Capstone
MINTO MINE
OPERATED BY MINTO EXPLORATIONS LTD.

Minto Mine

Environmental Monitoring, Surveillance and Reporting Plan

Prepared by:
Minto Explorations Ltd.
Minto Mine
December 2015

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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
MVFES2	Mill Valley Fill Extension Stage 2
MWD	Main waste dump
NP	Neutralizing potential
PRL	Plan Requirement Letter
QA/QC	Quality Assurance/Quality Control
QML	Quartz Mining Licence
RISS	Regulatory Information Submission System
ROD	Reclamation overburden dump
SECP	Sediment and Erosion Control Plan
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 QZ14-031

Acronym	Definition
YISC	Yukon Invasive Species Council
YWB	Yukon Water Board

1 Introduction

The *Environmental Monitoring, Surveillance and Reporting Plan* (EMSRP) is a requirement of Quartz Mining Licence QML-0001 (QML) and Water Use Licence QZ14-031 (WUL). The QML defines the EMSRP as *"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 of both the QML and WUL including the conditions related to the water monitoring program, geochemical monitoring program, meteorological monitoring program, physical monitoring program, aquatic environmental monitoring program, terrestrial environment monitoring program, progressive reclamation effectiveness monitoring program and quality assurance and quality control programs. The EMSRP has been developed to meet the requirements of the QML Plan Requirements Letter (dated in 2014-12-18 (PRL)), and WUL conditions 83 through 104.

Additionally, as a metal mine in the Yukon, the Minto Mine is required to comply with the *Metal Mine Effluent Regulations* (MMER) (Metal Mine Effluent Regulations, 2002), which regulates the monitoring frequency and reporting of effluent discharged from the Minto Mine.

The 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 2014 *Environmental Monitoring, Surveillance and Reporting Plan*, submitted in July 2014 by Minto Explorations Ltd. and approved in December 2014.

The content of this EMSRP was originally derived from the *Plan Requirement Guidance for Quartz Mining Projects* (Yukon Government, 2013) and this recent itineration and has been prepared to meet the requirements of the WUL and the QML.

Table 1-1: 2015 EMSRP Regulatory Concordance Table

	2015 EMSRP Regulatory Concordance Table			
Monitoring Program	**Associated Licence or Regulation**	**EMSRP Licence Required Updates**	**Regulatory Monitoring Programs - Key Managers**	**EMSRP Section**
Water Monitoring Program	**WUL**		Environmental Manager	2
Surface Water Surveillance Program	WUL	WUL 85, 86, Schedule 1	Environmental Manager	2.1
Groundwater Monitoring Program	WUL	WUL 90 a-i, 91	Environmental Manager	2.2

	2015 EMSRP Regulatory Concordance Table			
Monitoring Program	**Associated Licence or Regulation**	**EMSRP Licence Required Updates**	**Regulatory Monitoring Programs - Key Managers**	**EMSRP Section**
Seepage Monitoring Program	WUL	WUL 92 a-b, 93	Environmental Manager	2.3
Geochemical Monitoring Program	**WUL**	WUL 94 / QML PRL 3 (c)	Chief Geologist	3
Acid Base Accounting (ABA) Monitoring Program	WUL	WUL 95	Chief Geologist	3.1
Waste Rock Management Verification Program	WUL	WUL 95	Chief Geologist	3.2
Meteorological Monitoring Program	**WUL**		Environmental Manager	4
Climate Monitoring Program	WUL	WUL 96	Environmental Manager	4.1
Snow Survey Program	WUL	WUL 96	Environmental Manager	4.2
Physical Monitoring Program	**WUL / QML**	WUL 97 a-h, 98, 99 a-b / QML PRL 3(a) (b)	Chief Engineer	5
Aquatic Environmental Monitoring Program	**WUL / MMER**	WUL 102	Environmental Manager	6
Metal Mine Effluent Regulations Monitoring Programs	WUL / MMER	WUL 101 a	Environmental Manager	6.1
Sediment Quality and Toxicity Monitoring	WUL	WUL 101 b	Environmental Manager	6.2
Periphyton and Benthic Invertebrate Tissue Monitoring	WUL	WUL 101 c	Environmental Manager	6.3
Fish Monitoring Program	WUL / MMER	WUL 101 a	Environmental Manager	6.4
Terrestrial Environment Monitoring Program	**QML**		Environmental Manager	7
Invasive Plant Species Monitoring Program	QML		Environmental Manager	7.1

	2015 EMSRP Regulatory Concordance Table			
Monitoring Program	**Associated Licence or Regulation**	**EMSRP Licence Required Updates**	**Regulatory Monitoring Programs - Key Managers**	**EMSRP Section**
Wildlife Monitoring Program	QML		Environmental Manager	7.2
Erosion and Sedimentation Monitoring Program	QML		Environmental Manager	7.3
Vegetation Metal Uptake Program	QML	QML PRL 3 (d)	Environmental Manager	7.4
Progressive Reclamation Effectiveness Monitoring Program	**WUL / QML**		Environmental Manager	8
Quality Assurance and Quality Control Programs	**WUL**	WUL 103, 104	Environmental Manager	9

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 V/VI of development.

Figure 1-1: Minto Mine Location Map

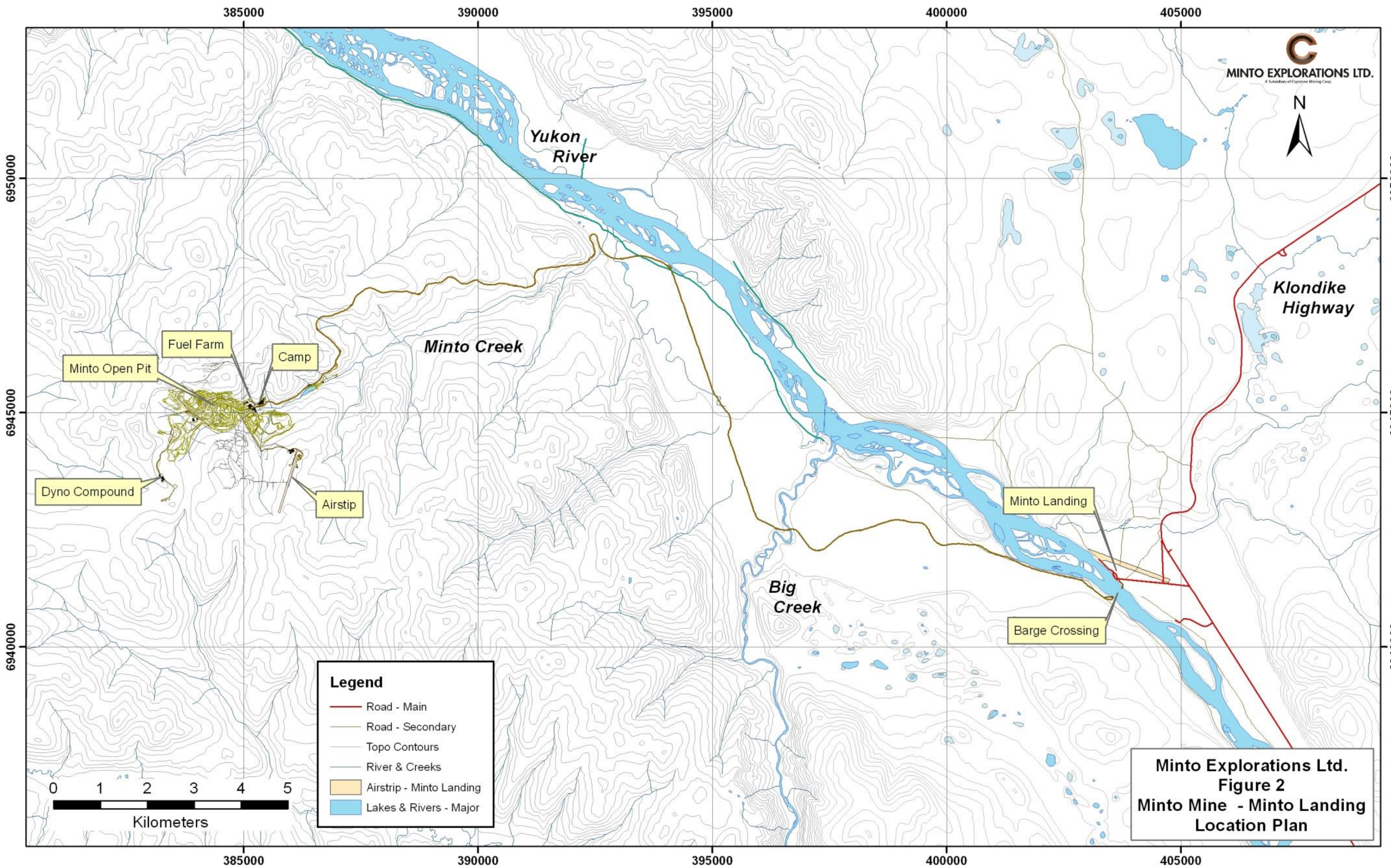

Figure 1-2: Minto Mine Access Location

2 Water Monitoring Program

Water quality and hydrology monitoring at the Minto Mine is conducted in accordance with the requirements outlined in WUL and in the MMER. Monitoring programs for water quality and hydrology at the Minto Mine, McGinty Creek, groundwater, and seepage are detailed below in Sections 2.1 through 2.3; details regarding water monitoring and the MMER are presented in Section 6.1. Monitoring stations are described in Table 2-1 and are shown in Figure 2-1, and Figure 2-2. The locations of several monitoring stations are not identified in Table 2-1 and Figure 2-1 as a result of monitoring stations not having been developed as the associated Phase V/VI structures have not been constructed. As the Phase V/VI mine plan progresses the specific locations of these monitoring stations will be identified and included in the Annual Report.

