For Nitrite, the on-site laboratory and ALS have good correlation, while the correlation with Maxxam is poor, most likely because of a difference in the detection limits between the labs. Ammonia has poor correlation across all labs, this correlation may be due to differences in testing time and detection limits.

Table 9-3: Correlation between Minto Mine On-site Laboratory, Maxxam and ALS for Nutrients and TSS.

Lab Comparisons	Ammonia	Nitrate	Nitrite	TSS
Maxxam vs. On-site	0.32	0.81	0.37	0.92
Maxxam vs. ALS	0.22	1.00	0.89	0.99
On-site vs. ALS	0.15	0.75	0.99	0.98

10 Data Evaluation and Reporting

The QML requires that the Licensee provide, as part of the annual report, "*a summary of the program undertaken for environmental monitoring and surveillance as outlined in the Environmental Monitoring Plan and the Wildlife Protection Plan, including an analysis of these data and any action taken or adaptive management strategies implemented to monitor or address any changes in environmental performance*". Additionally, WUL QZ96-006 requires that the Licensee "*submit the data that is compiled as a result of these programs and studies as a component of the required monthly data submissions, quarterly reports and annual reports*". All data collected in the previous year is submitted to the Yukon Government, Energy, Mines and Resources Branch and to the Yukon Water Board as a single report by March 31st of the following year. WUL monthly data submission and quarterly and annual report requirements are summarized in Table 10-1. Monitoring data included in the annual report is summarized in Table 10-2 and summarizes of the data to be presented are provided below.

Table 10-1: WUL QZ96-006 Reporting Requirements

Licence Requirement	Frequency	Requirements
WUL 11.-14.	Monthly Data Submissions*	Submission of water quality surveillance data, water withdrawals from all water sources, water use, and conveyance flow data, site meteorological data records, physical stability instrumentation data records, geochemical testing records.
WUL 15.-16.	Quarterly Report*	Summaries of all data generated as a result of the monitoring requirements of the licence, including preliminary discussion of any variances from expected or required performance and any data collected in the quarter.
WUL 17.-18.	Annual Report	Summaries of the annual activities conducted in the licence, and summarized in the EMSRP.

*Minto intends to request to remove redundancy of preparing both monthly and quarterly reports as part of the Phase V/VI licencing process.

Table 10-2: Monitoring Program Reporting Requirements

Monitoring Program	Reporting Requirements	
	Internal Reporting	External Reporting
Water Monitoring Program		
Surface water quality and hydrology	Monthly data compilation	Monthly data submission Quarterly report Annual report
McGinty Creek surface water quality and flow	Monthly	-
Seepage	-	Annual report
Vibrating wire piezometer and thermistor	-	Monthly data submission Quarterly report
Groundwater	-	Annual report
MCDS seepage	-	Annual report

Monitoring Program	Reporting Requirements	
	Internal Reporting	External Reporting
Metal Mine Effluent Regulations	-	Quarterly & Annually to Environment Canada's Regulatory Information Submission System (RISS)
Geochemical Monitoring		
ABA monitoring program	-	To YWB on a semi-annual basis (March and September). Any divergence from the program must be reported within 30 days.
Waste rock management verification program	-	Annual report
Meteorological Monitoring		
Climate	-	Monthly data submission Quarterly report Annual report
Snow surveys	-	Annual report
Mine Infrastructure and Workings Monitoring Program		
Deformation monitoring program	-	Annual report
Weekly Highwall inspection report	Every Sunday	-
Semi-annual geotechnical review report	-	Semi-annually, after spring melt (May/June) and before freeze-up (September)
Aquatic Environmental Monitoring Program		
Biological monitoring program		Annual report
EEM Program	-	Subsequent Interpretative Reports are to be submitted within 36 months after the day on which the interpretative report of the *previous* biological monitoring study water was required to be submitted; OR if the results of the previous two consecutive biological monitoring studies indicate no effect, within 72 months.
Terrestrial Monitoring		
Invasive species monitoring	-	When invasive species are discovered
Wildlife monitoring	-	Annual Report
Progressive reclamation effectiveness monitoring program	-	Annual Report

11 References

ASTM. (2013). *Standard Guide for Sampling Ground-Water Monitoring Wells.* ASTM International.

CCME. (2011). *Protocols Manual for Water Quality Sampling in Canada.* Canadian Council of Ministers of the Environment. Ottawa: Canadian Council of Ministers of the Environment.

CCME. (2014, January 15). *Sediment Quality Guidelines for the Protection of Aquatic Life.* Retrieved February 12, 2014, from Canadian Environmental Quality Guidelines Summary Table: http://st-ts.ccme.ca

Clark, M. (2003). *British Columbia Field Sampling Manual.* Water, Air and Climate Change Branch Ministry of Water, Land and Air Protection. Victoria: Province of British Columbia.

Duncan, D., & Bruynesteyn, A. (1979). Determination of acid production potential of waste materials. (p. 10). Metallurgical Society of AIME paper A-79-29.

Environment Canada . (2011). *Metal Mining EEM Guidance Document. Chapter 4 - Effects on Fish Habitat: Benthic Invertebrate Community Structure Survey.* Ottawa.

Environment Canada. (2001). *Guidance Document for Flow Measurement of Metal Mining Effluent.* Ottawa: Minister of Public Works and Government Services Canada.

Environment Canada. (2001). *Guidance Document for the Sampling and Analysis of Metal Mining Effluents.* Ottawa: Minister of Public Works and Government Services Canada.

Environment Canada. (2011). *Field Manual: Wadeable Streams.* Canadian Aquatic Biomonitoring Network, Science and Technology Branch. Dartmouth: Environment Canada.

Interstate Technology Regulatory Council. (2010, August). *Mining Waste Treatment Technology Selection*. Retrieved February 11, 2014, from http://www.itrcweb.org/miningwaste-guidance/

Mathues, P., & Omtzigt, T. (2013). *Yukon Revegetation Manual: Practical Approaches and Methods.* Retrieved January 22, 2014, from http://www.yukoncollege.yk.ca/downloads/YEPbk_reveg_CH1.pdf

MEND. (1991). *Mine Environment Neutral Drainage Program: Acid Rock Drainage Prediction Manual, MEND Project 1.16.1 (b). Prepared by Coastech Research Inc., North Vancouver, B.C. March 1991.*

Metal Mine Effluent Regulations, SOR/2002-222 (06 06, 2002).

Mills, C. (1997). *An Assessment of the Results of Acid Base Accounting (ABA) and Mineralogical Test Work on Eight Samples from the Proposed Minto Project, Yukon Territory.* Consulting Environmental & Mineral Process Engineer for the Selkirk First Nation, Pelly Crossing, Yukon Territory, Vancouver.

Ministry of Environment. (1981). *Snow Survey Sampling Guide.* Province of British Columbia, Water Management Branch Surface Water Section, Victoria.

Ministry of Environment. (2009). *Manual of British Columbia Hydrometric Standards.* Science and Information Branch. Victoria: Resources Information Standards Committee.

Minto Explorations Ltd. (2014). *Minto Mine Phase V/VI Expansion, Waste Rock and Overburden Management Plan.*

Yukon Government. (2002). *Contaminated Sites Regulations O.I.C. 2002/171.*

Yukon Government. (2013, August). *Plan Requirement Guidance for Quartz Mining Projects.* Retrieved from http://www.yukonwaterboard.ca/forms/quartz/Plan%20Requirement%20Guideline%20for%20Quartz%20Mining%20Projects%20-%20August%202013-kh.pdf

Appendix 1

Minto Mine Surface Water Quality Monitoring Standard Operating

MINTO MINE
SURFACE WATER QUALITY MONITORING
STANDARD OPERATING PROCEDURES

Prepared by: Minto

Explorations Ltd

October 2012

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TABLE OF APPENDICES

1. Purpose

The standard operating procedures (SOP) in this document serve as a guideline for the collection of surface water quality samples from water bodies at Minto Mine (Minto) specified by Water Use Licence QZ96-006. The Minto Mine Water Quality Monitoring SOP follows methods and procedures described in *Protocols Manual for Water Quality Sampling in Canada* (CCME, 2011), *Guidance Document for the Sampling and Analysis of Metal Mining Effluents* (Environment Canada, 2001) and *Ambient Freshwater and Effluent Sampling Manual* (RISC, 2003). This document is intended for Minto Mine employees familiar with the location of water quality sites at Minto, and who are knowledgeable in surface water sampling methods. Along with on the job training, the purpose of this document is to ensure the Minto Mine Water Quality Monitoring Program is carried out consistently and that all surface water samples are representative of the environmental conditions at the time of sampling.

2. Responsibilities

The reliability and quality of data generated by the Water Quality Monitoring Program is dependent on the staff involved and attention given to the sampling procedures, quality control protocols, and field equipment. It is crucial that water quality samples be collected in a consistent manner with the appropriate equipment to generate the most accurate field measurements and analytical results. Erroneous results which do not represent the water body being sampled can lead to inaccurate conclusions about water quality and have the potential to influence management actions.

The following is a typical allocation of responsibilities associated with the Water Quality Monitoring Program at Minto:

Field Staff

Field staff must have the appropriate knowledge to collect representative samples and protect samples from contamination and deterioration. A sampler is responsible for minimizing field error and collecting the best sample possible. This includes consistency in sampling procedure, correct use of sampling equipment, accurate labelling, and completion of detailed field notes.

Field staff are responsible for coordinating all sampling events in accordance with the requirements of the current WUL, including sampling locations, sampling frequency, and parameter requirements. Staff performing sampling and monitoring duties shall ensure that all site and sample specific details are clearly documented, and that all quality assurance and quality control (QA/QC) protocols are being followed.

Field staff must be experienced in the operation and safety requirements for all field instruments, sampling gear, equipment and reagents used for sampling. They are responsible for maintaining equipment and maintaining stock and inventory of sampling supplies.

Field staff are also responsible for submitting all samples to the appropriate laboratory for analysis in a timely manner, and performing data entry related to the Water Quality Monitoring Program.

Supervisors

Supervisors are responsible for ensuring field staff understand the requirements of the WUL and that all WUL requirements and internal QA/QC protocols are being met and documented. Supervisors are responsible for ensuring sample and data collection and management procedures are being carried out consistently and identifying variance from standard procedures. This includes ensuring digital copies of all field data and laboratory results are saved with the correct file names to the appropriate location on the server.

The first step in ensuring proper sampling techniques is to provide staff with training for the sampling conditions they encounter. Supervisors are responsible for providing appropriate levels of training to all field staff and ensuring that all samplers are proficient to carry out their responsibilities or are adequately supervised.

It is the responsibility of supervisors to compare water quality data to the applicable standards and to previously collected data to review trends, outliers, etc.

Supervisors must also periodically review sampling procedures and the content of this SOP to ensure the best methods are being used and that adequate QA/QC is being incorporated into the program.

3. Safety

Safety is the most important component of any field program. All staff must be aware of all potential safety hazards and personal protective equipment (PPE) requirements for any task they are completing. At no time should field staff feel unsafe and all questions or concerns about safety must be brought to the attention of a supervisor.

It is crucial that monitoring activities are completed in a safe manner. This includes having first aid equipment, communication equipment, and wearing proper footwear and gloves for the job. It also means that sampling is frequently completed by two field staff. Field staff and supervisors should review all appropriate Job Hazard Analyses and Safe Work Procedures to ensure that the safety related elements of all tasks related to sampling are understood.

4. General Guidelines for Surface Water Quality Monitoring

Water samples, field measurements, and observation of site conditions are collected from the same area for every sampling event whenever possible to achieve representative results over time.

Standard field forms are used to document all the required details for each sampling event, including thorough descriptions of unusual conditions and variations to the sample site or procedure. This data is stored in the Minto Water Quality Database.

The following procedures, practices, and considerations will be followed by all staff involved in the Water Quality Monitoring Program:

- All field staff will have the appropriate training and experience with field equipment, sampling procedures and objectives prior to performing monitoring duties or be accompanied by experienced staff.
- Organize a sufficient supply of bottles, labels, preservatives and filters to complete the sampling ahead of time. Sufficient quantities of these items should be stocked at the mine at all times.
- Sample containers are supplied by the analytical laboratory pre-cleaned and capped. Hands should be clean prior to sampling and clean gloves worn. Metal jewellery should not be worn on hands or wrists and smoking is not permitted while sampling.
- Do not use a preservative after the expiry date and always store preservatives where they will not freeze or overheat. Return expired preservatives to the laboratory for proper disposal.
- Do not take a sample or wade into a stream if conditions are unsafe. Ensure safe footing and solid points if contact when sampling from shore.
- Rinsing of bottles should be done slightly downstream from the actual sample location to prevent contaminants from entering the sample bottle.
- Sampling ponded water should be avoided as it will not provide accurate representation of water quality. Avoid collecting sediment and surface films if present.
- When wading to sample, always collect the sample while facing upstream to ensure that contaminants that may be on the sampler do not flow into the container. Care must be taken to avoid stirring up any sediment.
- During sample collection, the inner portion of sample bottles and caps must not be touched with anything other than sample water.
- Filter and/or add preservatives immediately or as soon as possible after sample collection.
- Gloves, syringes and filters will be kept in clean, sealed plastic bags.

- If a particular parameter cannot be completed for the site (e.g. the pH probe is not working) a note must be made on the field data form explaining why it could not be taken.
- As much as possible at a mine site, sample containers should be kept in a clean environment. Bottles must be capped at all times. Vehicle cleanliness is an important factor in minimizing the risk of contamination.
- All samples should be kept upright, and as close as possible to 4°C at all times until they are delivered to the laboratory. They must not be allowed to freeze unless freezing is part of the preservation protocol.
- Ship samples to the external laboratory as soon as reasonably possible. Samples should be analyzed within the time limits specified by the analytical laboratory.

5. Surface Water Sampling Procedures

Preparation

Prior to departure for sampling, staff will ensure that all field equipment is checked for functionality and cleanliness and that sample bottles are clean and unopened. All equipment, calibration standards, preservatives, sampling gear and sample bottles will be organized and stored in a clean environment and transported in clean, dry containers. Field instruments should be tested to ensure batteries are charged and all parts are accounted for.

Sample bottles, preservatives, syringes, filters and coolers are currently supplied by Maxxam Analytics. Current contact information and shipping label for Maxxam Analytics is provided in Appendix 1.

Preparation for water quality sampling must also include provision for quality control samples. The number of quality control samples taken must correspond to a minimum of 10% of the total number of samples taken for all sampling events.

The following is a list of equipment and sampling supplies regularly used to complete surface water quality monitoring:

- Sample bottles and labels
- Field notebook and/or field forms
- Water quality meter
- Nitrile gloves
- Syringes and filters
- Sample preservatives
- Cooler and sufficient ice packs
- Deionized water

- Cooler labels and laboratory Chain Of Custody (COC)
- Chisel, axe and/or ice auger (when sampling under ice)
- Spare parts and batteries

General field gear typically includes:

- PPE
- Radio
- Rubber boots or waders
- Camera
- Pencils, pens, permanent marker
- Sample site map, GPS
- Flagging tape
- Multi tool
- First aid kit
- Appropriate clothing
- Water and food

Maintenance of Field Instruments

All instruments used for performing field measurements are stored and calibrated in accordance with manufacturer's specifications. Proper maintenance of field instruments is very important as instruments must be in good working condition in order to produce accurate readings. Field staff are trained how to calibrate and use all water quality field instruments prior to going in the field.

Minto primarily uses an YSI Professional Plus handheld multi-parameter meter (YSI) for monitoring water quality field parameters. Performance of the meter is tracked and verified through daily checks and regular calibrations. Calibration checks are recorded to identify problems and to review in the event of equipment malfunction.

Alternatively, a Eutech (Oakton) PCTestr 35 handheld meter is used for monitoring sites W13 and W14. The meter measures temperature, pH, and conductivity only and is checked prior to use and calibrated according to the manufacturer's specifications.

Routine maintenance on all field instruments is performed according to the manufacturer with a record of all repairs and maintenance stored on site.

Field Measurement of Water Quality Parameters

Water quality field parameters are recorded with every water sample including water temperature, pH, conductivity, dissolved oxygen (DO), and oxidation reduction potential (ORP). Water quality meters are used according to the instructions provided by the manufacturer for greatest efficiency. The following procedures and considerations are followed by trained Minto staff:

- Field measurements are always made in situ (in the water body) or using a sub-sample taken in a separate container which is discarded once the measurements are recorded. Sub-samples are not used for further chemical analyses.
- Instrumentation must display stable in-situ parameters before field staff record parameters. For example, field staff will allow the YSI to stabilize in-situ for 10-15 minutes ensuring that dissolved oxygen readings are stable.
- Dissolved oxygen measurements are always taken in-situ rather than from a sample container.
- Field parameters are measured just below the water surface (0.1 m depth).
- Water quality data is screened on site during sample collection and suspicious readings are re-measured to prevent the recording of false information. Any indication of malfunctioning equipment is recorded in the notes for that station.

Sample Collection

Surface water samples should be collected mid-stream whenever possible to reduce potential contamination from foreign material, sediments, and/or other effects from stream banks, back eddies, seepage areas, etc. When the stream is small, the current is too strong, water too deep, or ice is too thin, samples should be collected from the stream bank reaching as far out into the stream as safely possible. When field staff are able to safely wade into a stream, the sampling location should be approached from downstream. Samples are always collected upstream of the sampler.

The following surface water sampling procedures are followed by trained Minto staff:

- Locate the station using a station map or GPS coordinates then select an area representative of the stream to collect the sample.
- Clearly label all sample bottles with station name, date, time (24 hour clock), and analysis code (provided in Table 1).
- Put on clean nitrile gloves prior to collecting the sample.
- Handle sample bottles and caps appropriately to avoid contact with internal surfaces.
- Plunge the bottle under the water with the mouth facing upstream away from the sampler’s hand.

- All bottles will be triple-rinsed.
- Ensure that samples requiring filtering are rinsed with filtered water only.
- Collect the water sample until the bottle is full and remove it from the water. Pour some water out to make room for preservatives if needed.
- Use new syringes and filters for every station.
- Filter at the sampling location whenever possible and otherwise from a sub-sample taken in a separate container in a clean environment as soon as possible after sample collection.
- Add preservatives to the required samples as soon as possible after sample collection and filtering.
- Replace caps immediately and tightly to prevent sample loss. Invert bottles to mix preserved samples.
- Place samples in a cooler with sufficient ice packs.

The following tables list the current requirements for water quality samples sent to Maxxam Analytics and the Minto On Site Laboratory (Minto Lab).

Table 1: Sample Requirements for Samples Analyzed by Maxxam Analytics

Analysis Name	Analysis Code	Parameters (not inclusive)	Bottle (plastic)	Filter	Preservative
Physical Parameters	RAW	TSS, TDS, pH, EC, hardness, alkalinity	1 L	Not required	Not required
Nutrients/Anions	RAW	SO_4, Cl, Fl, NO_2, NO_3	500 mL	Not required	Not required
Nutrients/Anions	NH4, TP	P, NH_3	120 mL	Not Required	1 mL Sulphuric Acid (H2SO4)
Total Metals	TM	Al, As, Cd, Cr, Cu, Fe, Hg, Pb, Mn, Mo, Ni, Se, U, Zn, Na, K, Ca, Mg, S	120 mL	Not required	1 mL Nitric Acid (HNO3)
Dissolved metals	DM	Al, As, Cd, Cr, Cu, Fe, Hg, Pb, Mn, Mo, Ni, Se, U, Zn, Na, K, Ca, Mg, S	120 mL	Required (0.45 µm filter)	1 mL Nitric Acid (HNO3)
Dissolved Organic Carbon	DOC	DOC	120 mL	Required (0.45 µm filter)	1 mL Sulphuric Acid (H2SO4)
Total Organic	TOC	TOC	120 mL	Not required	1 mL Sulphuric Acid

Carbon					(H_2SO_4)
Cyanide	CN	CN	120 mL	Not Required	1 mL Sodium Hydroxide (NaOH)
Radium	Ra 226	Ra 226	1 L	Not required	4 mL Nitric Acid (HNO_3)

Table 2: Sample Requirements for Samples Analyzed by Minto Lab.

Analysis Name	**Analysis Code**	**Parameters**	**Bottle (plastic)**	**Filter**	**Preservative**
Physical Parameters/ Nutrients	RAW	TSS, NO_2, NO_3, NH_4	1 L	Not required	Not required
Total Metals	TM	Al, Cd, Cu, Se	120 mL	Not required	1 mL Nitric Acid (HNO_3)
Dissolved metals	DM	Al, Cd, Cu, Se	120 mL	Required (0.45 µm filter)	1 mL Nitric Acid (HNO_3)

Under Snow or Ice Sampling

During winter months water quality monitoring stations will freeze over and water quality samples will need to be collected from under snow and/or ice. Only field staff specifically trained in ice safety will follow these procedures:

- Store and transport chisels, axes and augers in clean environments to limit contamination.
- When sampling on ice always work with a partner and proceed with caution at all times. If the ice is unsafe or you are unsure stop work immediately.
- Ice thickness must be tested with an axe or chisel prior to walking onto a frozen water body and every few steps afterwards. Special care must be taken at outflow and inflow areas.
- Clear snow and loose ice away from the sampling location and drill through the ice with an ice auger, either motorized or a hand auger. The area around the drill hole should be kept clean and free from potential contamination such as gas, dirt from the drill or work boots, etc.

- Once the hole is drilled, all the ice chips and slush should be removed from the hole using a slotted spoon, etc. Allow several minutes for the water to flow freely under the ice, allowing potential contaminants to clear before taking a sample.

Field Notes and Photographic Record

In addition to recording water quality field parameters and the samples collected at each site, trained field staff must document all relevant environmental conditions observed at the time of sampling and any unusual occurrences. Deviations from standard protocols whether deliberate or accidental (e.g. samples taken from a different location due to safety or access considerations, procedures used that differ from those outlined in this SOP) must be recorded in the field notes.

Standard field forms are used as much as possible to ensure all the required information, water samples and field parameters are collected. A current copy of the Minto Water Quality Field Form is provided in Appendix 2. If a field notebook is used, as a minimum the field notes must include the following information:

- Station name, date, time, and names of field staff present;
- Weather conditions and observations on the physical conditions at the sampling location;
- GPS coordinates for new sites or when the sampling location has changed (more specific to winter sampling); and
- Details of any other site specific information relevant to the sampling event.

Field notes must always be clear, concise, and include the station name and date. All field notes should be completed on site. Finally, it is good practice to refrain from erasing mistakes when recording field notes. Crossing out the error and rerecording the data is preferred. Field notes are entered into the Minto Water Quality Database upon return from the field and all field notes and field forms are stored on site.

Photographs can be taken during any sampling event to document current conditions at each station. At a minimum, photos must be taken to show changes in physical conditions at the sampling location. Photos from one sampling event will typically include one upstream and one downstream facing shot. Aerial photos should also be taken when the opportunity is available. Photographs are an important tool to assist with data interpretation. Photos are stored in digital format and must be accurately labeled by field staff upon return from the field.

Sample Custody and Shipment

Water quality samples are handled at all times to prevent damage and potential sample loss, thereby reducing the risk of contamination. Samples are transported around the mine site in sealed coolers with sufficient ice packs until they are placed in a sample fridge or delivered to the Minto Lab. Samples are stored upright in clean refrigerators equipped with thermometers. Samples are maintained as close to 4°C as possible from the time of collection until they are delivered to a laboratory.

After surface water quality samples have been transported back to the office, field staff are responsible for inspecting the samples to ensure they are properly preserved, labeled, and sealed. If the samples are to be analyzed on site they should be delivered to the Minto Lab as soon as possible.

Samples that require external analysis must be shipped to the appropriate laboratory with a completed chain of custody (COC) form. An example of a COC form is provided in Appendix 3. This form is used to request sample analysis and track sample custody. Filling out a COC should be done with field forms and samples on hand to confirm that all the sample containers for each station are accounted for and labeled correctly.

All samples must be submitted to the appropriate laboratory for analysis based on the maximum sample hold time. Each parameter has a specific hold time that ensures the results generated are accurate. However, due to the remoteness of Minto Mine the maximum hold times for some samples will not be met. For this reason it is essential that samples be shipped to the laboratory as soon as possible. It may be necessary to ship samples on the same day as they are collected to preserve the accuracy of the sample analysis. It is the responsibility of field staff to ensure the hold times are met where possible.

All samples must be well sealed and packed with paper, bubble wrap, etc. to prevent spills or breakage. Pack each cooler with sufficient ice packs to maintain the samples at 4°C. Samples collected during the winter will be cooler and will not require the same amount of packaging and ice packs as samples collected in the summer. Samples must not be permitted to freeze. If samples are being shipped in temperatures significantly below freezing, collapsible jugs of warm water may need to be added to the packaging.

Enclose a printed copy of the COC form in a sealed plastic bag or envelope and place it inside one of the coolers with the sample shipment. Label all coolers or shipping containers with the address of the laboratory and the sender and attach it with enough clear tape to protect the label. An example of a laboratory shipping label is provided in Appendix 1.

Data Management

All water quality data including field notes, photographs, completed COC forms and laboratory results are carefully handled, organized and stored to ensure the information can be located for future use. The information collected during water quality sampling events is critical to the interpretation of the data, in some cases even several months or years after the sampling event has taken place.

The following surface data management procedures are followed by trained Minto staff:

- After completing a COC form, an electronic copy is saved with the appropriate file name to the designated location on the server.

- When samples are received at the lab, an automated confirmation email is sent to Minto environment staff. The lab job number is entered into the Minto Water Quality Database.
- When lab results are received by email they are reviewed by supervising staff at the earliest opportunity. Supervisors are responsible for importing the data into the Minto Water Quality Database regularly.
- If reviewing new results in comparison to past trends suggests that results are suspect, or if the results exceed the applicable standards for a particular parameter, an investigation will be initiated. The lab should be requested to review their QA/QC for that batch and re-run the sample, or analyze waters from another sample bottle for the suspect parameter(s).
- Unless it is obvious that the anomalous result that is over discharge criteria is false, new samples should be taken and sent immediately.

6. Quality Assurance and Quality Control

The Minto Quality Assurance and Quality Control plan has been created to provide confidence in the data collected for all environmental monitoring and sampling programs. QA/QC is an integral component to quality surface water quality sampling. General QA/QC procedures that apply to the Water Quality Monitoring Program are described in this section.

Quality Control

Quality control protocols are the set of routine procedures and methods designed to achieve and maintain a recognized level of quality. Therefore, the collection of reliable surface water quality field data at Minto is accomplished by following the procedures described in this document. Quality assurance includes the procedures that keep track of those procedures and provide a check on the quality of the data produced.

Some of the most common quality-related problems introduced in surface water quality sampling include the mislabelling or switching of bottles, failure to add proper preservatives, improper storage conditions, and sample contamination from sampling equipment or other sources.

Quality control samples are collected and analyzed to verify the integrity of water samples, detect errors introduced during sampling. Quality control samples represent 10% of the total number of samples collected and consist of a random combination of the types provided in Table 3. Field staff are responsible for documenting where quality control samples are prepared on the field forms and in the Minto Water Quality Database.

Table 3: Quality Control Sample Descriptions

Type	Description and Sample Purpose
Trip Blank (TB)	A sealed container of deionized water sent from the laboratory used to detect any widespread contamination during transport and storage. The trip blank is transported with the sample bottles for the entire duration of the sampling event. Trip blanks indicate contamination within the bottle or from volatile compounds.
Field Blank (FB)	A sample of deionized water that is prepared in the field using the same procedures for collecting the field sample. Preservative is added after the sample is collected. Field blanks measure contamination from bottles, collection methods, the sampling environment, and preservatives.
Duplicate (DUP)	Duplicate samples are independent samples collected from the same place and time to determine the precision of environment and laboratory heterogeneity. Duplicate samples measure the reproducibility of the sampling and analysis.
Field Split (FS)	Aliquots taken from the same sample container and assumed to be identical. Split samples can be sent to separate laboratories for analysis and the results can be used to determine inter-lab variability. Care must be taken to ensure that the samples are split homogeneously.

Quality Assurance

Quality assurance protocols help ensure that the Minto Water Quality Monitoring Program is quantifiable and able to produce quality data. Minto Mine is continuously involved in consultation with professionals and technical experts regarding program design, standard operating procedures, and data review. Ongoing staff training and inspections of staff (especially new hires) performing monitoring activities ensure data collection and results are consistent, representative and high quality.

The steady improvement of quality assurance protocols involves developing more detailed and program specific verification processes and automated checks, as well as peer reviews and audits by external professionals on a regular basis. Effective quality assurance will identify potential problem areas and necessary corrections to procedures and data management, and facilitates evaluation and improvement of the monitoring program.

Quality Assurance on Data

Examination and evaluation of field data and data entry is an integral part of quality control. While it is not possible to check all aspects of input data, calculations, and interpretations, checks can be performed on selected sets of data at appropriate intervals. A review of work procedures and data collection methods will identify potential sources of error.

Reported water quality data is reviewed, and evaluated by Minto Mine staff on a monthly and annual basis. The water quality database is audited by Minto Mine and a professional consultant on an annual basis. As mentioned previously the Minto water quality database is checked on a monthly basis and is completed by cross checking the database with the sample tracking and log spreadsheet. If inconsistences are found, further investigation is performed using field notes, COC, and lab result files depending on the nature of the error.

7. Closure

Not all of the situations encountered by field staff have been included in this document (e.g. water column/depth profile sampling) as they are not part of routine sampling events. A JHA should be conducted prior to completing any new or irregular task to identify what work will take place, list all of the potential hazards that could be encountered during the work, and the measures necessary to avoid or mitigate the hazards.

8. References

Resources Information Standards Committee (RISC). 2003. Ambient Freshwater and Effluent Sampling Manual.

Environment Canada. 2001. Guidance Document for the Sampling and Analysis of Metal Mining Effluents.

Canadian Council of Ministers of the Environment (CCME). 2011. Protocols Manual for Water Quality Sampling in Canada.

Appendix 1: Current Maxxam Contact and Shipping Label

Minto Explorations Ltd. **COC #________________**

Suite 900-999 West Hastings Street
Vancouver, BC V6C 2W2
Mine Tel: (604) 759 0860

Maxxam Analytics Inc.

attn: Kelly Janda

4606 Canada Way

Burnaby, BC V5G 1K5

Ph: (604) 638 5019

Air North Cargo: Please deliver to address above
c/o Air North Account # 15979218

Regular Delivery

Appendix 2: Minto Environment Water Quality Field Form

Minto Water Quality Field Form

<table>
<tr><td colspan="3">Sample Site:</td><td colspan="2">Date:</td><td colspan="2">Time:</td><td>Sampler(s):</td><td></td></tr>
<tr><td colspan="3">Sky:</td><td colspan="2">Temp:</td><td colspan="2">Precip:</td><td>Wind:</td><td></td></tr>
<tr><td colspan="3">Lab Analysis?
E I</td><td colspan="6">QA/QC taken? Y N
DUP TB FB</td></tr>
<tr><td colspan="4">Photos? Y N</td><td colspan="5">YSI Callibration? Y N</td></tr>
<tr><td>RAW 1 L</td><td>RAW 500 ml</td><td>NUT 120 ml</td><td>TM 120 ml</td><td>DM 120 ml</td><td>DOC 120 ml</td><td>TOC 120 ml</td><td>Ra 226 1L</td><td>Bioassay various</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Temp C</td><td>DO %</td><td>DO mg/L</td><td>SPC µs/cm</td><td>EC µs/cm</td><td>pH</td><td>ORP mv</td><td>Turb NTU</td></tr>
<tr><td colspan="2"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Flow Recorded?
Y N</td><td colspan="2">Staff Gauge (m):</td><td colspan="2">Flume RIGHT (ft):</td><td colspan="2">Flume LEFT (L/S):</td></tr>
<tr><td colspan="9">Notes (site conditions or variations from normal, i.e. ice cover, sediment, flows, etc.)</td></tr>
<tr><td colspan="5">Data entered:</td><td colspan="4">Data reviewed:</td></tr>
</table>

Appendix 3: Sample Chain of Custody Form

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 #:** EB530912 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
	Vancovuer, B.C. PC: V6C 2W2
Phone / Fax#:	Ph: 604-684-8894 Fax: 604-688-2120
E-mail	minto_environment@mintomine.com

PO #:	113796
Quotation #:	
Project # :	
Proj. Name:	Minto Env. Monitoring
Location:	Yukon
Sampled by:	

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

Lab Use Only

	Sample Identification	Lab Identification	Sample Type	Date/Time(24hr) Sampled	Field Filtered? ☑ / Dissolved Metals (DM)	Field Acidified? ☑	Field Acidified? ☑ / Total Metals	Ammonia ☑ / Nitrite ☑ / Nitrate ☑	TDS ☑ / Total Suspended Solids (TSS) ☑	Alkalinity ☑ / Conductivity ☑ / pH ☑	Sulphate ☑ / Fluoride ☑ / Chloride ☑	Phosphate	DOC (Diss'd Organic Carbon)	TOC (Total Organic Carbon)	Ra 226																		Number of Containers
1																																	
2																																	
3																																	
4																																	
5																																	
6																																	
7																																	
8																																	
9																																	
10																																	
11																																	
12																																	

Print name and sign | Print name and sign | Laboratory Use Only

*Relinquished By:	Date (yy/mm/dd):	Time (24hr):	Received by :	Date (yy/mm/dd):	Time (24 hr):	Time Sensitive ☑	Temperature on Receipt (°C) A) B) C) / Just sampled & rec'd on ice: ☐	Custody Seal	Yes	No
								Present?	☐	☐
								Intact?	☐	☐

*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 ©

Appendix 2

Minto Mine Surface Water Hydrology Monitoring Standard Operating

CAPSTONE MINING CORP.