The location description, and expected frequency of monitoring are summarized in the tables within this section.

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
W6	Tributary on the North side of Minto Creek	387583	6946392
W7	Mouth of the 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	Upgradient of South Diversion Ditch	385351	6944072

Station	Description	UTM Coordinates – Zone 8	
		Easting	Northing
W35	South Diversion Ditch	385223	6944427
W36	Minto Creek detention structure (MCDS)	385892	6945191
W37	100 m downstream of MCDS (W36 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	384775	6944153
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 when RO not operating	385126	6945154
RO	Treated water from RO	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	386209	6945007
W62	MVFES2 Collection Sump	386079	6945335
C4	Tributary on the south side of Minto Creek, downstream of W3	388407	6946571
C10	Tributary on the south side of Minto Creek, downstream of W3	391868	6947914
MN	Minto North pit water	384342	6946090
MN-0.2	Upper west arm of McGinty Creek (Reference Station)	382267	6947299
MN-0.5	West arm of McGinty Creek just upstream of the confluence with the east arm	385251	6951262
MN-1.5	Upper east arm of McGinty Creek downstream of the Minto North deposit	384473	6947055
MN-2.5	East arm of McGinty Creek just upstream of confluence with the west arm	385493	6950788
MN-4.5	Lower mainstream McGinty Creek near confluence with Yukon River	386231	6952851
UG 1	Minto South underground mine dewatering	384916	6944098
UG 2	Wildfire underground mine dewatering		
UG 3	Copper Keel underground mine dewatering		

Station	Description	UTM Coordinates – Zone 8	
		Easting	Northing
UG 4	Minto East underground mine dewatering		

Deviations from the WUL Schedule 1 Part 1 and the EMSRP Table 2-1 include the following:

- W12A has not been included as a station in Table 2-1 as W12 and W12A are water equivalent to one another.
- In Table 2-1, the site described as “Main Pit Dam Seepage” has been named “W54”. In WUL Schedule 1, Part 1 the monitoring site nomenclature “W53” was repeated twice and the second occurrence was used in the site described as “Main Pit Dam Seepage”. To avoid confusion, this site has been renamed to W54 in Table 2-1.

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ENVIRONMENTAL MONITORING, SURVEILLANCE AND REPORTING PLAN

FIGURE 2-1

SURFACE WATER SURVEILLANCE PROGRAM MONITORING STATION LOCATIONS

DECEMBER 2015

▲ Surface Water Surveillance Program Monitoring Station Locations

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0 250 500

Meters

ALEXCO ENVIRONMENTAL GROUP

Aerial imagery obtained from Challenger Geomatics. Imagery acquired September 9th 2014. Hydrology data provided by Minto Explorations Ltd, May 2009.

Datum: NAD 83 Projection: UTM Zone 8N

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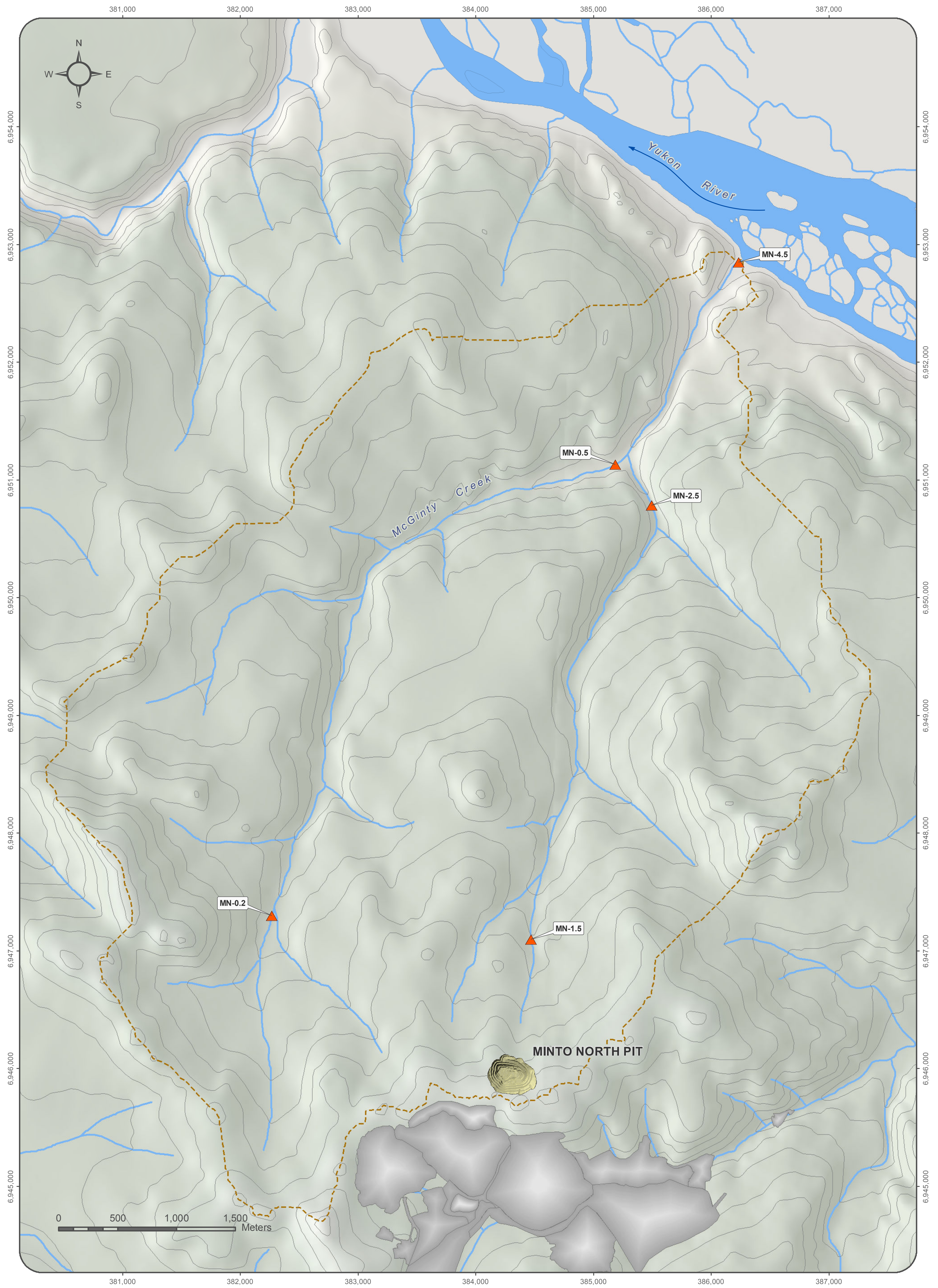

Monitoring Station

Minto North Pit

Other Mine Feature Footprints

Contour (100 ft interval)

McGinty Creek Catchment

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ENVIRONMENTAL MONITORING, SURVEILLANCE AND REPORTING PLAN

FIGURE 2-2

SURFACE WATER SURVEILLANCE PROGRAM MCGINTY CREEK MONITORING STATION LOCATION

DECEMBER 2015

Datum: NAD 83; Projection: UTM Zone 8N

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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 and 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 Annual Report.

The Surface Water Surveillance Program monitoring schedule contains weekly, monthly, and quarterly 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 (DOC), 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*. The water quality standard operating procedures (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*. 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).

The *Minto Mine Surface Water Quality Monitoring Standard Operating Procedures* and *Minto Mine Surface Water Hydrology Standard Operating Procedure* are updated on an as-required basis to ensure that the BMPs described in the documents remain current.

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	Chronic Toxicity Testing	
				Frequency	Analytical Suite	Frequency			Frequency	Test
W1	C	-	-	-	-	-	-	-		
W2	-	-	W/Wd	W/Wd	A,N,DOC	Wd	-	-	Md	CD-7d
									Q	CD-7d, CT-30d, CA-72hr
W3	C	-	W/Wd	W/Wd	A,N,DOC	Wd	Md	Md	-	-
W4	-	-	Q	Q	A,N, DOC	-	-	-	-	-
W5	-	-	Q	Q	A,N, DOC	-	-	-	-	-
W6	M	-	M	M	A,N, DOC	-	-	-	-	-
W7	C	-	M	M	A,N,DOC	-	-	-	-	-
W8	-	-	W	W	A,N	W	-	-	-	-
W8A	-	-	W	W	A,N	W	-	-	-	-
W10	-	-	M	M	A,N	-	-	-	-	-
W12	-	W-WL, TV	M	M	A,N	-	-	-	-	-
W14	-	-	M	M	B	-	-	-	-	-
W15	C	-	M	M	A,N, DOC	Wd	-	-	-	-
W16	-	W-WL	Mnf/Wd	Mnf/Wd	A,N, DOC	Wnf	-	-	-	-
W16A	Wd	-	Wd	Wd	A,N,DOC	Wd	Md	Md	-	-
W17	C	-	W/Wd	W/Wd	A,N, DOC	Wd	-	-	-	-
W30	M	-	M	M	A,N	-	-	-	-	-
W33	M	-	M	M	A,N	-	-	-	-	-
W35	C	-	M	M	A,N, DOC	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	M/Wd	A,N,DOC	Wd	M	M	M	CD-7d
MC-1	C	-	M/Wd	M/Wd	A,N,DOC	-	-	-	-	-
WTP	Wd	-	Wd	Wd	A,N,DOC	Wd	-	-	-	-
RO	Wd	-	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	-	-	-	-	-

Station	Flow	Water Level	Field Parameters Frequency	External Analytical Suite		Internal Suite	96-Hr LT50	48-Hr LT50	Chronic Toxicity Testing	
				Frequency	Analytical Suite	Frequency			Frequency	Test
W54	C	-	M	M	A,N	-	-	-	-	-
W55	M	-	M	M	A,N	-	-	-	-	-
W62	C		M	M	A,N					
C4	M	-	M	M	A,N,DOC	-	-	-	-	-
C10	M	-	M	M	A,N,DOC	-	-	-	-	-
MN	Cdw	W-WL	M	M	A,N	-	-	-	-	-
MN-0.2	M	-	M	M	A,N,DOC	-	-	-	-	-
MN-0.5	M	-	M	M	A,N,DOC	-	-	-	-	-
MN-1.5	C	-	M	M	A,N,DOC	-	-	-	-	-
MN-2.5	C	-	M	M	A,N,DOC	-	-	-	-	-
MN-4.5	C	-	M	M	A,N,DOC	-	-	-	-	-
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	**A**: Physical parameters, conductivity, total suspended solids, total dissolved solids, hardness, alkalinity, sulphate, ICP scan- total metals, ICP – dissolved metals
W: Weekly	**B:** Physical parameters, conductivity, total dissolved solids, alkalinity, sulphate, ICP – dissolved metals
Wd: Weekly while discharging	**N**: Nutrients: Ammonia-N, Nitrate-N, Nitrite-N
Wnf: Weekly, when not frozen	**Field parameters:** In-situ pH, Conductivity, Temperature, Dissolved Oxygen
M: Monthly	**Internal lab parameters:** dissolved metals: copper, aluminum, cadmium, selenium; ammonia, nitrite, nitrate and total suspended solids
Md: Monthly while discharging	**DOC**: Dissolved organic carbon
Mnf: Monthly, when not frozen	**96 hr LT50**: LT50 Rainbow trout static bioassay, 96 hrs at 100%, pH non-adjusted
Cdw: Continuous when dewatering	**48 hr LT50**: LT50 *Daphnia magna* static bioassay, 48 hrs at 100%, pH non-adjusted
WL: Surface Water Level Elevation	**CD-7d**: Chronic Toxicity – *Ceriodaphnia dubi*a 7 day test (EPS 1/RM/21)
TV: Track Tailings Volume	**CT-30-d:** Chronic toxicity – 30 day Early Stage Toxicity for Rainbow Trout (EPS 1/RM/28)
	CA-72hr: Chronic Toxicity – 72-hour for Algae (EPS 1/RM/25)

Definitions made in the EMSRP Table 2-2 that are not included in the WUL include the following:

- The “B” Analytical Suite has been defined in Table 2-2 as physical parameters, conductivity, total dissolved solids, alkalinity, sulphate, ICP – dissolved metals. No definition of the suite was provided in the WUL.
- The metals description in the internal lab parameters have been defined as dissolved metals: copper, aluminum, cadmium and selenium in lieu of copper, aluminum, cadmium selenium as described in the WUL.
- The acronym Wnf has been defined as “weekly, when not frozen”.
- The description of the 48-hr LT50 has been amended to reflect that the test is a 48-hour test and not a 96 hour test as described in the WUL.
- W62 has been added as a monitoring site as the MVFE2 Collection Sump. Monitoring of W62 will occur on a monthly basis.

2.2 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. The Groundwater Monitoring Program includes several components including groundwater water quality, aquifer characterization, evaluation of longitudinal flow paths, leaching tests, and the monitoring of long-term phreatic levels in tailing management facilities. Details of the Groundwater Monitoring Program components are discussed in the *Groundwater Monitoring Plan* in Appendix 1.

Monitoring areas are both up-gradient and down-gradient of mine activities and include, but are not limited to, the dry stack tailings storage facility (DSTSF), mill area, Main Pit Tailings Management Facility, Area 2 Pit Tailings Management Facility, Minto North Pit, mill valley fill, 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 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).

Groundwater wells at Minto include multi-level monitoring wells, stand pipe wells and drivepoint wells. The "Westbay MP" multi-level monitoring system allow for monitoring below shallow permafrost as the system can be operated with anti-freeze in the sealed access pipe. Standpipe wells are simple wells consisting of a standpipe tube inserted into a borehole. Drivepoint wells are small diameter wells that are used to monitor shallow groundwater conditions.

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, category and frequencies are provided in Table 2-3 for operational monitoring and in Table 2-4 for baseline groundwater monitoring. The Minto Mine Groundwater Monitoring Program has been included as Appendix 1.

Table 2-3: Operational Groundwater Monitoring

Mine Project Component	Monitoring Installation	Monitoring Required	Monitoring Frequency
Main Waste Dump	MW09-01	Water Level, Water Quality	Quarterly
Southwest Waste Dump	MW12-DP1 MW12-DP2 MW12-DP3	Water Level, Water Quality	Quarterly
Dry Stack Tailings Storage Facility and Mill Valley Fill Expansion	MW12-06 MW15-09	Water Level, Water Quality	Quarterly
Main Pit	MW12-07 MW11-01A	Water Level, Water Quality	Quarterly
Water Storage Pond	MW12-05	Water Level, Water Quality	Quarterly
Minto North Pit	MW09-03	Water Level, Water Quality	Quarterly
Up-gradient of Mine Activities	MW15-08	Water Level, Water Quality	Quarterly

Table 2-4: Baseline Groundwater Monitoring

Baseline Monitoring Location	Monitoring Installation	Monitoring Required	Monitoring Frequency
East of Proposed Ridgetop North Pit	MW11-02 MW11-03	Water Level, Water Quality	Quarterly
South of Proposed Ridgetop South Pit	MW11-04	Water Level, Water Quality	Quarterly

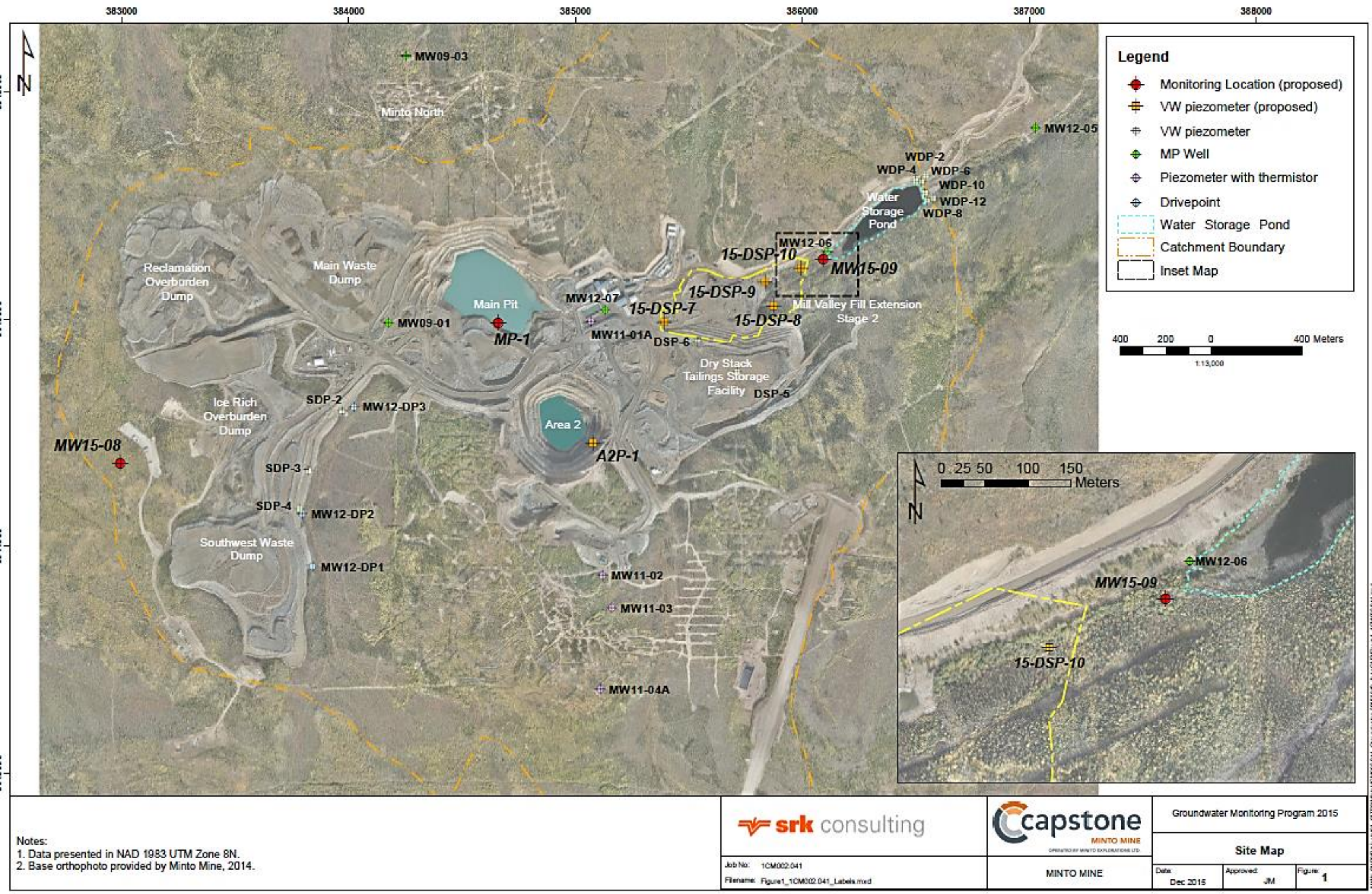

Figure 2-3: Groundwater Monitoring Site Locations

2.3 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 pit wall seepage; ore stockpile areas; overburden dumps; waste rock dumps including low grade, medium grade and high grade waste storage areas; dry stack tailing storage facility (DSTSF); mill valley fill (MVF) area (extension 1 and 2); mill area; and other known seepage locations. The monitoring locations and monitoring frequency are summarized in Table 2-5, and the analytical parameters required for seepage samples are also detailed in Table 2-5. Seepage survey locations and routes are shown on

There are several monitoring sites in the Surface Water Surveillance Program that provide seepage water quality information. The scheduled monitoring frequency and analytical parameters for these sites is detailed in Section 2.1. The Surface Water Surveillance Program monitoring sites that provide information related to seepage water quality include: W8, W8A, W17, W36, W37 and W62.