MINTO MINE

MINTO MINE
SURFACE WATER HYDROLOGY
STANDARD OPERATING PROCEDURES

Prepared by:

Minto Explorations Ltd

October 2012

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TABLE OF APPENDICES

1. Purpose

The standard operating procedures (SOP) in this document serve as a guideline for the collection of water quantity (flow, discharge) data from water bodies at Minto Mine (Minto) specified by Water Use Licence QZ96-006. Water quantity data is critical for a variety of assessment and planning purposes at Minto and is used to interpret water quality data, prepare site water balances, create operating plans, etc. The Minto Mine Hydrology SOP follows methods and procedures described in Guidance Document for Flow Measurement of Metal Mining Effluents (Environment Canada, 2001) and Manual of British Columbia Hydrometric Standards (RISC, 2009). This document is intended for Minto Mine employees familiar with the location of hydrology stations and the data collection methods outlined in this document. Along with on the job training, this SOP will to ensure that surface water hydrology data at Minto Mine is collected consistently and the data produced is reliable and representative.

2. Responsibilities

The quality of flow measurements and water quantity data collected at Minto Mine is dependent on the staff involved and the attention given to field procedures, field equipment, and quality control protocols. It is crucial that flow measurements be carried out in a consistent manner with the appropriate equipment to generate the most accurate results.

The following is a typical allocation of responsibilities associated with the collection of surface water hydrology data at Minto:

Field Staff

Field staff must have the appropriate knowledge and training to take precise flow measurements and collect representative data while minimizing field error as much as possible. This includes following all procedures correctly and consistently, correct use of field equipment, and completion of detailed field notes.

Field staff are responsible for coordinating all station visits in accordance with the requirements of the current WUL, including sampling locations, sampling frequency, etc. Staff performing station visits shall ensure that all site conditions and other required information are clearly documented, and that all quality assurance and quality control (QA/QC) protocols are being followed.

Field staff must be experienced in the operation and maintenance of all field instruments and the equipment used for measuring water quantity data. They are responsible for maintaining equipment and identifying equipment malfunction.

Field staff are also responsible for performing data entry related to surface water hydrology on site.

Supervisors

Supervisors are responsible for ensuring field staff understand the requirements of the WUL and that all procedures and protocols are being followed and documented. Supervisors are responsible for ensuring data collection and data management procedures are being carried out consistently and identifying variance from standard procedures.

Supervisors are responsible for providing appropriate levels of training to all field staff and ensuring that all field staff are proficient to carry out their responsibilities or are adequately supervised. This is especially important when field staff are processing data and completing field activities such as station installs and surveying.

It is the responsibility of supervisors to compare water quantity data collected throughout the year and review trends, outliers, etc. This is often completed with input from external professionals.

Supervisors must also periodically review data collection procedures including the content of this SOP to ensure the best methods are being used and that adequate QA/QC is being incorporated into the program.

3. Hydrometric Station Installation

There are many factors to consider when selecting and installing a hydrometric station in an open channel. Hydrometric stations at Minto typically consist of a pressure sensor and data logger installed in a perforated PVC tube. This instrumentation is accompanied by a staff gauge. All components are attached to a wooden frame and anchored to shore. Minto currently consults with external professionals regarding the establishment of new stations, however the following guidelines will be considered by trained Minto staff when selecting and installing hydrometric stations:

- Site can be accessed safely by field staff through the full range of stage;
- Site is located where the stream cross-section is stable, typically in a pool or run, avoiding turbulent riffle or cascade sections;
- The staff gauge and pressure sensor are able to record accurate water levels through the full range of stage and discharge can be accurately measured at all stages using acceptable flow measurement methods;
- All station components are structurally sound and will not move in any direction;
- Install staff gauges so they are protected from damage by floating debris and ice and are not affected by drawdown or pileup of water. It is typically easiest to read the staff gauge with the face parallel to the current;

- Ideally the depth and velocity of the stream should be fairly uniform with good cross-sections for flow measurements using a flow meter (e.g. single channel, no undercut banks, minimal obstructions, no backwater eddies); and
- No tributaries exist between the hydrometric station and wading cross-sections.

4. Field Instruments

All instruments used for collecting water quantity data are used and maintained according to the manufacturer's specifications. Prior to departure for sampling, staff will ensure that all field equipment is checked for functionality.

Minto currently uses a Hach FH950 Electromagnetic Velocity Meter (current meter) with a top-setting wading rod to perform manual discharge measurements whenever possible. Electromagnetic current meters are factory calibrated and require little maintenance. The Hach FH950 current meter performs a diagnostic self-test each time it is powered on and instructions for checking zero velocity settings are provided in the user manual. Records of all checks and maintenance are stored on site.

Continuous water level readings and barometric pressure are recorded using Solinst data loggers for open channels and inline flow meters for pipe flows. These instruments are received factory tested and calibrated, and are installed, programmed and maintained according to the manufacturer. All information provided with the flow measurement equipment is kept and stored on site.

5. Safety

Wading is the most common method for taking flow measurements at Minto and can also be one of the most dangerous. It is strongly recommended that two people conduct flow measurements, particularly during high flows. Waders with wading belts, safety lines and life vests are available for all staff. Always explore the streambed for large obstacles or holes while wading carefully into the stream. Stream substrates are often slippery. If it is safe to wade the stream then the measurement can begin. Always assess and mitigate safety risks.

When the stream is too high and/or too swift for wading, then either an alternative method should be used or the measurement should not be taken. If conditions do not seem safe or you are unsure, do not attempt to wade the stream. If it is possible to take a measurement from shore, always ensure safe footing and solid points of contact.

6. Field Notes and Photographic Record

Detailed documentation of conditions and observations during station visits is necessary to ensure the quality and accuracy of the data collected. Field staff are responsible for thoroughly documenting site conditions including staff stage readings, stream characteristics up and downstream of the flow measurement site, weather conditions, deviation from standard procedures, and any other significant details about the visit. Standard field forms are used to ensure all the required information is collected. A current copy of the Minto Mine Hydrology Field Form is provided in Appendix 1.

All field notes should be completed at the station immediately following the observations. Field notes must be clear, concise, and include the station name, date and time. It is good practice to refrain from erasing mistakes when recording field notes. Crossing out the error and rerecording the data is preferred. Field notes are entered into the Minto Water Quantity Database upon return from the field and all field notes and field forms are stored on site.

Data logger files downloaded from the pressure sensors should be transferred immediately from the field laptop or Solinst handheld and saved with the correct file names to the appropriate location on the server.

Photographs should be taken to document current conditions at each station. At a minimum, photos must be taken to show changes in physical conditions around the station. Photos from one station visit will typically include one upstream and one downstream facing shot. Aerial photos should also be taken when the opportunity is available. Photographs are stored in digital format and must be accurately labelled by field staff upon return from the field.

7. Water Quantity Data Collection Methods

An explanation of the water quantity data collection methods carried out at Minto Mine and detailed procedures for each method are described in this section.

Staff Gauges

Staff gauges are used to record the stage (water level) of a water body. All discharge measurements and continuous water level readings are referenced to the staff gauge, therefore it is extremely important to read the staff gauge carefully and correctly each visit. Taking a photograph of the water level on the staff gauge is a useful reference in the field for ensuring accurate readings. Staff gauge readings should be taken before and after flow measurements as water levels can change in a small amount of time. Always record stage to three decimal places and document the exact time the reading was taken.

Depending on the orientation of the staff gauge, high flow conditions may sometimes result in water stacking up on the gauge. Readings should be taken at the downstream side of the gauge where the water is calmer.

It is also possible to have no surface flow when the station is visited. These conditions are very important to developing accurate discharge records. Zero flow conditions must be thoroughly documented and photographed. It is also possible to read a water level on a staff gauge when there is no visible flow. This must also be thoroughly documented if encountered.

Surveying and Tracking Staff Gauge Drift

Due to ice movement and natural freeze-thaw cycles, staff gauges are subject to move or drift over time. If a staff gauge moves the reference elevation to which all other measurements and records at that site are compared to changes. Always document conditions that may suggest the staff gauge moved in any direction. Photos and any estimates of amount and direction of drift are very useful when correcting data records and planning repairs.

Annual surveying of staff gauge elevation (typically in the spring) tracks changes in staff gauge location and allows for correction of water level records if needed. Detailed procedures for level surveys are not provided in this SOP; however the following elevation points must be collected:

- Elevation of 0.000m on the staff gauge (should be relative to an arbitrary elevation assigned to a benchmark in the area, typically a spike in the base of a large nearby tree);
- Elevations of at least two benchmarks; and
- Elevation of the water surface at the gauge;

Bench marks are permanent reference points with known elevations. They are established at each station in a stable location close enough to the gauge to allow for efficient surveying, anchored where they are not likely to move or be damaged. The ability of the benchmark to maintain its position in the local environment is essential. At Minto, benchmarks are typically a spike or lag bolt in a mature tree.

Discharge Measurement using a Current Meter

Minto uses the mid-section method for measuring flows using a current meter. This is a standard discharge measurement technique where the depth and velocity are measured at a number of verticals along a cross-section. Velocity measurements at a percentage of the stream depth are assumed to represent the average velocity through the vertical water column. Accurate current metering is critical to the accuracy of the discharge measurement.

Preparation

Upon arrival at the site, field staff will conduct an overall station inspection. Observing and documenting the overall channel conditions will help identify conditions that may affect the measurement and the stage-discharge relationship. Assessing channel conditions is also important in deciding whether or not it is safe to complete the measurement. This includes the presence of aquatic plants and floating debris, any obstructions in the stream, and signs of channel bank erosion and deposition in vicinity of the station.

Field staff are responsible for selecting the best cross-section to carry out discharge measurements during each station visit. The location of the cross-section often varies with changes in water levels or channel conditions.

The best sections for low, medium, and high flow measurements should be established and used as much as possible.

Make a preliminary crossing before stringing the tagline. Try to obtain an overall impression of the depths and velocities while wading. Select an appropriate cross-section where the bed and banks of the watercourse are straight and uniform and the channel bed is free from vegetation, immovable rocks, and other obstructions. Avoid muddy and sandy bottoms, backwater eddies, obstacles, etc. as much as possible.

Improve the cross-section by removing boulders and debris from the section and the area immediately above it. Remove significant vegetation from the area upstream and downstream from the section. On smaller watercourses it may be possible to construct small dikes to cut off sections of shallow flows and dead water. Once complete, allow sufficient time for conditions to stabilize before proceeding with the measurement. Improvements should not affect the staff gauge reading. Do not make changes to the cross-section during the course of the discharge measurement.

Performing the measurement

Proceed with the measurement as follows:

1. Note the date and time and record the staff gauge reading. This step is absolutely essential for plotting the results of the discharge measurement.

2. Secure the tagline (measuring tape) on either shore and string it across channel perpendicular to the direction of flow. Determine the overall width of the metering section. Assess the approximate spacing of the verticals, according to the channel width and flow pattern.

3. Record the distance along the tagline of the left or right bank. Left and right bank are determined facing downstream. If there is a steep drop at the edge of the stream, the first “vertical” depth and velocity observation should be taken as close to the edge as possible.

4. Begin the measurement at the first vertical along the tagline. Record the distance of the reading along the tagline then measure and record the water depth at each location using the wading rod. The water depth is the point where the water surface intersects the rod. Observations should be made to the nearest centimeter. This is used to calculate the total cross-sectional area.

5. Where water depth in the vertical is <1.0 m, observations are made at 0.6 depth from the water surface. To position the current meter sensor correctly, adjust the sliding rod to line up the scale on the rod to the value of the observed depth. Detailed instructions on how to adjust the rod are provided by the manufacturer.

6. Where water depth in the vertical is >1.0 m, the velocity is measured at both 0.2 and 0.8 depth from the water surface and the mean velocity is calculated. To set the current meter on 0.2 depth position, double

the value of the observed depth and adjust the sliding rod to line up the scale to read this value. For 0.8 depth position the scale to read half of the observed depth.

Note: The 0.2-0.8 method is not entirely satisfactory if the channel bed is very rough, irregular, or covered with aquatic growth. These conditions will often produce erratic results for the observation at the 0.8 depth. In some situations, more reliable results will be obtained by computing the average velocity on the basis of the 0.2 and 0.8 depths and averaging the computed value with the velocity from the 0.6 depth. This is known as the three-point method.

7. Allow sufficient time for the current meter to adjust to water conditions. Observe velocities for a minimum of forty seconds. The adjustment time will be a relatively short at high velocities and significantly longer at low velocities.

8. Continue the measurements across the stream until you reach the opposite bank and record the distance on the tagline. After taking the discharge measurement record the second staff gauge reading and the time.

9. After the measurement, download data logger readings, record real time data from the Solinst data logger, and service the instrument by checking the battery voltage and inspecting all of the cables and connections. During every visit to a hydrometric station, a complete inspection of the data logger and all related components should be conducted. Any sign of malfunction or deterioration of the station components must be recorded and repaired as soon as possible.

To obtain accurate measurements by wading, field staff must pay attention to detail and technique. There are many things to consider and numerous opportunities for error. The following guidelines will help obtain reliable results:

Number and Spacing of Verticals

All discharge measurements should include 20 verticals with no less than 10 observations of both depth and velocity for most cross-sections. The distance between verticals must be at least 5 cm when using the Hach FH950 current meter (equal to or greater than the width of the current meter).

The spacing of verticals along the metering section is not usually uniform. Where the water is shallow and/or slow moving, the spacing will be greater than where the water is deep and swift. Spacing depends largely on the several factors including overall width of the stream, unevenness of the channel bed, and variation in velocity across the channel.

Position of Field Staff

Field staff should stand to the side and downstream of the current meter to prevent any interference or effect on velocity readings. In very small channels the presence of a person in the water may significantly affect the flow measurement. In this case a plank can be placed across the stream for field staff to stand on.

Position of the current meter

Hold the wading rod in a vertical position and the current meter parallel to the direction of flow while measuring velocity.

Uneven Channel Bed

Measuring depths in a channel bed that is extremely soft or scattered with boulders requires extra attention. Be careful not to allow the bottom of the wading rod to sink into soft channel bed material. If the channel bed is very rough, take time to adjust the width of verticals so the observed depths so reflect the tops of the boulders and the depths between them.

Rated Structure

Minto currently has a prefabricated flume combined with a pressure sensor constructed in a four season shelter at W3. Water levels are read off an embedded staff gauge on the flume during each visit.

For optimal performance the flume floor and walls should be kept clean and free of sediment and algae growth and upstream of the structure should be kept free of sediment accumulation and debris.

Volumetric Measurements

Volumetric measurements are taken at the outlets of elevated pipes and culverts, and periodically at select stations when appropriate. This method involves collecting water in a container of known volume and recording the time it takes to fill in seconds. There must be a minimum of three trials to produce an average time. Volumetric containers should be calibrated and stopwatches should be water resistant.

8. Data Processing

Hydrology data is compiled by Minto Mine staff on a monthly and yearly basis, including discharge calculations and water level record corrections. Processing data into stage discharge curves, hydrographs, and other discharge records is presently completed or largely supported by a third party (Access Consulting Group) and is not included in this SOP.