As a result of the construction of the Mill Valley Fill Extension Stage 2 (MVFES2) the Minto Creek Detention Structure (MCDS) will be decommissioned and replaced with the MVFES2 Collection Sump. The MVFE2 Collection Sump, once completed, will be monitored as monitoring site W62 (detailed in Section 2.1). Water quality monitoring at W62 is scheduled on a monthly basis for in-situ field parameters, nutrients, physical parameters, conductivity, total suspended solids, total dissolved solids, hardness, alkalinity, sulphate, total and dissolved metals. Flow monitoring will be measured continuously. Physical monitoring of the MVFE2 Collection Sump is detailed in Section 5 as part of the Physical Monitoring Program.

Table 2-5: Seepage Monitoring Survey Locations and Sampling Frequency

Survey Locations	Monitoring Frequency	Analytical Parameters
Ore stockpile areas	Twice yearly; once in spring runoff conditions (typically May) and once in early fall conditions (typically September). Note that Pit walls can only be surveyed if safe conditions are present.	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		
Waste rock dumps		
Drystack tailings storage facility		
Mill Area		
Mill Valley Fill Extension (Stage 1 and 2)		
Water Storage Pond Dam Seepage		
Pit Walls		

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 sample as per the *Minto Mine Surface Water Quality Monitoring Standard Operating Procedures*.

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.

Results from the Seepage Monitoring Program will be compared to the source terms used in the Water Balance and Water Quality Model; additionally results will be summarized in the WUL Annual Report.

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ENVIRONMENTAL MONITORING, SURVEILLANCE AND REPORTING PLAN

FIGURE 2-4

SEEPAGE MONITORING PROGRAM SURVEY LOCATIONS

DECEMBER 2015

▲ WUL Seepage Water Quality Station

- - - Seepage Monitoring Survey

1:13,000

when printed on 11 x 17 inch paper

0 100 200 300 400 500

Meters

ALEXCO ENVIRONMENTAL GROUP

Aerial imagery obtained from Challenger Geomatics. Imagery acquired September 9th 2014.

Datum: NAD 83 Projection: UTM Zone 8N

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(Last edited by: mducharme; 12/1/2015/14:36 PM)

3 Geochemical Monitoring Program

The Geochemical Monitoring Program is comprised of the following 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;
- The Waste Rock Management Verification Program; and
- Low Grade and Oxide Ore Metals Leaching Characterization Program.

These programs are detailed in Sections 3.1 to 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, 2014).

The Low Grade and Oxide Ore Metal Leaching Program is currently under development. The Low Grade and Oxide Ore Metal Leaching Program monitoring requirements will be discussed as part of the Geochemical Monitoring Program section of the WUL and QML Annual Report.

3.1 Acid Base Accounting (ABA) Monitoring Program

3.1.1 Internal (On-site) Monitoring

On-site ABA monitoring is carried out on drill cuttings from every blast hole. Samples are collected for grade control purposes, and a portion of each sample is sent for 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, 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 Minto 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	1. Internal Laboratory: S(T) and C(T)

Material	Sample Frequency	Sampling Type	Analytical Requirement
		composite of blast hole cuttings)	
	Pre-selected based on the drill pattern, the ABA sampling occurs every 4-5 drill holes equilaterally in a drill pattern which is typically 20-25 m apart. The aim is to ensure even coverage for ABA analysis throughout the drill pattern.	Composite ABA samples are created based on the waste zone polygons. The number of ABA samples that go into the composite sample will depend on the size of the waste zone polygon and number of ABA samples taken within that polygon.	1. Internal Laboratory: S(T) and C(T) 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) 2. External Laboratory: ABA and trace element analyses
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 and QML Annual Report. The report will include:

- Comparison between new and historical data (including discussion), and
- 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 WROMP. 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.

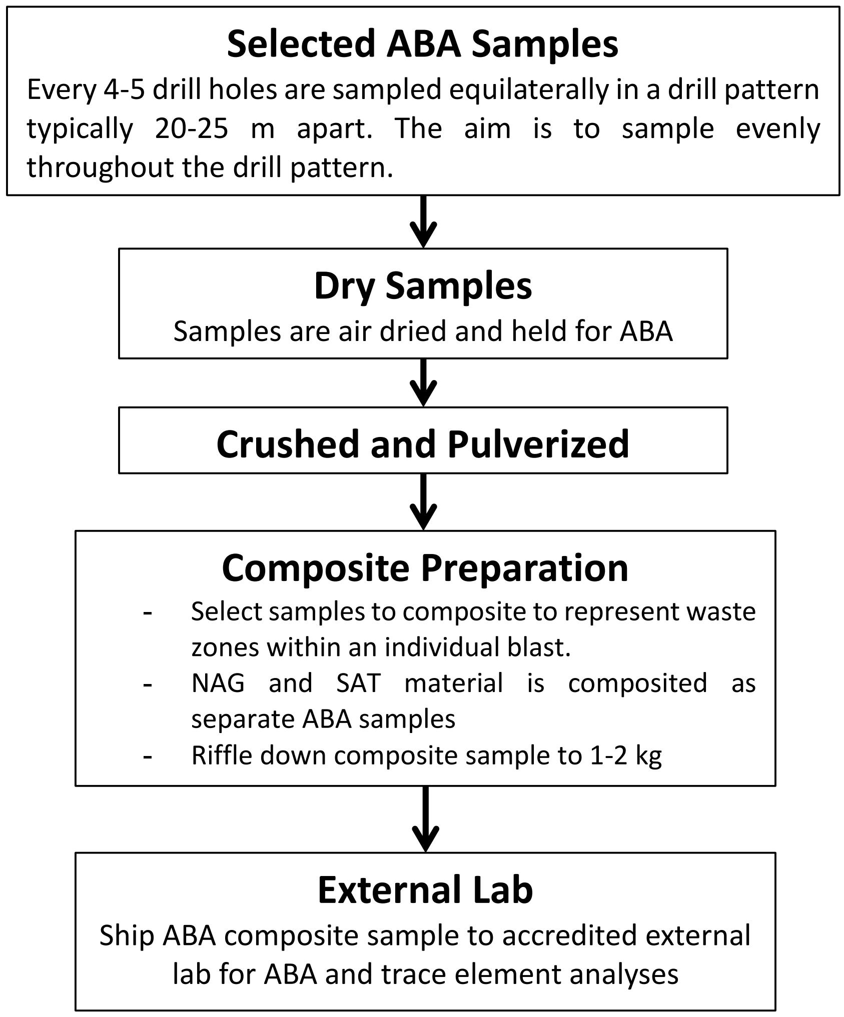

Figure 3-1: Open Pit Drill Hole ABA Sampling Flow Chart

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.

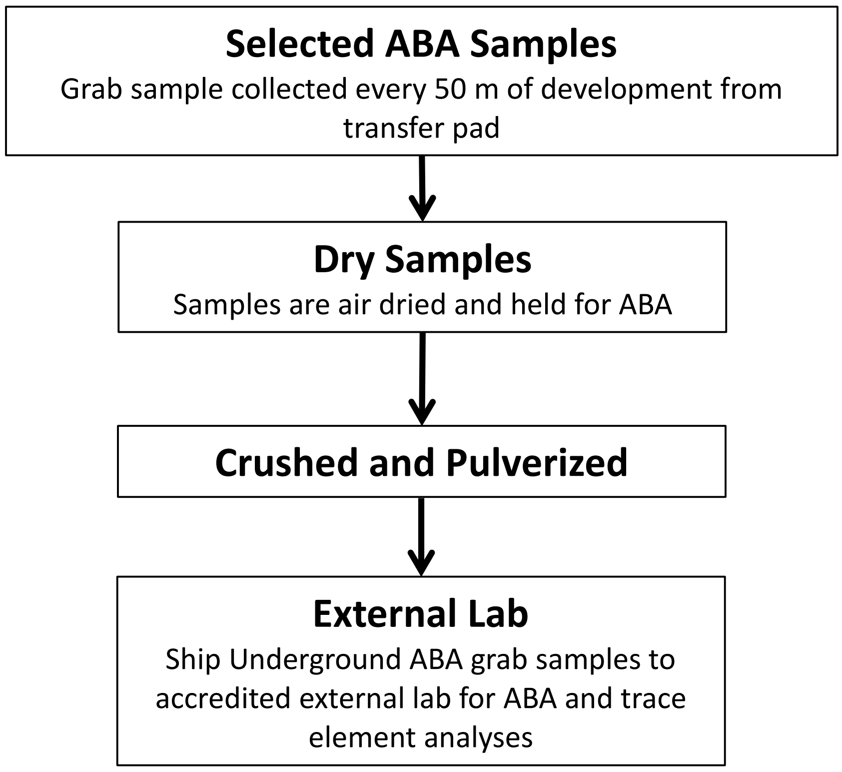

Figure 3-2: Underground Waste Rock ABA Sampling Flow Chart

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 and QML 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 requirements outlined in the WUL and QML to be used for construction:

Table 3-2: Criteria for Construction Grade Waste Rock as per the WUL and QML

WUL	QML
Total copper content of <0.10%	Copper content no greater than 10%
NP:AP greater than or equal to 3	NP:AP of at least 3:1
Total sulphur content of less than 0.3%	Total sulphur content of no greater than 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 results of this program will be detailed in the WUL and QML 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 WROMP.