Discharge Calculations

Discharge is defined as the volume of water flowing through a given cross-section of a stream over a given period of time. Discharge is typically expressed in L/s or m3/s. For any stream location there is a correlation between water level and discharge called the stage-discharge relationship. Once this is established, discharge can be estimated from recorded water levels and staff gauge readings to create a continuous discharge record. To develop this relationship, manual discharge measurements are obtained at the hydrometric station over the maximum range of stage possible. These corresponding points are graphed, then a stage-discharge curve can be drawn that best represents these points.

All field data from station visits is entered into the Minto Water Quantity Database and processed into discharge values using a template and standard formulas in Excel. Care must be taken to ensure the formulas are not modified during data entry.

Current Meter Measurements

The mid-section method allows for mean discharge (Q) to be calculated by multiplying the mean stream velocity (V) and the cross-sectional area (A); thus Q=VA. In this method the stream is divided into a number of panels. The flow in each panel is calculated by multiplying the mean velocity measured at each vertical by the corresponding width measured along the surface tape or cord. This width should be equal to the sum of half the distance between adjacent verticals. The velocity in the two half widths next to the banks can be estimated. For a detailed description of the mid-section method of computing discharge measurements, please refer to the Manual of British Columbia Hydrometric Standards (RISC, 2009).

Table 1 illustrates an example of a completed discharge calculation for a current meter measurement.

Table 1 Discharge Calculation

Site:	MC1	Start Time:		Staff Gauge:	0.249
Date:	8-Aug-12	End Time:	16:50	Staff Gauge:	0.249
Observations		Calculations		Samplers:	CB/PE
Tape Distance (m)	Depth (m)	Width (m)	Area (m^2)	Velocity (m/sec)	Discharge (m^3/s)
0.46	0	LB			
0.60	0.06	0.12	0.01	0.062	0.000
0.70	0.10	0.10	0.01	0.150	0.002
0.80	0.14	0.10	0.01	0.131	0.002
0.90	0.11	0.10	0.01	0.186	0.002
1.00	0.10	0.10	0.01	0.216	0.002
1.10	0.12	0.10	0.01	0.282	0.003
1.20	0.08	0.10	0.01	0.278	0.002
1.30	0.14	0.10	0.01	0.271	0.004
1.40	0.15	0.10	0.02	0.203	0.003
1.50	0.14	0.10	0.01	0.141	0.002
1.60	0.15	0.10	0.02	0.262	0.004
1.70	0.13	0.10	0.01	0.226	0.003
1.80	0.13	0.10	0.01	0.182	0.002
1.90	0.08	0.10	0.01	0.050	0.000
2.00	0.00	RB			
		Total Discharge (m^3/s)			0.0320

Continuous Water Level and Inline Pipe Flow Meter Data

Continuous water level readings from pressure sensors and inline flow meters are downloaded and compensated as needed using the manufacturer's software. At this time, instructions for compensating this data are not included in this SOP.

All continuous water level readings from pressure sensors require reference to the water level during station visits. Therefore, staff gauge readings must be accurate and always documented including the time of the observation. Basically, water level data is compensated by calculating the difference between the pressure sensor water depth and staff gauge reading for each point in time and the average of all these differences can be applied to the entire data record as a single offset adjustment.

Volumetric Measurements

To calculate discharge from a volumetric measurement the following formula is used:

Discharge = Volume of container (litres) / Average time to fill (seconds)

9. Quality Assurance and Quality Control

The Minto Quality Assurance and Quality Control plan has been created to provide confidence in the data collected for all environmental monitoring and sampling programs. QA/QC is an integral component to quality surface water hydrology data.

Quality Control

Quality control protocols are the set of routine procedures and methods designed to achieve and maintain a recognized level of quality. Therefore, the collection of reliable surface water hydrology data at Minto is accomplished by following the procedures described in this document.

For current meter measurements, errors in the measurement of width, depth, and velocity as well as the lack of care in choosing the number of verticals and observations in a vertical, all combine to reduce the overall accuracy of water quantity data. To a large extent, human errors can be avoided by careful attention to detail and by adhering to established and proven techniques and routines. Systematic errors can be reduced significantly by proper maintenance and calibration of instruments and equipment, and by adequate training. However, random errors will always occur. A significant reduction in these errors can be achieved if field staff performing the measurement can recognize the potential problem areas and can take the appropriate precautionary measures to avoid or minimize them. For a detailed description of common factors that lead to inaccuracies in current meter discharge measurements, please refer to the Manual of British Columbia Hydrometric Standards (RISC, 2009).

Quality Assurance

Quality assurance includes the procedures that provide a check on the quality of the data produced. Minto Mine is continuously involved in consultation with professionals and technical experts regarding program design, standard operating procedures, and data review. Ongoing staff training and inspections of staff (especially new hires) performing data collection activities help to ensure the results are consistent, representative and high quality.

Standardized management of data collected in the field is important in hydrological monitoring programs. Standard protocols and systems make the task of data processing easier and less likely prone to error. Processing of data often involves returning to the original field notes to cross check suspicious values or to analyze site conditions that might have been responsible for anomalies in the logger records. Therefore, it is easiest to evaluate the quality of water quantity data successfully when supportive values and observations have been well documented.

The steady improvement of quality assurance protocols involves developing more detailed and program specific verification processes and automated checks, as well as peer reviews and audits by external professionals on a regular basis. Effective quality assurance will identify potential problem areas and necessary corrections to procedures and data management, and facilitates evaluation and improvement of the monitoring program.

Quality Assurance on Data

Examination and evaluation of field data and data entry is an integral part of quality control. All data should be reviewed to determine if it is comparable to past recordings. While it is not possible to check all aspects of input data, calculations, and interpretations, checks can be performed on selected sets of data at appropriate intervals. A review of work procedures and data collection methods will identify potential sources of error.

All water quantity data including field notes, photographs and datalogger download files are carefully handled, organized and stored to ensure the information can be located for future use. Corrections or adjustments to abnormal or inaccurate data logger records rely on the availability of complete documentation.

10. References

Guidance Document for Flow Measurement of Metal Mining Effluents, Environment Canada, 2001

Manual of British Columbia Hydrometric Standards, Resources Information Standards Committee (RISC), 2009

Standard Operating Protocol Surface Water Hydrology Data Collection and Management, Access Consulting Group, 2010.

Appendix 1: Minto Environment Mine Hydrology Field Form

Minto Hydrology Field Form

Site:	Date:	Initials:
Start Time:		Start Staff Gauge:
End Time:		End Staff Gauge:
Datalogger download: Y / N		Photos Taken: Y / N

Notes (**precipitation**, changes to site conditions, datalogger info, etc):

Left & right banks chosen looking downstream

Left Bank Measurement:	Left Bank Depth:
Right Bank Measurement:	Right Bank Depth:

Section	**Tape Distance (m)**	**Depth (m)**	**Velocity (m/s)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Appendix 3

Minto Mine Groundwater Monitoring Plan

MINTO MINE
Groundwater Monitoring PLAN
VERSION 2013-01

Prepared for:
Minto Mine

Prepared by:
Minto Explorations Limited,
with contributions from SRK Consulting

Vancouver, British Columbia
March 2013

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1 Introduction

Minto Explorations Ltd. (Minto) was issued Water Use Licence QZ96-006 (Amendment 8) on October 18, 2012. Amendment 8 included a number of conditions including Condition 96, which requires Minto to file an updated Groundwater Monitoring Plan within 6 months of the effective date of the licence amendment. This document constitutes the required updated plan.

For reference, the text of Condition 96 is as follows:

> ***Condition 96***. *Within 6 months of the effective date of Amendment 8, the Licensee shall submit to the Board an updated detailed Groundwater Monitoring Program Plan for the purpose of monitoring potential impacts on groundwater from the mine project components including, but not necessarily limited to, the DSTSF, mill area, Main Pit, Area 2 Pit, waste rock dumps and Water Storage Pond.*
>
> *a) The monitoring network shall include stations down gradient of the Water Storage Pond, as well as stations down gradient of the pits to provide for the adequate assessment of the potential impacts of the long term storage of tailings in the pits on the downstream environment.*
>
> *b) The plan must be developed by a qualified professional specializing in hydrogeology and shall include specific groundwater monitoring locations, monitoring schedule and parameters.*

This updated Groundwater Monitoring Plan (GMP) provides details of the current monitoring system and monitoring schedule designed to meet the requirements of Water Use Licence QZ96-006.

2 Groundwater-related Monitoring

2.1.1 Groundwater Wells

A variety of groundwater wells have been installed at the Minto Mine site over the life of the project. These wells have been installed for a range of purposes and the information available for these wells varies case-by-case. Table 1 provides summary information of the installed wells. Individual reports describing the drilling results, installation, and preliminary testing results are provided in the Reference section of this GMP.

2.1.2 Vibrating Wire Piezometers

Several vibrating wire piezometers have been installed during geotechnical investigations at the Minto Mine. These instruments provide measurements of both piezometric pressure and temperature, the latter used to increase the accuracy of the calculated pressure measurements, when temperatures are above 0°C. The instruments will also continue to provide temperature data when temperatures are below 0°C and the transducer is frozen. Table 2 provides summary information about the existing vibrating wire piezometers.

Table 1 Summary of Groundwater Wells, Minto Mine

Groundwater Well Name	Location	Status
P94-20	Main Water Dam area	*Destroyed*
P93-E	Main Pit area	*Destroyed during mining*
MW09-01	Main Waste Dump area	Operational
MW09-02	DSTSF Area	*Destroyed*
MW09-03	Minto North Pit area	Operational
MW09-04	Main Pit area	*Destroyed*
MW11-01A	Downgradient of Main Pit	Operational (sometimes frozen)
MW11-02	NE of Ridgetop North Pit	Operational (sometimes frozen)
MW11-03	SE of Ridgetop North Pit	Operational (sometimes frozen)
MW11-04A	S of Ridgetop South Pit	Operational
MW12-DP1	West of Southwest Waste Dump	Operational
MW12-DP2	West of Southwest Waste Dump	Operational
MW12-DP3	West of Southwest Waste Dump	Operational
MW12-DP4	Downgradient of MVF/DSTSF	Operational
MW12-05	Downgradient of WSP	Operational
MW12-06	Downgradient of MVF/DSTSF	Operational
MW12-07	Downgradient of Main Pit	Operational
Unnamed auxiliary well near mill	Mill area	Operational
Unnamed camp water well	Camp area	Operational
08SWC270	Southwest Waste Dump area	*Destroyed*
08SWC271	Southwest Waste Dump area	*Destroyed*
08SWC272	Southwest Waste Dump area	*Destroyed (Buried by waste rock)*
08SWC273	Southwest Waste Dump area	*Destroyed*
08SWC274	Southwest Waste Dump area	*Destroyed*
08SWC275	Southwest Waste Dump area	*Destroyed*
08SWC277	Southwest Waste Dump area	*Destroyed*
08SWC278	Southwest Waste Dump area	*Destroyed*
08SWC280	Southwest Waste Dump area	*Destroyed (Buried by waste rock)*

Table 2 Summary of Existing Vibrating Wire Piezometers, Minto Mine

Vibrating Wire Piezometer Name	Location	Status
DSP-1	DSTSF area	Operational
DSP-2	DSTSF area	Operational
DSP-3	DSTSF area	Operational
DSP-4	DSTSF area	Operational
SDP-1	Southwest Dump area	Destroyed
SDP-2	Southwest Dump area	Operational
SDP-3	Southwest Dump area	Operational
SDP-4	Southwest Dump area	Operational

Note: installations at the Main Water Dam are excluded from this table

2.1.3 Ground Temperature Monitoring

Several thermistors (ground temperature cables) have been installed during geotechnical investigations at Minto Mine. These instruments provide measurements of temperature at various depths below ground at each location, but do not provide any piezometric data. Table 3 provides summary information about the existing thermistor cables.

Table 3 Summary of Existing Ground Temperature Cables, Minto Mine

Ground Temperature Cable Name	Location	Status
DST-1	DSTSF area	Destroyed
DST-2	DSTSF area	Destroyed
DST-3	DSTSF area	Operational
DST-4	DSTSF area	Operational
DST-5	DSTSF area	Destroyed
DST-6	DSTSF area	Operational
DST-7	DSTSF area	Destroyed
DST-8	DSTSF area	Destroyed
DST-9	DSTSF area	Destroyed
DST-12	DSTSF area	Operational
96-G08	DSTSF area	Destroyed
MWPT-1	Mill Water Pond area	Operational
MWPT-2	Mill Water Pond area	Operational
SDT-1	Southwest Dump area	Operational
SDT-2	Southwest Dump area	Operational
SDT-3	Southwest Dump area	Operational
SDT-4	Southwest Dump area	Operational
08SWC271	Southwest Dump area	Destroyed
08SWC274	Southwest Dump area	Destroyed
08SWC275	Southwest Dump area	Destroyed
08SWC277	Southwest Dump area	Destroyed
08SWC278	Southwest Dump area	Destroyed
08SWC280	Southwest Dump area	Buried under Southwest Dump

Note: installations at the Main Water Dam are excluded from this table

3 Groundwater Monitoring Plan

3.1 Monitoring Objectives

As stipulated in WUL QZ96-006, this groundwater monitoring plan is to provide for monitoring of potential impacts on groundwater from the mine components including, *but not necessarily limited to:*

- Dry Stack Tailings Storage Facility;
- Mill area;
- Main Pit;
- Area 2 Pit
- Main Waste Dump;
- Southwest Waste Dump; and the
- Water Storage Pond.

An additional objective of this groundwater monitoring plan is to provide for the development of baseline hydrogeological conditions in areas where future mine components are being planned. This groundwater monitoring plan contains provision for baseline monitoring of the following planned future mine components:

- Minto North Pit;
- Ridgetop North Pit;
- Ridgetop South Pit.

Monitoring well locations are shown in Figure 1.

3.2 Monitoring Requirements

Monitoring will be comprised of “operational” and “baseline” monitoring. Table 4 summarizes the operational monitoring requirements, and Table 5 summarizes the baseline monitoring requirements.

All monitoring systems have been installed down gradient of the expected final design footprint of the respective mine components.

3.3 Sampling Protocol

Groundwater samples will be collected according to the procedures summarized in ASTM D4448-01- Standard Guide for Sampling Ground-Water Monitoring Wells (ASTM 2007).

Table 4 Operational Groundwater Monitoring Requirements

Mine Project Component	Monitoring Installation	Monitoring Required	Monitoring Frequency
Main Waste Dump	MW09-01	Water Level, Water Quality	Spring/Fall
Southwest Waste Dump	MW12-DP1 MW12-DP2 MW12-DP3	Water Level, Water Quality	Spring/Fall
Dry Stack Tailings Storage Facility and Mill Valley Fill Expansion	MW12-DP4 MW12-06	Water Level, Water Quality	Spring/Fall
Main Pit	MW12-07	Water Level, Water Quality	Spring/Fall
Water Storage Pond	MW12-05	Water Level, Water Quality	Spring/ Fall

Table 5 Baseline Groundwater Monitoring Requirements

Baseline Monitoring Location	Monitoring Installation	Monitoring Required	Monitoring Frequency
North of Proposed Minto North Pit	MW09-03	Water Level, Water Quality	Spring/Fall
East of Proposed Ridgetop North Pit	MW11-02 MW11-03	Water Level, Water Quality	Spring/Fall
South of Proposed Ridgetop South Pit	MW11-04	Water Level, Water Quality	Spring/Fall

3.4 Analytical Suite for Groundwater Samples

Groundwater samples will be collected and analyzed for the parameters identified as suites B, N, and FP in Appendix 3 of Water Use Licence QZ96-006 (Amendment 8).

These analytical suites are defined as follows:

- Suite B: Physical Parameters, Conductivity, Total Dissolved Solids, Alkalinity, Sulphate, ICP Scan - Dissolved Metals.
- Suite N: Nutrients: Ammonia-N, Nitrate-N, Nitrite-N and Phosphorous.
- Suite FP: Field Parameters: In-situ parameters - pH, Conductivity and Temperature.

Groundwater samples will be submitted to an accredited laboratory for analysis.

3.5 Quality Assurance

Field duplicate samples will be collected at a frequency of one field duplicate sample per ten groundwater monitoring samples.

One field blank sample will be collected during each Spring/Fall groundwater monitoring event. Field blank samples will be collected from deionized water supplied by the analytical laboratory, using the exact methods employed to collect groundwater monitoring samples (including field filtration and preservation of the dissolved metals field blank).

3.6 Reporting

Results of the groundwater monitoring program will be included as part of the annual report for WUL QZ96-006.

The groundwater monitoring program summary will also reference results of thermal and piezometric monitoring carried out under other site monitoring plans.

4 References

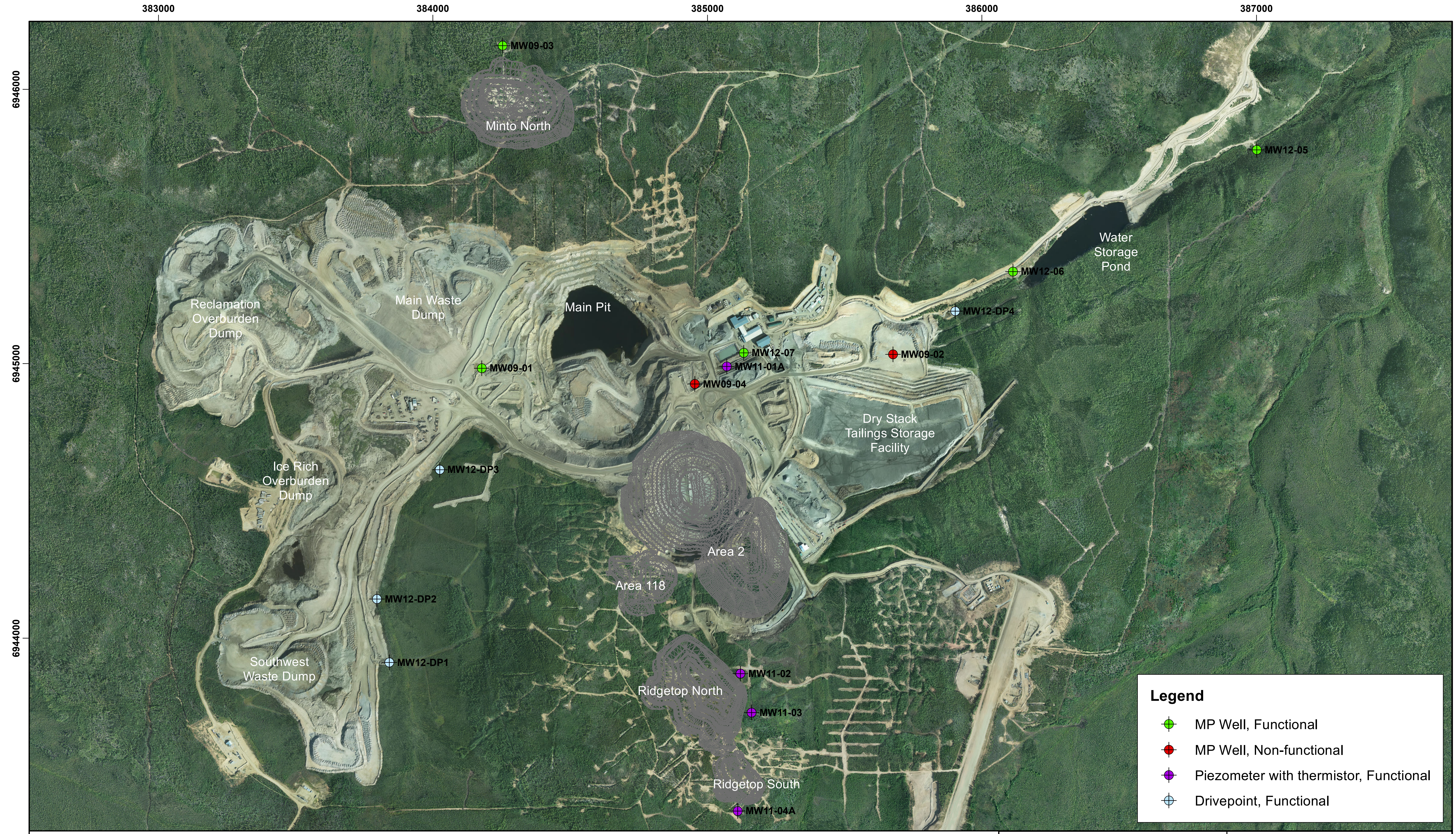
ASTM 2007: Standard Guide for Sampling Ground-Water Monitoring Wells. Designation: D4448 – 01 (Reapproved 2007).

Minto Explorations Ltd. 2011: Groundwater Monitoring Plan, VERSION 2011-01 Dated Sept 2011

SRK 2008: Waste Dump Overburden Drilling - Minto Mine, Yukon. Prepared for Minto Explorations Ltd., May 2008.

SRK 2012: Monitoring Well Installation Program 2011. Prepared for Minto Explorations Ltd., February 2012.

SRK 2013: 2012 Minto Mine Groundwater Monitoring Well Installation Report. Prepared for Minto Explorations Ltd., February 2013.



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Notes:
1. Data presented in NAD 1983 UTM Zone 8N.
2. Base airphoto flown August 2012.
3. Future pit designs from October 2012.

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Site Map Showing Well Locations

Date:	March 2013	Figure:	1

Appendix 4

Physical Monitoring Plan

Physical Monitoring Plan

Prepared by:
Minto Explorations Ltd.
Minto Mine
May 2014

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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 are licensed under water use license QZ96-006.

Mining structures at Minto are shown in Figure 1-1, and described in the following section.

Figure 1-1: Minto site plan (August 2013)

2 Structures Monitored

Mining structures currently being monitored at Minto include the following (shown in Figure 1-1):

Table 1: Description of Structures Monitored at Minto

Structure	Description	Instrumentation
Area 1 Pit (Main Pit)	Mining in the Area 1 Pit is complete and the pit is now used as a tailings storage facility. As such, no in-pit deformation monitoring is carried out. 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 construction of a waste rock buttress, known as the **South Wall Buttress**, in the pit along the south wall, completed in 2013. Instrumentation is currently monitored along the south rim of the pit to detect any continued movement of the wall and buttress.	• Survey hubs • Inclinometer
Area 2 Pit	The Area 2 Pit is completed to the extents licensed under Phase IV; the pit will be extended to the south as part of Phase V/VI. As part of Phase IV, a portal was created at the bottom of the pit to access an underground ore zone. Monitoring is therefore ongoing. The highwall crest is monitored via survey hubs to measure large scale stability of the wall. The highwall is monitored by realtime radar-based slope stability measurements, and a program of weekly inspections and prism readings monitors those portions of the wall not actively scanned by the radar.	• Survey hubs • Prisms • Radar
Area 118 Pit	Mining of the Area 118 Pit commenced in January 2014. Survey hubs are monitored along the northeast crest of the pit between Area 118 and Area 2. In-pit monitoring currently consists of regular inspections. Prisms will be installed along catch benches as mining progresses.	• Survey hubs • Prisms
Dry Stack Tailings Storage Facility (DSTSF)	Tailings placement was completed in November 2012; subsequently, a layer of overburden was placed over the stack as part of progressive reclamation activities. The DSTSF began showing deformation in 2009; the movement has been monitored continuously since then via inclinometers, which are typically short-lived due to the rate of deformation, and survey hubs. Ground temperature cables and piezometers have also been installed to better understand foundation conditions and to provide data for analytical work. The deformation is interpreted as primarily horizontal sliding towards the north/northeast on an ice-rich layer in the underlying overburden, several meters above bedrock.	• Survey hubs • Thermistors • Inclinometers • Piezometers
Mill Valley Fill Extension (MFVE)	A waste rock buttress to the north of the DSTSF, constructed from January 2012 to March 2013 in an attempt to prevent or decrease further movement of the DSTSF.	• Survey hubs • Inclinometers
Ice-rich Overburden Dump (IROD)	Originally constructed as a free-standing rockfill structure to contain a volume of ice-rich overburden. It is now entirely surrounded by the Southwest Dump rockfill which extends a minimum 210m down-slope. The crest and contents of the IROD are visually inspected once per year. No instrumentation is installed in the IROD.	None
Mill Water Pond (MWP)	The mill water pond is a small water storage pond used for excess process water and recirculation of mill process water.	• Thermistors
Minto Creek Detention Structure (MCDS)	Detains surface water considered impacted from upstream sub-catchment areas and directs it to the Area 1 pit or water treatment plant. Extensive instrumentation related to the MVFE is near the MCDS; however, no instrumentation specific to the MCDS is installed.	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. Due to the nature of the material placed within the dump, small-scale sloughs are expected and have been noted. Annual visual inspections have not noted large tension cracks that could be indicative of differential settlement. The dump is inspected annually, and contains no survey hubs or instrumentation. The material in the ROD is available for use in reclamation of the mine at closure.	None
Southwest Waste Rock Dump (SWD)	The southwest waste rock dump (SWD) is currently the main active waste rock dump at Minto. Design details on the SWD are contained in the report "Waste Rock and Overburden Management Plan" for Phase IV mining.	• Survey hubs • Inclinometers • Thermistors • Piezometers
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
Main Waste Dump (MWD)	This dump stores waste released during the mining of the first three stages of the Main pit. The dump is founded on bedrock. Movement below the toe is monitored by a single inclinometer.	• Inclinometers

3 Design References

Table 2: Design Documents and Monitoring/Inspection Guidance Documents

Structure	Design Reports	Monitoring/Inspection Guidance Reports
Area 1 Pit (Main Pit)	*Area 1 South Wall Buttress Design Report, Minto Mine, Yukon.* EBA File: W141010668.012, July 2011.	-
Area 2 Pit	*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.	*SWP – Area 2 Pit Wall and Crown Pillar Monitoring.* Minto, January 30, 2014.
Area 118 Pit	*Prefeasibility Geotechnical Evaluation, Phase IV, Minto Mine.* SRK, December 2009.	-
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 2011-1 EBA File: W14101068.001. January 2011.
Mill Valley Fill Extension (MVFE)	*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.	-
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.
Mill Water Pond (MWP)	-	*Construction Quality Assurance Manual for Waste Dumps, Tailings/Water Dam, Mill Water Pond, and Diversion Ditch, Minto Project, Yukon.* EBA File 0201-95-11509. August, 1997.
Minto Creek Detention Structure (MCDS)	*Minto Project: Minto Creek Detention Structure Seepage Monitoring Program.* EBA File: W14101068.001. October 25, 2011.	*Minto Project: Minto Creek Detention Structure Seepage Monitoring Program.* EBA File: W14101068.001. October 25, 2011.
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.

Structure	Design Reports	Monitoring/Inspection Guidance Reports
Southwest Waste Rock 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.
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.	*Draft Operation, Maintenance and Surveillance Manual, Water Retention Dam, Minto Mine, Minto, YT.* EBA File: W14101068.002. April 2008.

4 Roles and Responsbilities

The following table lists the roles and responsibilites for physical monitoring on the site.

Table 3: Roles and Responsibilities

Role	Responsibilities
Geotechnical Technicians	• 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, quarterly and annual water use license (WUL) reporting • Visual inspections at specified frequencies • Review and update Physical Monitoring Plan
Environmental Officers	• Compile Monthly, quarterly and annual water use license (WUL) reports
Chief Engineer	• Review annual WUL report • Ensure compliance with license requirements

5 Inspections

Table 4 lists the regular, required inspections for each mining structure.

Table 4: Inspections

Structure	Frequency	Description
Dry stack tailings facility, Mill Valley Fill, Main waste rock dump, Southwest waste dump, Reclamation Overburden dump, Ice-rich overburden dump, Mill water pond, Water storage pond dam, Area 1 Pit, South wall buttress, Mill and Camp, Minto Creek detention structure, Big Creek bridge, South diversion ditch.	May/June and September	Inspection and data review by geotechnical engineer as per QZ96-006 (Clause 11)
Area 2 and Area 118 pit walls	Weekly during active mining	Visual inspection by geotechnical engineer/geologist/mine engineer
Water storage pond dam	Weekly (daily during filling)	Visual inspection and inspection for water seepage flows as per QZ96-006 (Appendix 2)
Mill water pond	Weekly (daily during filling)	Visual inspection and inspection for water seepage flows as per QZ96-006 (Appendix 2)
Waste rock and overburden dumps	Daily	Visual inspection as per QZ96-006 (Appendix 2)
Diversion Ditch	Daily	Visual inspection as per QZ96-006 (Appendix 2)

6 Instrumentation

A map of sitewide active and inactive (damaged or destroyed) instrumentation is shown in Appendix A. Installation information, data collection schedules, procedures, documentation and reporting for active instrumentation are contained in the following sections.

6.1 Location and Installation Information

6.1.1 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

ID	Area	Northing (m)	Easting (m)	Elevation (m)	A0 Azimuth	Hole Depth (m)	Date Installed	Reading Frequency
A2I-1	Dry Stack Tailings	6944164.73	385298.95	822.46	302	55.5	2013-04-26	Quarterly
DSI-10	Dry Stack Tailings	6944926.43	386114.98	780.13	-	85	2010-11-12	Bi-monthly
DSI-14	Dry Stack Tailings	6945107.35	385579.80	768.23	62	53	2013-04-08	Bi-weekly
DSI-16	Dry Stack Tailings	6944843.36	385919.57	792.51	354	92.5	2013-04-15	Bi-weekly
DSI-17	Dry Stack Tailings	6945034.51	385963.96	764.53	352	57	2013-04-09	Bi-weekly
DSI-18	Dry Stack Tailings	6945090.95	386132.08	764.60	322	101.5	2013-04-08	Quarterly
DSI-19	Dry Stack Tailings	6945218.17	386262.61	747.76	321	43.5	2013-04-08	Quarterly
DSI-20	Dry Stack Tailings	6944989.60	385394.56	780.47	35	32.5	2013-04-19	Bi-weekly
DSI-21	Dry Stack Tailings	6944587.73	385679.34	793.15	22	27	2013-04-21	Bi-weekly
MDI -2	Area 1 Pit/Main Waste Dump	6945013.08	384217.20	858.67	93	50.5	2010-02-10	Monthly
SDI - 1	Southwest Dump	6944770.08	384174.61	836.46	0	59.5	2010-02-10	Bi-weekly
SDI - 3	Southwest Dump	6944591.11	383966.00	847.42	90	46.5	2010-02-11	Bi-weekly
SDI - 5	Southwest Dump	6944328.87	383823.17	860.57	-	59.5	2011-10-24	Bi-weekly

6.1.2 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

ID	Area	Northing (m)	Easting (m)	Elevation (m)	Date Installed	Reading Frequency
A210	Area 2 Pit – south crest	6944268.42	384934.69	861.28	2011-07-01	Weekly
A211	Area 2 Pit – south crest	6944257.41	384891.47	869.88	2011-07-01	Weekly
ASH05	Airport road	6944280.52	385830.65	850.16	2011-03-07	Monthly
ASH06	Airport road	6944331.73	385623.79	824.17	2011-03-07	Monthly
DSSH-06	Dry Stack Tailings	6944971.61	385553.16	773.83	2010-04-06	Weekly
DSSH-10	Dry Stack Tailings	6944992.62	385807.51	763.12	2010-04-06	Weekly
DSSH-12	Dry Stack Tailings	6944933.16	385704.30	773.99	2010-04-06	Weekly
DSSH-14	Dry Stack Tailings	6944920.27	385606.55	782.88	2012-04-21	Weekly
DSSH-15	Dry Stack Tailings	6944942.65	385503.43	782.61	2012-04-21	Weekly
DSSH-17	Dry Stack Tailings	6944980.74	385896.26	772.07	2012-04-21	Weekly
DSSH-18	Dry Stack Tailings	6945069.81	385522.12	771.39	2014-02-28	Weekly
DSSH-19	Dry Stack Tailings	6945085.22	385642.14	769.16	2014-02-28	Weekly
DSSH-20	Dry Stack Tailings	6945137.83	385730.25	765.83	2014-02-28	Weekly
DSSH-21	Dry Stack Tailings	6945074.87	385735.67	767.74	2014-02-28	Weekly
DSSH-22	Dry Stack Tailings	6945023.66	385710.13	770.65	2014-02-28	Weekly
DSSH-23	Dry Stack Tailings	6944599.38	385491.13	797.40	2014-02-28	Weekly
DSSH-24	Dry Stack Tailings	6944757.90	385712.10	792.07	2014-02-28	Weekly
DSSH-25	Dry Stack Tailings	6944753.94	385894.65	793.38	2014-02-28	Weekly
M73	Area 1 Pit – south wall/buttress	6944723.57	384312.30	840.77	2011-05-23	Semi-weekly
M74	Area 1 Pit – south wall/buttress	6944670.85	384401.18	838.65	2011-05-23	Semi-weekly
M75	Area 1 Pit – south wall/buttress	6944639.43	384475.64	837.55	2011-05-23	Semi-weekly
M76	Area 1 Pit – south wall/buttress	6944623.10	384560.12	835.27	2011-05-23	Semi-weekly
M79	Area 1 Pit – south wall/buttress	6944846.97	384208.90	847.66	2011-09-04	Semi-weekly
M80	Area 1 Pit – south wall/buttress	6944931.70	384256.33	842.06	2011-09-04	Semi-weekly
M81	Area 1 Pit – south wall/buttress	6944971.63	384890.13	806.83	2012-05-08	Semi-weekly
SWD01	Southwest Dump	6944760.85	384077.86	859.07	2011-03-07	Monthly
SWD01A	Southwest Dump	6944762.95	384187.87	837.49	2011-03-07	Monthly
SWD02	Southwest Dump	6944570.23	383884.64	870.82	2011-03-07	Monthly
SWD02A	Southwest Dump	6944741.35	384108.95	840.78	2011-03-07	Monthly
SWD03A	Southwest Dump	6944510.77	383917.28	850.16	2011-03-07	Monthly
SWD04A	Southwest Dump	6944161.48	383793.96	861.32	2011-03-07	Monthly