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.

A monthly dump sampling program takes place at Minto. 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.

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. Isolated failures will be accepted with no further action.

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. Should the material remain non-conforming it will be evaluated as to whether it is appropriate to remain in place or excavate it to a waste rock dump that will be saturated at closure. If it is determined to be a geochemical risk (i.e. large volume concentrated in one area) to the waste dump it 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, pan evaporation, barometric pressure, solar radiation and calculated evapotranspiration.

Data is downloaded, compiled and reported in monthly and annual WUL 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, snowpack 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:

Weather: Clear & sunny

Snow Temp: -6°C

Surface snow conditions:

Wet	Soft
Dry X	Crusted X
Flat	Drifted
Freeze	Thaw

Sampling conditions:

Easy	Moderate	Difficult

Remarks:

Density range: 19.7 to 24.3% = 4.6%

Av core to snow depth = 81%

Station 9 discarded (outlier).

Figure 4-1: Sample Snow Survey Field Form

5 Physical Monitoring Program

The objective of the Physical Monitoring Program is to monitor the performance of key mine infrastructure and workings. Outlined in Table 5-1 is the mine infrastructure that requires monitoring under the Physical Monitoring Program; the infrastructure descriptions and instrumentation in place are further outlined in Table 5-1.

The Physical Monitoring Program consists of two main components: instrumentation to measure ground conditions and deformation; and, regular geotechnical inspections. Instrumentation to measure ground conditions and deformation include the following:

- Survey hubs;
- Inclinometers;
- Thermistors; and
- Vibrating Wire Piezometers.

Monitoring and inspection schedules for each structure and associated reporting requirements are detailed in the *Physical Monitoring Plan* (Appendix 2)

Table 5-1: Physical Monitoring Program Mine Structures and Instrumentation

Structure	Description	Instrumentation
Area 2 Pit and Area 2 Pit Tailings Management Facility (A2PTMF)	The Area 2 Pit was completed in 2015 to the extents licensed under Phase IV (Stages 1 and 2); the pit will be extended to the south as part of Phase V/VI (Stage 3). Tailings deposition into the pit began in March, 2015 and the pit is now maintained as a tailings management facility.	• Survey hubs
Area 118 Pit	Mining of the Area 118 Pit was carried out in 2014. The pit is currently inactive and the access is barricaded.	• Survey hubs
Area 118 Underground	The Area 118 underground began development in 2013 and is accessed by a portal and decline south of the Area 2 and Area 118 Pits. Production mining is currently taking place using a longhole stoping method and is expected to be completed in 2016.	None
Big Creek Bridge	Bridge on the Minto access road crossing Big Creek, located at Km 19. Licenced under Type B water licence MS04-227.	None
Camp	The camp consists of several connected bunkhouse buildings (Sherwood, Minto, Selkirk), a kitchen building, and several separate buildings including the gym and Site Services offices.	None
Dry Stack Tailings Storage Facility (DSTSF)	Construction of the DSTSF with filtered tailings placement was carried out from 2007 to November 2011. As part of progressive reclamation activities in 2012-2013, the DSTSF was covered with a layer of overburden approximately one to four meters thick. The DSTSF began showing deformation in 2009, interpreted as primarily horizontal sliding towards the north/northeast on an ice-rich layer in the underlying overburden, several meters above bedrock. The movement has continued since then but at a decreasing rate in response to construction of the Mill Valley Fill waste rock buttress.	• Survey hubs • Thermistors • Inclinometers • Piezometers
Ice Rich Overburden Dump (IROD)	Originally constructed as a free-standing rockfill structure to contain ice-rich overburden. The IROD is no longer active and is now entirely surrounded by the Southwest Waste Dump rockfill.	None
Main Pit (Area 1 Pit) and Main Pit Tailings Management Facility (MPTMF)	Mining in the Main Pit was completed in 2011. Instability in the south wall of the pit occurred in 2009 during mining of Stage 3 of the pit, and subsequently a larger failure occurred in 2011 after completion of Stage 5. Continued sloughing and creep movement of the south wall led to the design and construction of a waste rock buttress, known as the South Wall Buttress, completed in 2013. Slurry tailings deposition into the pit began in 2012 and the pit is now maintained as a tailings management facility. Dumping of NP: AP<3 waste rock (SAT), intended to be below the final water table at closure, continues into the pit, forming several benches of "in-pit dumps". Tension cracking on the west in-pit dump is monitored with a series of survey hubs installed in 2015 as recommended in previous inspection reports.	• Survey hubs • Inclinometer

Structure	Description	Instrumentation
Main Pit Dam	The Main Pit Dam is included in the Phase V/VI licence and has not been constructed yet. The dam will be located on the east end of the Main Pit to increase the tailings storage capacity of the MPTMF.	• Thermistors
Main Pit Dump	The Main Pit Dump is included in the Phase V/VI licence and has not commenced yet. The dump will be located on the southwest side of the Main Pit, partially on top of the South Wall Buttress.	N/A
Main Waste Dump (MWD)	The Main Waste Dump stores waste rock released during the mining of the first three stages of the Main Pit. The dump is no longer active however dumping is taking place nearby on the Main Waste Dump Expansion.	• Inclinometers
Main Waste Dump Expansion (MWDE)	This dump is an extension of the MWD and is currently the main active waste rock dump storing waste rock released from the Minto North Pit.	• Inclinometers
Mill Site	The mill site consists of the mill building, crusher and crusher stockpile pad.	None
Mill Valley Fill Extension (MFVE)	A waste rock buttress to the north of the DSTSF, constructed from January 2012 to March 2013 to prevent or decrease further movement of the DSTSF.	• Survey hubs
Mill Valley Fill Extension 2 (MVFE2)	An extension of the MVFE waste rock buttress to begin in Q4 2015 to further decrease movement of the DSTSF.	• Piezometers • Survey hubs
Mill Valley Fill Extension 2 Collection Sump	A replacement sump for the MCDS to be constructed in November 2015. It will detain surface water considered impacted from upstream sub-catchment areas and will direct it to the MPTMF or water treatment plant.	None
Mill Water Pond (MWP)	A small water storage pond that was previously used for excess process water and recirculation of mill process water. Currently not in use.	• Thermistors
Minto Access Road	Road from the Yukon River barge crossing to the mine site. Licenced under Type B water licence MS04-227.	None
Minto Creek Detention Structure (MCDS)	A small sump to detain surface water considered impacted from upstream sub-catchment areas (DSTSF) and direct it back to the Main Pit or water treatment plant.	None
Minto East, Area 2, Copper Keel, Wildfire Underground	The Area 2, Minto East, Copper Keel and Wildfire underground are in the phase V/VI mining plan and have not commenced yet.	N/A
Minto North Pit	Mining of the North Pit commenced in August 2015 and is scheduled to be completed in 2016.	• Radar
Ore Stockpiles	There are two primary ore stockpiles on site – North and South stockpile. These are located south of the crusher and east of the Area 2 pit.	None
Reclamation Overburden Dump (ROD)	Received the bulk of the overburden released as part of Phase IV and earlier mining of the Main Pit. The material in the ROD is available for use in reclamation of the mine at closure.	None
Ridgetop Pit (Ridgetop North Pit, Ridgetop South Pit)	The Ridgetop Pit (North and South) is included in the Phase V/VI licence and has not commenced yet.	• Thermistors
Ridgetop Waste Dump	The Ridgetop Waste Dump is included in the Phase V/VI licence and has not commenced yet.	N/A
South Diversion Ditch (SDD)	A diversion ditch located southeast of the Area 2 Pit to divert unaffected surface water around the mine workings.	None
South Wall Buttress (SWB)	Waste rock buttress constructed against the Main Pit south wall from 2009-2011 as a result of instability in the south wall of the pit.	• Survey hubs
Southwest Waste Dump (SWD)	The Southwest Waste Dump (SWD) stores waste rock released during phase IV mining. Dumping at the SWD is now complete and reclamation re-sloping began in 2015. Re-sloping is expected to be completed in 2016.	• Survey hubs • Inclinometers • Thermistors • Piezometers

Structure	Description	Instrumentation
Tailings Diversion Ditch (TDD)	A diversion ditch located south of the DSTSF to divert unaffected water around the tailings facility.	None
Water Storage Pond Dam (WSP)	The Water Storage Pond and Dam are located east of the mine along Minto Creek. The dam was constructed in 2006 as a clay-core water retention dam for collecting precipitation and surface water runoff at the site. Maximum depth of water at the face of the dam is approximately 15 m.	• Survey hubs • Thermistors • Piezometers

Roles and responsibilities for the Physical Monitoring Program are detailed in Table 5-2, below.

Table 5-2: Physical Monitoring Program Roles and Responsibilities

Role	Responsibilities
Mine Technician Assistants	• Collect instrumentation data at specified frequencies • Input data into monitoring spreadsheets/databases • Internal reporting of monitoring data • Maintain equipment
Geotechnical Engineers	• QA/QC of data collection • Ensure compliance with license requirements • Monthly and Annual reporting • Visual inspections at specified frequencies • Communicate with consultants as required • Review and update *Physical Monitoring Plan*
Environmental Department	• Compile Monthly and Annual reports • Visual inspections of water diversion/collection structures
Chief Engineer	• Review Annual Physical Monitoring report • Ensure compliance with license requirements

The Physical Monitoring Program is updated annually as part of the WUL and QML Annual Report. New instrumentation, replaced damaged instrumentation and changes in monitoring methods and procedures are detailed if applicable. Results and interpretation of the program are detailed in the Annual Report. Furthermore, the Physical Monitoring Program is reported as part of the WUL monthly reporting; each month a Geotechnical Engineer reviews, summarizes and signs a report detailing the information collected as part of the Physical Monitoring Program.