ID	Area	Northing (m)	Easting (m)	Elevation (m)	Date Installed	Reading Frequency
SWD05A	Southwest Dump	6943939.94	383837.70	869.16	2011-03-07	Monthly
WSP1	Water Storage Pond Dam	6945613.04	386480.98	723.31	2011-06-09	Monthly
WSP2	Water Storage Pond Dam	6945644.59	386545.46	724.42	2011-06-09	Monthly
WSP3	Water Storage Pond Dam	6945551.85	386548.62	719.73	2011-06-09	Monthly
WSP4	Water Storage Pond Dam	6945531.56	386555.22	719.93	2011-06-09	Monthly
WSP5	Water Storage Pond Dam	6945504.74	386560.23	721.02	2011-06-09	Monthly

6.1.3 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

ID	Area	Northing (m)	Easting (m)	Elevation (m)	Thermistor String No.	Nodes	Hole Depth (m)	Date Installed	Reading Frequency
A2T-1	Area 2 Pit	6944162.01	385305.61	822.39	3491	16	63.4	2013-04-21	Monthly
DST-10	Dry Stack Tailings	6944584.06	385489.49	797.13	3492	16	63.4	2013-04-17	Monthly
DST-11	Dry Stack Tailings	6944899.64	385538.89	787.66	3494	16	86.9	2013-04-05	Monthly
DST-13	Dry Stack Tailings	6945014.60	386271.29	777.01	3495	16	101.5	2013-04-02	Monthly
DST-14	Dry Stack Tailings	6944769.09	385713.42	791.47	3497	16	66.5	2013-04-12	Monthly
DST-15	Dry Stack Tailings	6945033.78	385958.17	764.51	3493	16	64.0	2013-03-25	Monthly
MWPT1	Mill Water Pond	6944992.23	385062.50	784.12	2070	16	23.8	2007-11-02	Quarterly
MWPT2	Mill Water Pond	6945015.72	385113.61	784.22	2071	16	23.8	2007-11-02	Quarterly
MW11-01A	Mill Water Pond	6945010.90	385097.00	784.50	2320	11	101.70	2011-11-20	Quarterly
MW11-02	Ridgetop	6943887	385118	861.4	2322	7	30.79	2011-11-21	Quarterly
MW11-03	Ridgetop	6943730	385159	868.2	2321	7	30.79	2011-11-21	Quarterly
WDT - 1	Water Storage Pond	6945523.08	386550.83	720.03	2072	16	42.49	2007-11-16	Monthly
WDT - 2	Water Storage Pond	6945532.89	386574.77	713.66	2073	6	44.50	2007-11-07	Monthly
WDT - 3	Water Storage Pond	6945544.10	386544.43	719.78	2074	16	49.42	2007-11-11	Monthly
WDT - 4	Water Storage Pond	6945534.98	386547.90	719.85	2075	16	49.42	2007-11-10	Monthly
WDT - 5	Water Storage Pond	6945504.57	386557.50	721.03	2076	16	35.13	2007-11-13	Monthly
WDT - 6	Water Storage Pond	6945505.55	386556.32	721.03	2077	16	33.72	2007-11-13	Monthly
WDT - 7	Water Storage Pond	6945504.65	386556.39	721.08	2078	16	33.92	2007-11-13	Monthly
WDT - 8	Water Storage Pond	6945532.89	386574.77	713.66	2079	16	34.14	2007-11-07	Monthly
SDT-1	Southwest Dump	6944766.71	384779.13	836.36	2220	16	59.1	2010-02-04	Monthly
SDT-2	Southwest Dump	6944595.06	383971.30	847.11	2221	16	14.6	2010-01-31	Monthly
SDT-3	Southwest Dump	6944333.87	383824.67	860.17	2222	16	15.8	2010-01-28	Monthly
SDT-4	Southwest Dump	6944163.62	383783.54	860.99	2223	16	13.1	2010-01-30	Monthly

6.1.4 Vibrating Wire Piezometers

Vibrating wire piezometer strings are used to measure pore water pressure profiles in boreholes. They consist of mutltiple 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

ID	Area	Northing (m)	Easting (m)	Elevation (m)	Sensor	No.	Sensor Elevation (m)	Date Installed	Reading Frequency
DSP-5	Dry Stack Tailings	6944769	385713	791.47	DSP-5A	VW24851	765.47	2013-04-16	Monthly
					DSP-5B	VW24853	761.47		
DSP-6	Dry Stack Tailings	6944900	385539	787.66	DSP-6A	VW24850	769.56	2013-04-05	Monthly
					DSP-6B	VW24852	765.56		
WDP-2	Water Storage Pond	6945632	386545	701.67	WDP-2	VW7212	701.67	2007-11-04	Monthly
WDP-3A	Water Storage Pond	6945618	386498	712.62	WDP-3A	VW7557	712.62	2007-11-28	Monthly
WDP-3	Water Storage Pond	6945609	386500	712.60	WDP-3	VW7202	712.60	2007-11-12	Monthly
WDP-4	Water Storage Pond	6945609	386500	702.60	WD -4	VW7210	702.60	2007-11-14	Monthly
WDP-5	Water Storage Pond	6945605	386526	712.35	WDP-5	VW7204	712.35	2007-11-20	Monthly
WDP-6	Water Storage Pond	6945605	386526	701.50	WDP-6	VW7214	701.50	2007-11-20	Monthly
WDP-7	Water Storage Pond	6945605	386526	689.20	WDP-7	VW7208	689.20	2007-11-20	Monthly
WDP-8	Water Storage Pond	6945554	386542	693.10	WDP-8	VW7200	693.10	2007-11-18	Monthly
WDP-9	Water Storage Pond	6945554	386542	687.93	WDP-9	VW7206	687.93	2007-11-18	Monthly
WDP-10	Water Storage Pond	6945554	386542	676.17	WDP-10	VW7211	676.17	2007-11-18	Monthly
WDP-11	Water Storage Pond	6945523	386551	712.96	WDP-11	VW7201	712.96	2007-11-16	Monthly
WDP-12	Water Storage Pond	6945523	386551	694.64	WDP-12	VW7209	694.64	2007-11-16	Monthly
WDP-13	Water Storage Pond	6945533	386578	684.55	WDP-13	VW7205	684.55	2007-11-07	Monthly
SDP-2	Southwest Dump	6944595.06	383971.30	843.41	SDP-2A	VW12912	843.414	2010-01-31	Monthly
					SDP-2B	VW12911	842.714		
SDP-3	Southwest Dump	6944333.87	383824.67	854.27	SDP-3A	VW12906	854.266	2010-01-28	Monthly
					SDP-3B	VW12907	853.566		
SDP-4	Southwest Dump	6944163.62	383783.54	858.49	SDP-4A	VW12908	858.494	2010-01-30	Monthly
					SDP-4B	VW12909	857.794		

7 Procedures and Documentation

7.1 Data Collection Schedule

Data is collected by geotechnical technicians in the mine technical department. A regular schedule is followed and is used for tracking compliance with license requirements. The schedule is stored in the following location:

X:\Mine Technical\03 – Monitoring\Monitoring To Do Frequency.xlxs

7.2 Data Collection Procedures

Data collection manuals for all monitoring devices are included in Appendix B.

7.3 Documentation

After collection, data is input into a series of spreadsheets and databases used for storing, tracking and plotting instrumentation data. Instructions for data input are contained in the instrumentation manuals in Appendix B.

Data input files are stored in the following location:

X:\Mine Technical\03 - Monitoring

8 Quality Assurance/Quality Control

Task observations are routinely performed on monitoring technicians to verify data collection is consistent with the designed procedures. These reviews are documented as Job Observations.

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 monthly Water Use Licence submission.

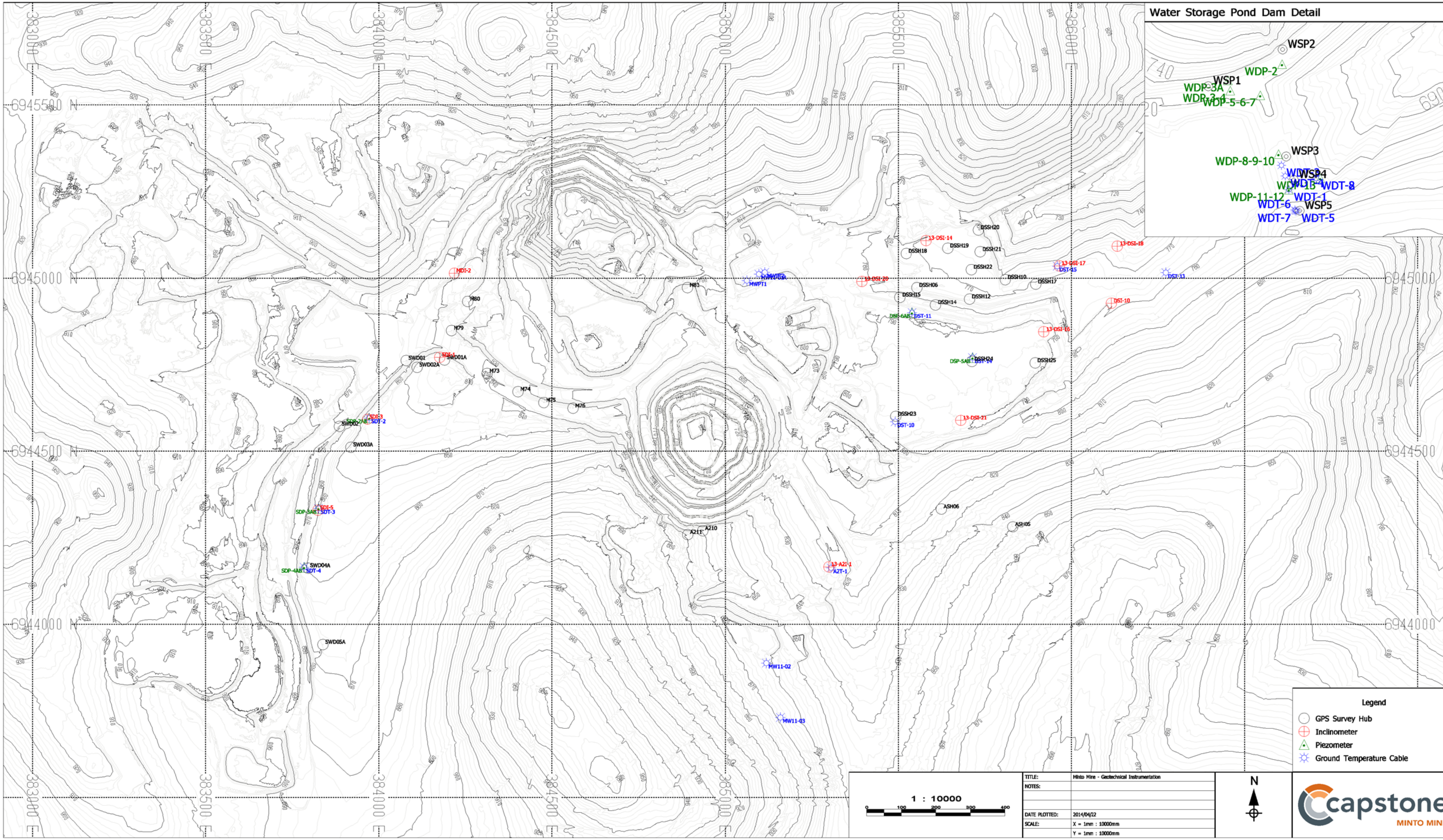
9 Reporting

Regular processing and review of monitoring data is completed and presented in the following documents, as mandated in QZ96-006, Amendment 8.

Table 9: Reporting

Report	Frequency	Submission
Pit Wall Inspection Report	Weekly	Submitted internally every Sunday
Minto Mine Water Licence QZ96-006 Monthly Report (Clause 11)	Monthly	Submitted to Yukon Water Board maximum 30 days following each month
Minto Mine Water Licence QZ96-006 Quarterly Report (Clause 15)	Quarterly	Submitted to Yukon Water Board maximum 90 days following each quarter
Minto Mine Water Licence QZ96-006 Annual Report (Clause17)	Annually	Submitted to Yukon Water Board by March 31 each year
Semi-Annual Geotechnical Review Report (Clause 82)	Semi-annually, after spring melt (May/June) and before freeze-up (September)	Submitted to Yukon Water Board within 45 days of inspections

Appendix A: Instrumentation Map



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.

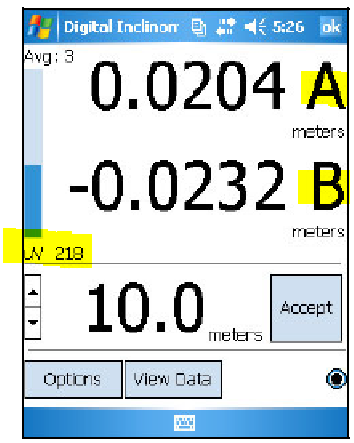
11. Lower the probe gently to ensure the bottom of the hole is encountered. (Slightly passed the designated depth). Double check your correct depth by pulling out reel to the next 5m mark and counting back each 0.5m for each increment.

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*”.

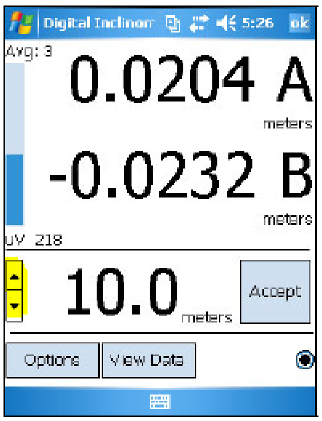
15. At each depth allow the A and B readings as well as the noise level become stabilized before you accept the readings. Ideally noise level should be at or below 30 µV.



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.

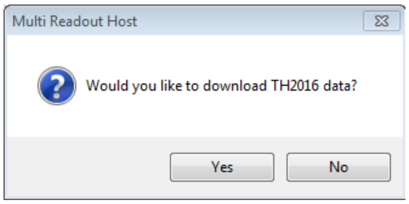
To read EBA thermistors:

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.

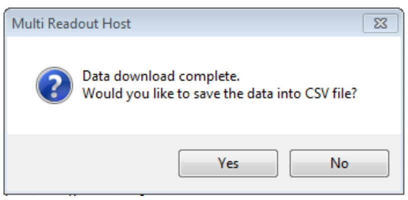
Data Downloading

1. Connect USB cord from computer to the readout box.
2. Open the software Multi Readout Host.

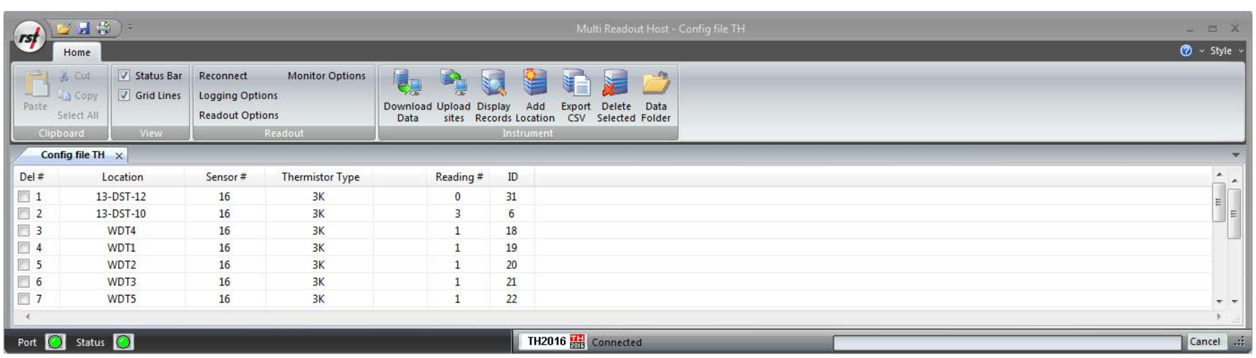
3. Turn on the power on the readout box.
4. The software will recognize the readout unit and prompt to download data. Choose "Yes" to download the data from the readout unit.