6 Aquatic Environmental Monitoring Program

Under the WUL Minto is required to implement an Aquatic Environmental Monitoring Program (AEMP) as part of the EMSRP. The AEMP includes several elements as listed in the WUL. Specifically, Clause 101 of the WUL indicates:

The Aquatic Environmental Monitoring Program shall be updated to include:

a) MMER Environmental Effects Monitoring;

b) Sediment Toxicity sampling, analyses and reporting; and

c) Invertebrate Tissue Chemistry sampling, analyses and reporting.

Clause 102 of the WUL indicates:

The Licensee shall review and evaluate the Aquatic Environmental Monitoring Program design every three (3) years and submit the findings to the Board, along with any recommendations for further refinements, as a part of the Annual Report, starting in 2016.

The WUL re-iterates the need for Environmental Effects Monitoring (EEM) under the Metal Mining Effluent Regulations (MMER) of the federal Fisheries Act in WUL Clauses 87 and 88. Minto has been implementing all aspects of the MMER (including EEM) in accordance with the regulation (Government of Canada, 2015) and technical guidance for EEM (Environment Canada, 2012) since becoming subject to the regulation on July 10, 2006. Similarly, the Minto Mine has been implementing environmental monitoring programs in accordance with WUL requirements since the issue of the first WUL in 1996 (WUL QZ96-006).

Section 6 provides an overview of the integrated AEMP, which includes EEM and the additional aquatic environmental monitoring requirements of the WUL. The Minto Mine's substantial routine effluent and water quality monitoring program, also implemented to meet requirements of both the MMER and the WUL, is presented elsewhere. Current components of the integrated AEMP include: site characterization, effluent characterization, effluent sublethal toxicity testing, supporting water quality, sediment quality, sediment toxicity testing, periphyton chlorophyll α, periphyton tissue quality, periphyton community, benthic invertebrate community, benthic invertebrate tissue quality, fish population study, and other supporting measures (Table 6-1, Figure 6-1, Figure 6-2). In accordance with WUL Clause 108, the AEMP study design will be reviewed and evaluated every three years, with the findings and recommendations for further refinements submitted to the Yukon Water Board as part of the Annual Report starting in 2016. Each of the current AEMP components is described in the sections that follow. Additionally, a summary table of the AEMP programs and study design components and AEMP supporting measures is presented in Appendix 3.

Table 6-1: AEMP Programs and Components

AEMP Program	Components
Environmental Effects Monitoring	Site Characterization
	Effluent Characterization
	Effluent Sublethal Toxicity Testing
	Supporting Water Quality
	Benthic Invertebrate Community
	Fish Population Study[1]
	Other Supporting Measures
Sediment Quality and Toxicity	Sediment Quality
	Sediment Toxicity Testing
Periphyton and Benthic Invertebrate Tissue	Periphyton Chlorophyll α
	Periphyton Community
	Periphyton Tissue
	Benthic Invertebrate Tissue

AEMP Sections
1) Site Characterization
2) Effluent Characterization
3) Effluent Sublethal Toxicity Testing
4) Supporting Water Quality
5) Sediment Quality
6) Sediment Toxicity Testing
7) Periphyton Chlorophyll α
8) Periphyton Community
8) Periphyton Tissue
9) Benthic Invertebrate Community
10) Benthic Invertebrate Tissue
11) Fish Population Study
12) Other Supporting Measures

[1] Fish tissue monitoring is not triggered under the MMER due to effluent mercury <0.10 ug/L

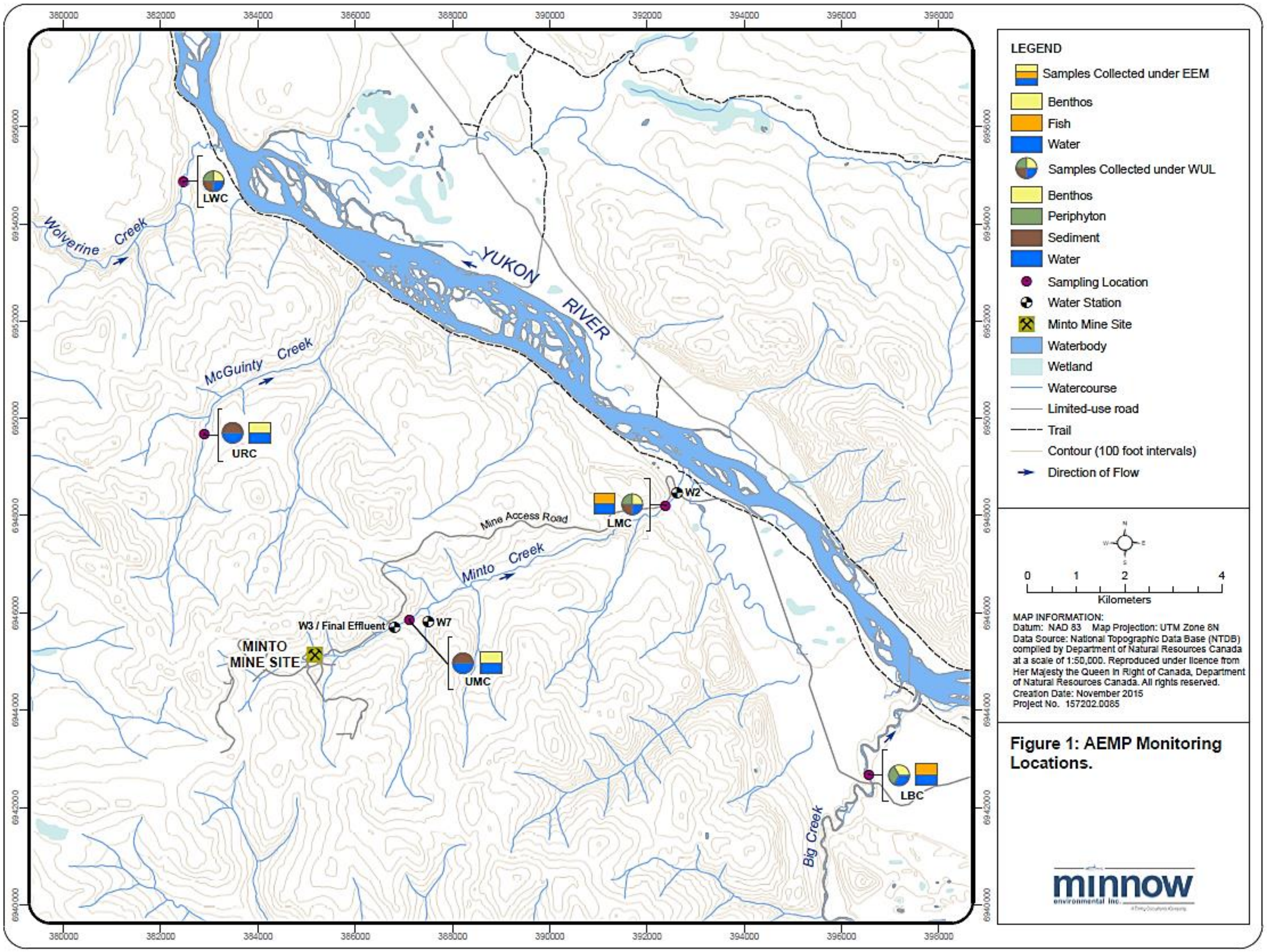

Figure 6-1: AEMP Monitoring Locations

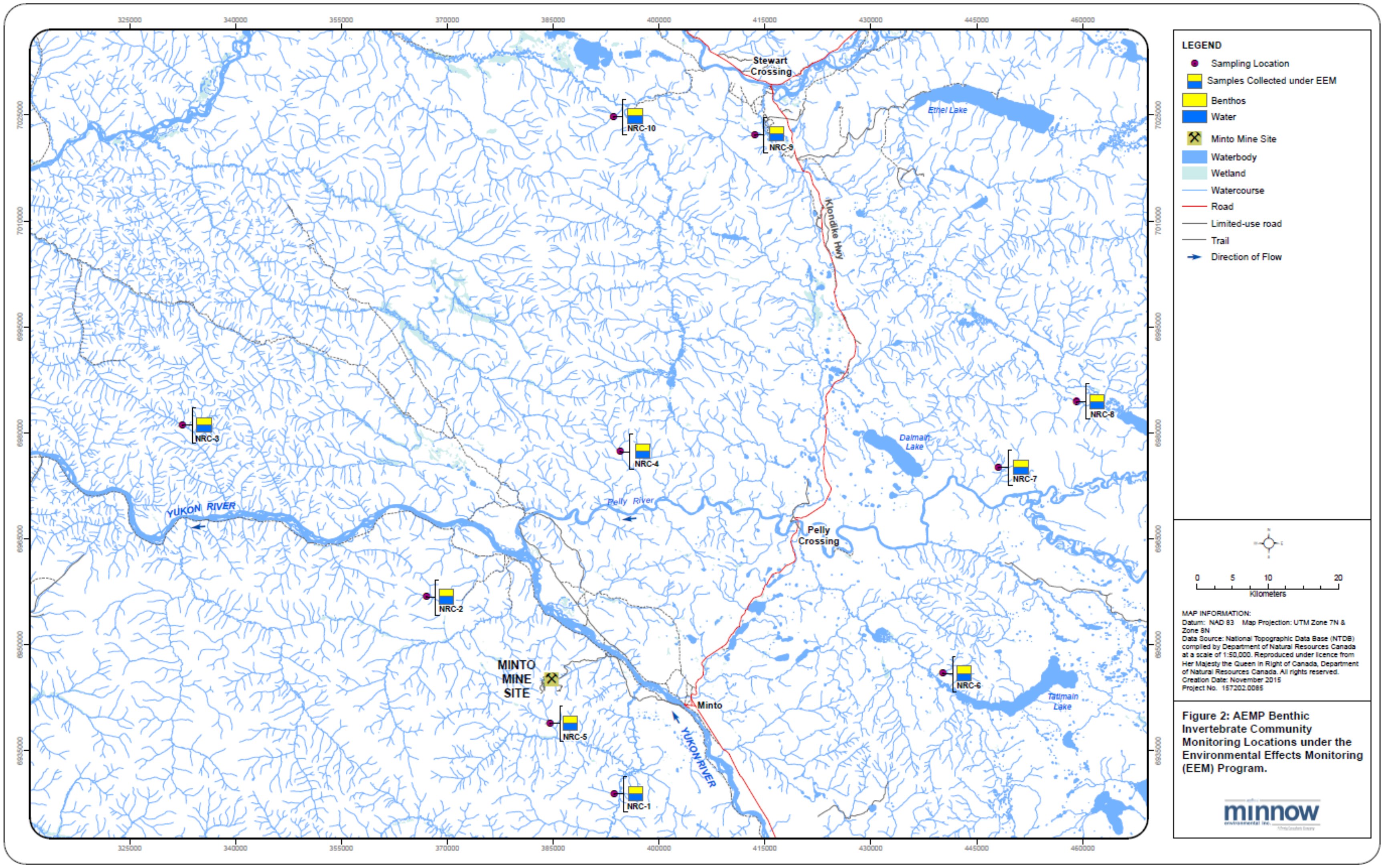

Figure 6-2: AEMP Benthic Invertebrate Community Monitoring Locations under the EEM Program

6.1 Metal Mine Effluent Regulations Monitoring Programs

The *Metal Mine Effluent Regulations* (MMER) Monitoring Programs are composed of Effluent Monitoring and the Environmental Effects Monitoring programs. Sections 6.1.1 and 6.1.2 describe each program.

6.1.1 Metal Mine Effluent Monitoring

The *Metal Mine Effluent Regulations* (MMER) 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 effluent monitoring with sampling at station W3, downstream of the end of pipe discharge (Figure 2-1). Effluent monitoring requirements are outlined in Table 6-2. Effluent monitoring samples are collected when there is a deposit of water at W3; testing occurs weekly for deleterious substances. Radium 226 and acute lethality tests are conducted quarterly due to the reduced frequency guidelines outlined in the MMER. The MMER specifies requirements for increased testing frequencies if the Radium 226 or acute lethality tests do not meet the prescribed standards as detailed in the MMER.

Weekly effluent monitoring samples are tested for the deleterious substances as described in the MMER including the total metals arsenic, copper, lead, nickel and zinc; total suspended solids (TSS) and pH. Weekly samples are collected at least 24 hours apart.

Reporting of the effluent monitoring results, and discharge volumes is required quarterly and annually to Environment Canada, under the Regulatory Information Submission System (RISS).

Table 6-2: 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 metals
	Quarterly	3. Water Quality: Radium 226 and acute lethality tests on both Daphnia magna and Rainbow trout (*Oncorhynchus mykiss*).

6.1.2 Environmental Effects Monitoring

Environmental Effects Monitoring under the MMER includes Site Characterization, Effluent Characterization, Effluent Sublethal Toxicity and Supporting Water Quality Monitoring.

6.1.2.1 Site Characterization

Site characterization is prescribed for EEM under the MMER (Government of Canada, 2015), with requirements described in associated technical guidance (Environment Canada, 2012). Site characterization is required with every EEM Study Design Report, which is submitted to Environment Canada for review and approval every three years prior to the implementation of EEM biological monitoring. The purpose of site characterization is to provide a review and update of features of the site and the effluent receiving environment pertinent to the design of the EEM study (Table 6-3).

Table 6-3: Site Characterization Information in the EEM Study Design Report

Component	Consideration
Mine History	Date of startup
	Dates of major operational changes
	Dates of changes to tailings management
	Dates of changes to effluent management
Current Operations	Mining processes
	Milling processes
	Water management
	Waste rock disposal
	Tailings disposal
	Wastewater disposal
	Reagent use
	Environmental protection processes
	Effluent management and discharge
	Effluent mixing
Effluent Quality	MMER routine compliance monitoring
	MMER effluent characterization
	MMER sublethal toxicity
	Other regulations applicable to effluent
Water Quality	MMER water quality characterization
Habitat Inventory and Classification	Habitat classification
	Physiography and geomorphology
	Hydrology
	Geology
	Substrates
	Plant communities
	Chemistry
Fish and Other Aquatic Resources	Fish community
	Population abundance

Component	Consideration
	Benthic communities
	Other
Potential Confounding Factors	Historical versus current influences
	Other historical or current discharges or seeps

6.1.2.2 Effluent Characterization

Effluent characterization is also prescribed under MMER (Government of Canada, 2015) and described in associated technical guidance (Environment Canada, 2012). Briefly, MMER effluent characterization is conducted four times per year, not less than one month apart. Effluent characterization includes a broader suite of analytes than routine effluent monitoring under the MMER, including hardness, alkalinity, aluminum, cadmium, iron, mercury, molybdenum, selenium, ammonia and nitrate (Government of Canada, 2015). In accordance with the MMER, Minto no longer has to include mercury as concentrations have been less than 0.10 µg/L in 12 consecutive samples collected for effluent characterization. As previously indicated, the Minto Mine completes substantial additional effluent quality monitoring, described elsewhere in the EMSRP.

6.1.2.3 Effluent Sublethal Toxicity Testing

Effluent sublethal toxicity testing is also prescribed under MMER (Government of Canada, 2015) and associated technical guidance (Environment Canada, 2012). Effluent toxicity testing is required using a total of four tests; one each of a fish, invertebrate, algae and plant species. Minto Mine initially implemented these tests twice per year, but in accordance with the MMER now implements them once per year as more than three years of testing have been completed. Tests are completed using Environment Canada Biological Test Methods and include sublethal tests of rainbow trout (*Oncorhynchus mykiss*) development or fathead minnow (*Pimephales promelas*) survival and growth, the invertebrate *Ceriodaphnia dubia* survival and reproduction, the algae *Pseudokerchneriella subcapitata* growth, and the plant *Lemna minor* growth using Environment Canada test methods (1998, 2007, 2011).

6.1.2.4 Supporting Water Quality

Water quality monitoring is also prescribed under MMER (Government of Canada, 2015) and associated technical guidance (Environment Canada, 2012). Briefly, MMER water quality monitoring is conducted four times per year, not less than one month apart. MMER water quality monitoring is completed in lower Minto Creek (Station W2) and a reference tributary to Minto Creek (Station W7; Figure 6-1) and includes pH, hardness, alkalinity, electrical conductivity, aluminum, arsenic, cadmium, copper, iron, lead, molybdenum, nickel, selenium, zinc, total suspended solids, ammonia and nitrate (Government of Canada, 2015). In accordance with the MMER, Minto Mine no longer has to include mercury or radium-226 as relaxation conditions have been met based on previous monitoring results. Water samples are also collected as supporting measures for biological sampling (periphyton, benthic invertebrates and fish) and include, at minimum, all analytes listed above (and generally those listed in Table 6-4). As with effluent quality monitoring, and as previously indicated, the Minto Mine completes substantial additional water quality monitoring, described elsewhere.

Table 6-4: AEMP Laboratory Analysis for Water, Sediment and Tissue samples

Water	Sediment	Periphyton and Benthic Tissue
Conductivity	Total Kjeldahl Nitrogen	Total Aluminum (Al)
Hardness (as $CaCO_3$)	Particle Size	Total Antimony (Sb)
pH	Inorganic Carbon	Total Arsenic (As)
Total Suspended Solids	Inorganic Carbon (as $CaCO_3$ Equivalent)	Total Barium (Ba)
Total Dissolved Solids	Total Carbon by Combustion	Total Beryllium (Be)
Turbidity	Total Organic Carbon	Total Bismuth (Bi)
Alkalinity, Total	Total Aluminum (Al)	Total Boron (B)
Ammonia, Total (as N)	Total Antimony (Sb)	Total Cadmium (Cd)
Chloride (Cl)	Total Arsenic (As)	Total Calcium (Ca)
Fluoride (F)	Total Barium (Ba)	Total Cesium (Cs)
Nitrate (as N)	Total Beryllium (Be)	Total Chromium (Cr)
Nitrite (as N)	Total Bismuth (Bi)	Total Cobalt (Co)
Phosphorus (P)-Total dissolved	Total Cadmium (Cd)	Total Copper (Cu)
Phosphorus (P)-Total	Total Calcium (Ca)	Total Iron (Fe)
Sulfate (SO_4)	Total Chromium (Cr)	Total Lead (Pb)
Cyanide, Total	Total Cobalt (Co)	Total Lithium (Li)
Dissolved Organic Carbon	Total Copper (Cu)	Total Magnesium (Mg)
Total Organic Carbon	Total Iron (Fe)	Total Manganese (Mn)
Total Inorganic Carbon	Total Lead (Pb)	Total Mercury (Hg)
Total and Dissolved Metals	Total Lithium (Li)	Total Molybdenum (Mo)
Aluminum (Al)	Total Magnesium (Mg)	Total Nickel (Ni)
Antimony (Sb)	Total Manganese (Mn)	Total Phosphorus (P)
Arsenic (As)	Total Mercury (Hg)	Total Potassium (K)
Barium (Ba)	Total Molybdenum (Mo)	Total Rubidium (Rb)
Beryllium (Be)	Total Nickel (Ni)	Total Selenium (Se)
Bismuth (Bi)	Total Phosphorus (P)	Total Sodium (Na)
Boron (B)	Total Potassium (K)	Total Strontium (Sr)
Cadmium (Cd)	Total Selenium (Se)	Total Tellurium (Te)
Calcium (Ca)	Total Silver (Ag)	Total Thallium (Tl)
Chromium (Cr)	Total Sodium (Na)	Total Tin (Sn)
Cobalt (Co)	Total Strontium (Sr)	Total Uranium (U)
Copper (Cu)	Total Thallium (Tl)	Total Vanadium (V)
Iron (Fe)	Total Tin (Sn)	Total Zinc (Zn)
Lead (Pb)	Total Titanium (Ti)	Total Zirconium (Zr)
Lithium (Li)	Total Uranium (U)	
Magnesium (Mg)	Total Vanadium (V)	
Manganese (Mn)	Total Zinc (Zn)	
Mercury (Hg)		