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.

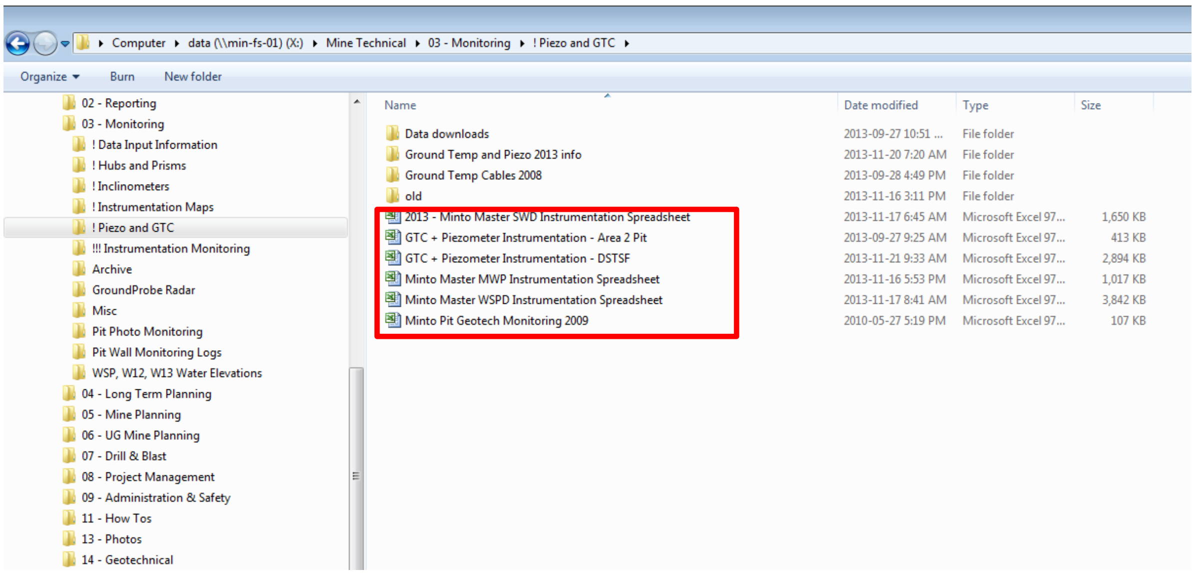


Data Input

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.

8												
9	**WDT-3**											
10												
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	
28												

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

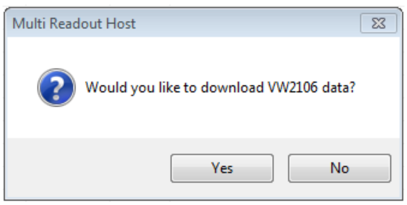
c. Scroll with the Up/Down arrows to the station being monitored and press enter to store the reading

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.

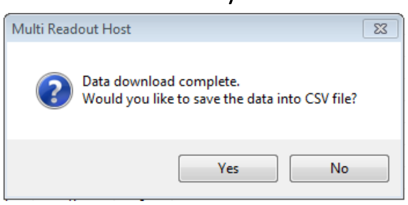
Data Downloading

7. Connect USB cord from computer to the readout box.
8. Open the software Multi Readout Host.

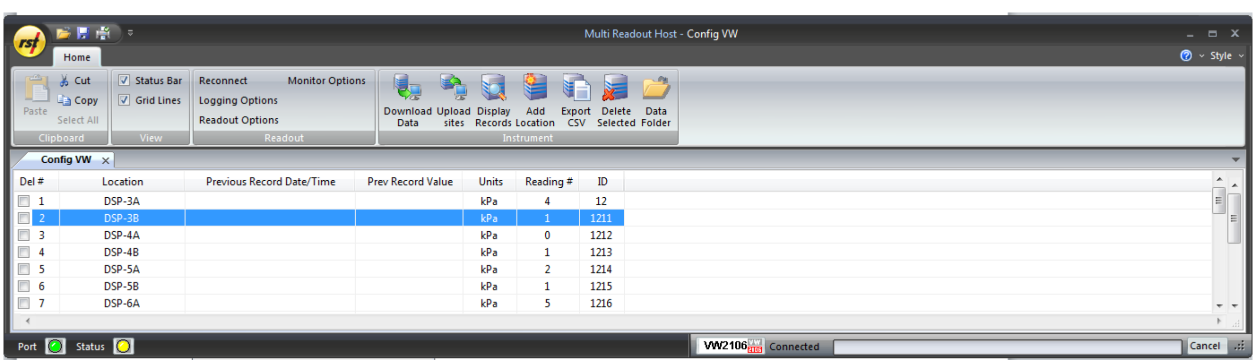
9. Turn on the power on the readout box.
10. The software will recognize the readout unit and prompt to download data. Choose "Yes" to download the data from the readout unit.



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.

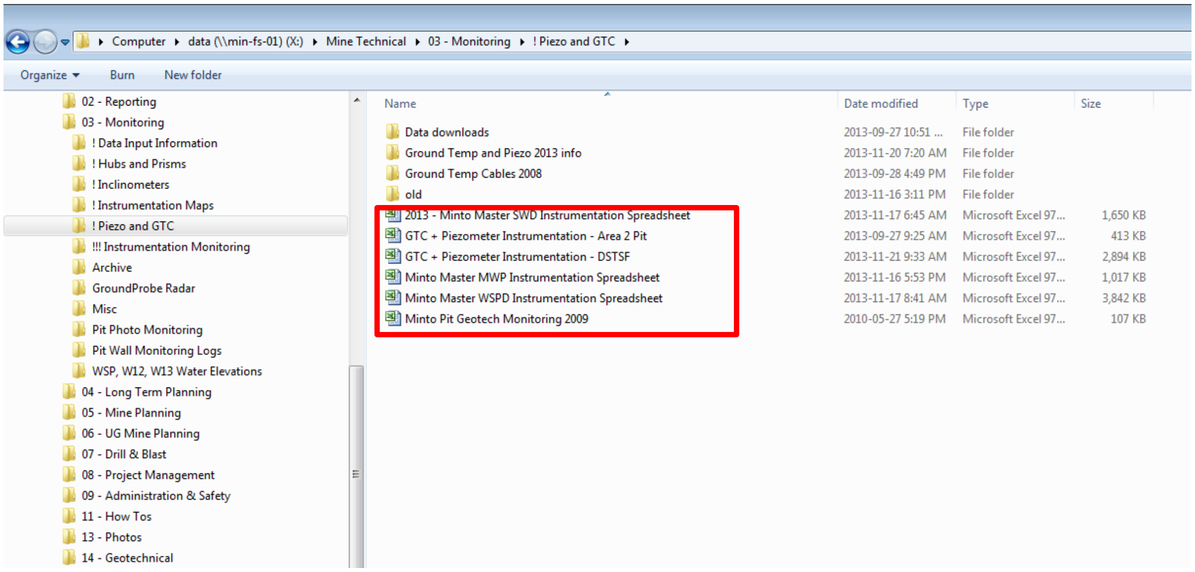


Data Input

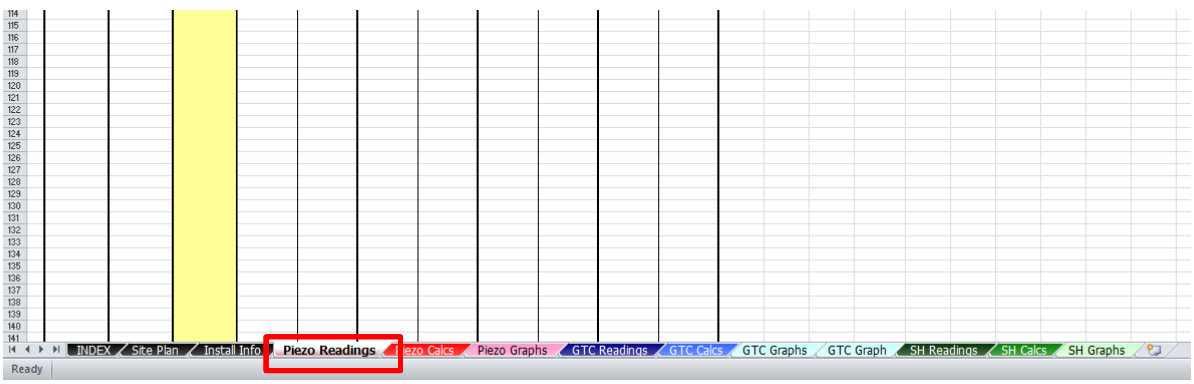
Spreadsheets for piezometer data input and tracking are stored here:

X:\Mine Technical\03 - Monitoring\! Piezo and GTC

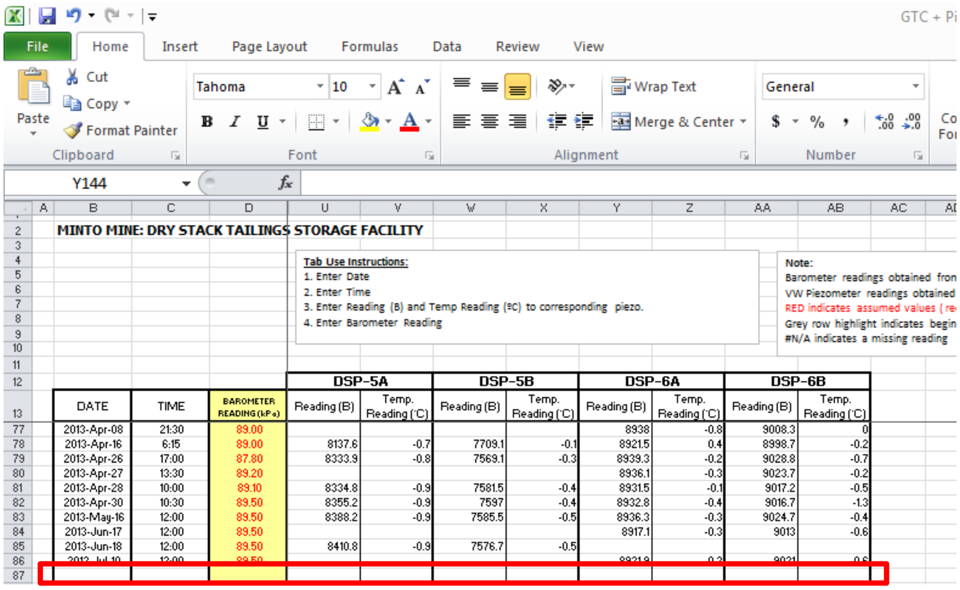
4. Open the spreadsheet for the area monitored



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.



MINTO MINE: DRY STACK TAILINGS STORAGE FACILITY

Tab Use Instructions:
1. Enter Date
2. Enter Time
3. Enter Reading (B) and Temp Reading (ºC) to corresponding piezo.
4. Enter Barometer Reading

Note:
Barometer readings obtained fron
VW Piezometer readings obtained
RED indicates assumed values (re
Grey row highlight indicates begin
#N/A indicates a missing reading

				DSP-5A		DSP-5B		DSP-6A		DSP-6B	
13	DATE	TIME	BAROMETER READING (kPa)	Reading (B)	Temp. Reading (°C)	Reading (B)	Temp. Reading (°C)	Reading (B)	Temp. Reading (°C)	Reading (B)	Temp. Reading (°C)
77	2013-Apr-08	21:30	89.00					8938	-0.8	9008.3	0
78	2013-Apr-16	6:15	89.00	8137.6	-0.7	7709.1	-0.1	8921.5	0.4	8998.7	-0.2
79	2013-Apr-26	17:00	87.80	8333.9	-0.8	7569.1	-0.3	8939.3	-0.2	9028.8	-0.7
80	2013-Apr-27	13:30	89.20					8936.1	-0.3	9023.7	-0.2
81	2013-Apr-28	10:00	89.10	8334.8	-0.9	7581.5	-0.4	8931.5	-0.1	9017.2	-0.5
82	2013-Apr-30	10:30	89.50	8355.2	-0.9	7597	-0.4	8932.8	-0.4	9016.7	-1.3
83	2013-May-16	12:00	89.50	8388.2	-0.9	7585.5	-0.5	8936.3	-0.3	9024.7	-0.4
84	2013-Jun-17	12:00	89.50					8917.1	-0.3	9013	-0.6
85	2013-Jun-18	12:00	89.50	8410.8	-0.9	7576.7	-0.5				
86	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
87											

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 this page is left blank

Appendix 5

Yukon Invasive Plants by Taxonomy

Invasiveness Rank
1 - highly invasive - may displace or replace native ecosystems
2 - aggressive - widespread, persistent, but may not replace native species or change ecosystem function
3 - taxa present in the territory that area not known to be invasive here - but have been found to be invasive in other jurisdictions
4 - has been reported in the territory. Has not been shown to be problematic, may not persist
5 - species that likely don't persist
6 - false reports
7 - native and introduced populations exist

General Abundance
C common - widespread established
F falsely reported,
P possible but not yet documented
R rare known from only 1 or two localities,
U unknown
X possibly not persistent,
? possibly native,

Persistence
1=widespread
2=local
3=not persistent,
4=falsely reported

Alaska Invasiveness Rank
not ranked
<40 = Very Weakly Invasive
40-49 = Weakly Invasive
50-59 = Modestly Invasive
60-69 = Moderately Invasive
70-79 = Highly Invasive
>80 = Extremely Invasive
Ranking from: Matthew L. Carlson, Irina V. Lapina, Michael Shephard, Jeffery S. Conn, Roseann Densmore, Page Spencer, Jeff Heys, Julie Riley, and Jamie Nielsen. 2008.
Invasiveness Ranking System for non-native plants if Alaska. USDA Forest Service Alaska Region R10-TP-143 http://www.fs.fed.us/r10/spf/fhp/invasive/invasiveness%20ranking%20report.pdf
Introduced Plants of the Yukon - Source Cody, 1996 (cody et al 1998, 2000, 2001, 2002, 2003, 2004, 2005) Bennett, B. et al. (2008)
revised by B.A. Bennett December 2011 - this is a tentative list for review purpose only

Invasiveness Rank	Family	Genus	Species	Common Name	Abundance	Persistence	Alaska Rank	Source	Date of first collection
1	Grass family	Agropyron	cristatum	Crested Wheat Grass	C	1	nr	revegetation	1947
4	Grass family	Agropyron	fragile	Siberian Wheat Grass	U	2	nr	revegetation	1949
4	Grass family	Agrostis	capillaris	Colonial Bent Grass	R	2	nr	agriculture, revegetation	1993
3	Grass family	Agrostis	gigantea	Redtop	R	2	nr	revegetation	1916
P	Grass family	Agrostis	stolonifera	Creeping Bent Grass	P	P	nr	revegetation	
5	Grass family	Aira	caryophyllea	Silver Hair Grass	X	3	nr	transportation	1946
5	Grass family	Alopecurus	geniculatus	Water Foxtail	R	2	49	agriculture	1899
3	Grass family	Alopecurus	pratensis	Meadow Foxtail	C	1	52	agriculture	1947
3	Grass family	Avena	fatua	Wild Oasts	R	3	nr	agriculture	1943
5	Grass family	Avena	sativa	Cultivated Oats	X	3	nr	agriculture, transportation	1949
4	Grass family	Bromus	carinatus	California Brome	R	2		revegetation	1995
5	Grass family	Bromus	japonicus	Japanese Brome	X	3		revegetation	2003
5	Grass family	Bromus	racemosus	Bald Brome	X	3		agriculture	1902
1	Grass family	Bromus	inermis	Smooth Brome	C	1	62	agriculture, revegetation	1943
5	Grass family	Bromus	secalinus	Rye Brome	X	3	nr	agriculture	**1902**
5	Grass family	Bromus	tectorum	Downy Brome	X	3	78	agriculture	1916
2	Grass family	Dactylis	glomerata	Orchard Grass	R	3	53	revegetation	2000
5	Grass family	Deschampsia	danthonioides	Annual Hairgrass	X	3	nr	unknown	1902
5	Grass family	Deschampsia	elongata	Slender Hairgrass	X	3	35	transportation (railway)	1902

Invasiveness Rank	Family	Genus	Species	Common Name	Abundance	Persistence	Alaska Rank	Source	Date of first collection
2	Grass family	Elymus	repens	Creeping Wild Rye	U	2	59	revegetation	1949
2	Grass family	Elymus	sibiricus	Siberian Wild Rye	C	1	53	revegetation	1980
3	Grass family	Festuca	rubra ssp. rubra	Red Fescue	C	1		revegetation	
4	Grass family	Festuca	trachyphylla	Hard Fescue	R	2		agriculture	1949
5	Grass family	Hordeum	vulgare	Common Barley	R	3	39	agriculture	1983
1	Grass family	Leymus	angustus	Narrow-leaved (Altai) Lyme Grass	R	2	nr	revegetation	1998
4	Grass family	Lolium	multiflorum	Annual Rye Grass	R	1	41	revegetation	1902
2	Grass family	Lolium	perenne	Perennial Rye Grass	R	1	52	revegetation	1994
5	Grass family	Lolium	temulentum	Bearded Rye Grass	X	3	nr	unknown	1902
1	Grass family	Phalaris	arundinacea	Reed Canary Grass	?	1	83	agriculture, revegetation	1979
5	Grass family	Phalaris	canariensis	Common Canary Grass	X	3	nr	agriculture	1941
4	Grass family	Phleum	pratense	Common Timothy	C	1	54	agriculture	1902
3	Grass family	Poa	annua	Annual Blue Grass	C	1	46	transportation	1968
3	Grass family	Poa	compressa	Canada Blue Grass	U	1	39	revegetation	1980
7	Grass family	Poa	nemoralis	Forest Blue Grass	?	2		revegetation	
2	Grass family	Poa	pratensis ssp. pratensis	Kentucky Blue Grass	C	1	52	unknown	
3	Grass family	Poa	trivialis	Rough Blue Grass	U	1	52	revegetation	1902
5	Grass family	Polypogon	monospeliensis	Rabbit's-foot Grass	X	3		unknown	**1902**
3	Grass family	Psathyrostachys	juncea	Russian Wild-Rye	R	2	nr	agriculture	1960
7	Grass family	Puccinellia	distans	Spreading Alkali Grass	?C	1			
3	Grass family	Schedonorus	arundinaceus	Tall Fescue	R	2	66	revegetation	1980
5	Grass family	Secale	cereale	Common Rye	R	3	nr	agriculture, transportation	1949
5	Grass family	Setaria	viridis	Green Bristle Grass	X	3	nr	transportation	1998
4	Grass family	Thinopyrum	intermedium	Intermediate Wheat Grass	R	2		transportation	1999
2	Grass family	Thinopyrum	ponticum	Tall Wheat Grass	R	1	nr	agriculture	2000
5	Grass Family	Triticum	aestivum	Common Wheat	X	3	nr	agriculture, transportation	**1943**
5	Grass family	Vulpia	myuros	Rat-tail Six-weeks Grass	X	3	nr	unknown	**1902**
5	Nettle family	Urtica	urens	Burning Nettle	X	3	nr	unknown	1904
5	Goosefoot family	Atriplex	patula	Spear Saltbush	X	3	nr	unknown	
5	Knotweed family	Fagopyrum	esculentum	Buckwheat	X	3	nr	agriculture (birdseed)	1997
2	Knotweed family	Polygonum	achoreum	Leathery Knotweed	U	1		transportation	1997
7	Knotweed family	Polygonum	buxiforme	Prairie Knotweed	?C	1	45	transportation	
3	Knotweed family	Fallopia	convolvulus	Eurasian Black-bindweed	C	1	50	horticulture	1975
5	Knotweed family	Polygonum	fowleri	Fowler's Knotweed	X	3		unknown	**1943**
6	Knotweed family	Persicaria	maculosa	Spotted Lady's-Thumb	F	4	47		
3	Knotweed family	Rheum	rhaponticum	Rhubarb	C	1	nr	agriculture	1999
4	Knotweed family	Rumex	acetosella	Sheep Sorrel	R	2	51	unknown	**1994**
3	Knotweed family	Rumex	crispus	Curled Dock	R	2	48	unknown	**1980**
3	Knotweed family	Rumex	longifolius	Door-yard Dock	R	2	48	transportation	1980
3	Knotweed family	Rumex	pseudonatronatus	Field Dock	R	2	nr	transportation	2004

Invasiveness Rank	Family	Genus	Species	Common Name	Abundance	Persistence	Alaska Rank	Source	Date of first collection
3	Goosefoot family	Chenopodium	album	Lamb's-Quarter	C	1	37	unknown	1883
4	Pink family	Cerastium	fontanum	Common Mouse-ear Chickweed	U	1	36	unknown	1968
4	Goosefoot family	Spinacia	oleracea	Spinach	R	2		agriculture	1980
4	Pink family	Cerastium	glomeratum	Sticky Mouse-ear Chickweed	R	2	36	horticulture	2004
4	Pink family	Cerastium	nutans	Nodding Chickweed	R	2		horticulture	1996
5	Pink family	Dianthus	plumarius	Carnation	R	3		horticulture	**1994**
5	Pink family	Gypsophila	elegans	Showy Baby's-breath	R	3	nr	unknown	1980
3	Pink family	Silene	noctiflora	Night-flowering Catchfly	R	2	43	revegetation	1996
2	Pink family	Silene	vulgaris	Bladder Campion	R	2	42	agriculture, horticulture	1984
5	Pink family	Spergula	arvensis	Corn Spurry	X	3	32	unknown	**1902**
4	Pink family	Spergularia	rubra	Red Sandspurry	R	2	34	unknown	1977
2	Pink family	Stellaria	media	Common Chickweed	C	1	42	agriculture, horticulture	1943
5	Pink family	Vaccaria	hispanica	Cowcockle	R	3	nr	agriculture (birdseed)	1902
2	Buttercup family	Clematis	tangutica	Golden Clematis	R	1	nr	horticulture	1958
5	Buttercup family	Ranunculus	repens	Creeping Buttercup	X	3	54	transportation	1977
4	Buttercup family	Thalictrum	dasycarpum	Purple Meadow-rue	R	2		agriculture	1991
4	Buttercup family	Thalictrum	venulosum	Veiny Meadow-rue	?R	2		unknown	1949
4	Poppy family	Papaver	croceum	Saffron Poppy	U	2	39	horticulture	1949
4	Mustard family	Arabis	caucasica	Gray Rockcress	R	2		horticulture	2001
4	Mustard family	Arabis	glabra	Tower Mustard	?R	2	nr	transportation	1977
6	Mustard family	Armoracia	rusticana	Horse Radish	F	4			
3	Mustard family	Brassica	rapa	Bird's Rape	R	1	50	agriculture, revegetation	1980
4	Mustard family	Camelina	microcarpa	Little-pod False Flax	R	2	nr	unknown	1943
5	Mustard family	Camelina	sativa	Large-seeded False Flax	R	3	nr	agriculture	2007
3	Mustard family	Capsella	bursa-pastoris	Shepherd's Purse	C	1	40	agriculture	1916
4	Mustard family	Descurainia	sophia	Herb-Sophia	U	2	41	unknown	1943
5	Mustard family	Erysimum	cheiri	Wallflower	X	3		horticulture	2001
3	Mustard family	Hesperis	matronalis	Dames Rocket	R	2	41	horticulture	2010
3	Mustard family	Lepidium	ramosissimum	Branched Pepperwort	C	1	nr	unknown	1979
5	Mustard family	Lepidium	sativum	Garden Pepperwort	X	3	nr	horticulture	1902
5	Mustard family	Neslia	paniculata	Yellow Ball-mustard	X	3	nr	agriculture	1904
5	Mustard family	Rorippa	curvipes var. truncata	Blunt-leaved Yellowcress	R	3		unknown	1982
5	Mustard family	Sinapis	alba	White Mustard	X	3	nr	unknown	1902
5	Mustard family	Sinapis	arvensis	Corn Mustard	R	3	36	unknown	2002
5	Mustard family	Sisymbrium	altissimum	Tall Hedge Mustard	R	3	nr	unknown	1916
3	Mustard family	Thlaspi	arvense	Field Pennycress	C	1	42	agriculture	1949
5	Rose family	Potentilla	biennis	Biennial Cinquefoil	X	3	nr	unknown	1902
2	Rose family	Prunus	padus	Maytree or European Bird Cherry	C	2	74	horticulture	2003
2	Rose family	Sorbaria	sorbifolia	False Spiraea	R	2	nr	horticulture	1992
2	Pea family	Astragalus	cicer	Chick-pea Milk-vetch	R	2	nr	revegetation	1995

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2	Pea family	Caragana	arborescens	Siberian Peashrub	R	2	74	horticulture	1949
3	Pea family	Lotus	corniculatus	Garden Bird's-foot Trefoil	R	3	63	revegetation	2000
1	Pea family	Medicago	falcata	Lucerne	C	1	64	argiculture	1967
3	Pea family	Medicago	lupulina	Black Medick	R	2	48	transportation	2007
2	Pea family	Medicago	sativa	Alfalfa	C	1	59	agriculture, revegetation	1980
1	Pea family	Melilotus	alba	White Sweetclover	C	1	81	agriculture	1935
1	Pea family	Melilotus	officinalis	Yellow Sweetclover	C	1	69	argiculture	1980
3	Pea family	Onobrychis	viciifolia	Common Sainfoin	R	2	nr	revegetation	1980
5	Pea family	Trifolium	cyathiferum	Cup Clover	X	3		agriculture	1902
2	Pea family	Trifolium	hybridum	Alsike Clover	C	1	57	agriculture, revegetation	1902
2	Pea family	Trifolium	pratense	Red Clover	C	1	53	agriculture, revegetation	1902
2	Pea family	Trifolium	repens	White Clover	C	1	59	agriculture, revegetation	1916
7	Pea family	Vicia	americana	American Vetch	?R	1		unknown	
3	Pea family	Vicia	angustifolia	Garden Vetch	R	2		unknown	1992
1	Pea family	Vicia	cracca	Tufted Vetch	C	2	73	agriculture, transportation, horticulture	1943
5	Pea family	Vicia	villosa	Wolly Vetch	X	3	53	unknown	1916
3	Maple family	Acer	negundo	Manitoba or Ash-leaf Maple	R	2	nr	horticulture	1998
1	Euphorbia family	Euphorbia	esula	Leafy Spurge	R	2	84	argiculture	1992
4	Violet family	Viola	tricolor	Johnny-jump-up	C	1	34	horticulture	**1995**
4	Oleaster family	Hippophae	rhamnoides	Sea-Buckthorn	R	2		horticulture	2007
3	Carrot family	Heracleum	sibiricum	Siberian Cow-parsnip	R	2		unknown	1991
5	Carrot family	Pastinaca	sativa	Wild parsnip	R	3	nr	agriculture	1949
3	Mallow family	Malva	neglecta	Common Mallow	R	2	nr	agriculture	2008
5	Jacob's ladder family	Gilia	capitata	Blue-headed Gily Flower	X	3		unknown	**1902**
3	Forget-me-not family	Amsinckia	menziesii	Menzies' Fiddleneck	R	2	nr	unknown	1943
5	Forget-me-not family	Asperugo	procumbens	German Mad-wort	X	3	nr	horticulture	1949
7	Forget-me-not family	Hackelia	deflexa	Nodding Stickseed	?X	3		unknown	
3	Forget-me-not family	Lappula	squarrosa	European Stickseed	U	2	44	unknown	1973
5	Forget-me-not family	Myosotis	scorpioides	True Forget-me-not	R	3	54	horticulture	2000
7	Forget-me-not family	Plagiobothrys	scouleri	Scouler's Popcornflower	?R	3		unknown	
6	Verbena family	Verbena	hastata var. scabra	Simpler's-Joy	F	4			
5	Mint family	Dracocephalum	thymiflorum	Thyme-flowered Dragonhead	R	3	nr	agriculture	1949
3	Mint family	Galeopsis	tetrahit var. bifida	Bifid Hemp-nettle	R	1	50	revegetation, horticulture	1980
4	Mint family	Lamium	amplexicaule	Common Dead-nettle	R	3	nr	horticulture	2007
7	Mint family	Stachys	pilosa	Hedge-nettle	?R	2		unknown	
1	Figwort family	Linaria	dalmatica	Dalmatian Toadflax	X	3	58	unknown	2004
1	Figwort family	Linaria	vulgaris	Butter-and-Eggs	C	1	69	horticulture	1970
5	Figwort family	Veronica	arvensis	Corn Speedwell	R	3		unknown	**1970**
4	Figwort family	Veronica	longifolia	Long-leaf Speedwell	R	2	nr	agriculture, horticulture	1980
5	Figwort family	Veronica	serpyllifolia	Thyme-leaf Dragonhead	R	3	36	unknown	**1970**

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5	Plantain family	Plantago	aristata	Large-bract Plantain	X	3		unknown	**1902**
7	Plantain family	Plantago	major	Great Plantain	?C	1	44	unknown	
5	Bedstraw family	Galium	aparine	Sticky-willy	X	3		agriculture (birdseed)	2007
6	Bedstraw family	Galium	palustre	Common Marsh Bedstraw	F	4			
3	Valerian family	Valeriana	officinalis	Garden Valerian or Allheal	R	2	nr	horticulture	2007
4	Sunflower family	Achillea	ptarmica	Sneezeweed	R	2	46	horticulture	2011
5	Sunflower family	Anthemis	cotula	Stinking Chamomile	X	3	41	agriculture	**1902**
7	Sunflower family	Artemisia	biennis	Biennial Wormwood	R	4	nr	unknown	
5	Sunflower family	Centaurea	cyanus	Cornflower	X	3		horticulture	1998
1	Sunflower family	Centaurea	stoebe	Spotted Knapweed	X	3	86	unknown	1995
5	Sunflower family	Chrysanthemum	ircutianum	Early Daisy	X	3		unknown	1949
1	Sunflower family	Leucanthemum	vulgare	Oxeye daisy	R	1	61	horticulture, transportation	1980
1	Sunflower family	Cirsium	arvense	Creeping (Canada) Thistle	R	2	76	transportation	1995
5	Sunflower family	Crepis	capillaris	Smooth Hawksbeard	X	3	nr	transportation	1998
1	Sunflower family	Crepis	tectorum	Narrow-leaved Hawksbeard	C	1	56	transportation	1957
4	Sunflower family	Gaillardia	aristata	Great Blanket-flower	R	2	nr	agriculture	1973
7	Sunflower family	Gnaphalium	uliginosum	Marsh Cudweed	?R	2	nr	unknown	
5	Sunflower family	Helianthus	subrhomboideus	Stiff Sunflower	X	3		unknown	**1904**
1	Sunflower family	Hieracium	caespitosum	Field Hawkweed	R	2	79	transportation	2009
5	Sunflower family	Madia	glomerata	Mountain Tarplant	X	3	nr	unknown	1902
3	Sunflower family	Matricaria	discoidea	Pineapple Weed	C	1	32	unknown	1902
1	Sunflower family	Tripleurospermum	inodoratum	Scentless Chamomile	R	1	48	unknown	1980
5	Sunflower family	Senecio	eremophilus	Dryland Ragwort	R	3		transportation	1968
3	Sunflower family	Senecio	vulgaris	Common Ragwort	R	2	36	horticulture, agriculture	1902
1	Sunflower family	Sonchus	arvensis ssp. uliginosus	Field Sow-thistle	C	1	73	unknown	1980
2	Sunflower family	Sonchus	asper	Prickly Sow-thsitle	R	2	46	horticulture	1904
6	Sunflower family	Sonchus	oleraceus	Common Sow-thistle	F	4	46		
1	Sunflower family	Tanacetum	vulgare	Common Tansy	U	2	60	horticulture, transportation	1995
4	Sunflower family	Taraxacum	erythrospermum	Red-seeded Dandelion	X	2		unknown	1949
2	Sunflower family	Taraxacum	officinale	Common Dandelion	C	1	58	unknown	1943
2	Sunflower family	Tragopogon	dubius	Yellow Goat'sbeard	R	2	50	transportation	1995