Water	Sediment	Periphyton and Benthic Tissue
Molybdenum (Mo)		
Nickel (Ni)		
Phosphorus (P)		
Potassium (K)		
Selenium (Se)		
Silicon (Si)		
Silver (Ag)		
Sodium (Na)		
Strontium (Sr)		
Thallium (Tl)		
Tin (Sn)		
Titanium (Ti)		
Uranium (U)		
Vanadium (V)		
Zinc (Zn)		

6.2 Sediment Quality and Toxicity Monitoring

The Sediment Quality and Toxicity Monitoring components of the AEMP are described in the following sections.

6.2.1 Sediment Quality

The objective of sediment quality monitoring is to determine if the Minto Mine has influenced the sediment quality of Minto Creek. Sediment quality monitoring is completed annually in September in both upper and lower Minto Creek (Figure 6-1, Appendix 3). Sediment quality of upper Minto Creek (immediately downstream of Station W3) is monitored and compared to the reference area located at upper McGinty Creek (Figure 6-1, Appendix 3). Sediment quality of lower Minto Creek is monitored and compared to the reference area lower Wolverine Creek (Figure 6-1, Appendix 3). Depositional areas, quiescent pools and wetted backwater locations are targeted as these areas contain more fine sediment (silt and clay) and the most recently deposited sediment.

At upper Minto and upper McGinty creeks, sediment samples are collected using a stainless steel or Teflon spoon (Figure 6-1, Appendix 3). Fine surficial sediment is collected from five stations to represent each area. A sample for sediment chemistry is collected at each station. Because sediment is sparsely distributed in the upper creek areas, one supporting sample for sediment physical characterization (particle size analysis) is collected as a composite sample from all five stations to represent the area. Each sample is made up of at least 10 scoops. Samples in lower Minto and lower Wolverine Creek are collected using a hand corer for chemical characterization and a petite ponar grab sampler for particle size characterization. Fine surficial sediment is collected from five stations to represent each area. The top 2 cm of three cores or grabs, respectively, are collected to make a composite sample for each station.

Following collection, sediment samples are kept cool and are sent to a Canadian Association for Laboratory Accreditation (CALA) accredited analytical laboratory for analysis as soon as possible. Sediment quality analytes include particle size, total organic carbon, total Kjeldahl nitrogen, metals and metalloids (Table 6-4).

Sediment quality of Minto Creek is evaluated in comparison to Canadian Environmental Quality Guidelines (CEQG) for sediment (CCME, 2014), by statistical contrast of exposed (Minto Creek) and reference areas and by comparison to previous sediment quality data to evaluate temporal change.

6.2.2 Sediment Toxicity Testing

The objective of the sediment toxicity testing program is to determine if Minto Creek sediment adversely affects survival or growth of toxicity test organisms. Toxicity is evaluated using two standard sediment toxicity tests once a year in September, concurrent with sediment collections for sediment quality. Sediment toxicity tests are the 10-day *Chironomus dilutus* test of survival and growth (Environment Canada, 1997) and the 14-day *Hyalella azteca* test of survival and growth (Environment Canada, 2013). Sediment from lower Minto Creek and the reference area (lower Wolverine Creek) are tested (Figure 6-1, Appendix 3).

Sediment for toxicity testing is collected using a petite ponar grab sampler as described above, with samples collected at the same five replicate stations in lower Minto Creek and lower Wolverine Creek (Figure 6-1, Appendix 3). At each station, the top 2 cm of sediment is collected from three ponar grabs and combined to provide sediment for both toxicity tests. Samples are kept cool until they can be sent to an experienced toxicity testing laboratory. Percent survival and dry weight (mg) of both organisms are measured in each test.

Sediment toxicity test results for lower Minto Creek are evaluated by statistical comparison to laboratory control results and reference sediment (lower Wolverine Creek) results, and by comparison to previous sediment toxicity test data to evaluate temporal change. Relationships between any observed sediment toxicity and sediment chemistry are also evaluated.

6.3 Periphyton and Benthic Invertebrate Tissue Monitoring

The Periphyton and Benthic Invertebrate Tissue Monitoring components of the AEMP are described in the following sections.

6.3.1 Periphyton Chlorophyll α

The objective of periphyton monitoring is to evaluate chlorophyll *α* (productivity), community composition and tissue chemistry of periphyton in Minto Creek. Periphyton is made up of an assemblage of algae, bacteria, fungi and meiofauna attached to submerged substrates. The periphyton monitoring program is conducted on an annual basis (September).

Chlorophyll α, a photosynthetic pigment, is used to characterize periphyton productivity in lower Minto Creek. Samples for chlorophyll α are collected at five stations in each of lower Minto Creek and lower Wolverine Creek (reference; Figure 6-1, Appendix 3). At each station, samples are collected by first collecting five rocks from locations of similar depth and velocity. Periphyton is then scraped from the five rocks using a stainless steel razor blade and combined to form a composite sample. A sufficient volume of periphyton is scraped from the five rocks to be visible on the filter paper, and the associated surface area scraped is measured and recorded. Once all of the rocks are scraped, the filter paper is folded and placed in a black vial to avoid exposure to light (and potential photodegradation of chlorophyll *α*). The samples are frozen and later sent to a CALA accredited analytical laboratory for analysis of chlorophyll *α*.

The volume of chlorophyll *α* per unit area of stream (rock) surface is calculated as an index of periphyton productivity (mg/m^2) and is evaluated in comparison to the British Columbia Water Quality Guideline for the protection of aquatic life (100 mg/m^2; (BC MOE, 1985)), by statistical contrast of exposed (Minto Creek) and the reference area, and by comparison to previous chlorophyll *α* data to evaluate temporal change.

6.3.2 Periphyton Community

The objective of the periphyton community monitoring is to determine if the Minto Mine has influenced the periphyton community of Minto Creek. Samples are collected from lower Minto Creek and lower Wolverine Creek (Figure 6-1, Appendix 3) at five replicate stations following the collection of representative rocks as described above. Periphyton community samples are collected by scraping a 4x4 cm^2 area on each of the five rocks collected at each station. Samples are placed in small plastic jars with water and preserved with Lugol's solution. Periphyton community samples are kept cool and sent to a taxonomist for identification.

The periphyton community of lower Minto Creek is evaluated on the basis of summary metrics of organisms per sample, number of taxa, Simpson's Diversity, Simpson's Evenness, Bray-Curtis Index (Environment Canada , 2012), density ($cells/cm^2$), biomass ($\mu g/cm^2$) and relative proportions of dominant taxon groups. Summary metrics are evaluated by statistical contrast of exposed (Minto Creek) and the reference area, and by comparison to previous periphyton community data to evaluate temporal change.

6.3.3 Periphyton Tissue

The objective of the periphyton tissue monitoring is to determine if the Minto Mine has influenced periphyton tissue quality of Minto Creek. Samples are collected from lower Minto Creek, lower Wolverine Creek (reference), and lower Big Creek (reference; Figure 6-1, Appendix 3) at five replicate stations following the collection of representative rocks as described above. Periphyton tissue samples are collected by scraping the five rocks per replicate station to form a composite sample. At least 0.2 g wet weight of periphyton is collected and placed in small plastic jars. Samples are kept cool and sent to a CALA accredited analytical laboratory for analysis of metals and metalloids (Table 6-4).

Periphyton tissue quality of Minto Creek is evaluated by statistical contrast of exposed (Minto Creek) and reference areas and by comparison to previous periphyton tissue quality data to evaluate temporal change. Relationships between periphyton tissue quality and water chemistry are also evaluated.

6.3.4 Benthic Invertebrate Community

The objective of benthic invertebrate community monitoring is to monitor benthic invertebrate community condition of lower and upper Minto Creek and compare them to respective reference areas. Benthic invertebrate community monitoring falls under two different regulatory requirements, the WUL and EEM. The WUL monitoring in undertaken annually (September) whereas the EEM is implemented every three years (also in September).

Benthic invertebrate community monitoring under the WUL is completed at three areas, lower Minto Creek (exposed), lower Wolverine Creek (reference) and lower Big Creek (reference; Figure 6-1, Appendix 3), with five replicate stations per area. Benthic invertebrate community samples are collected using a Hess sampler (0.1 m2 sampling area; 500 µm mesh), with each replicate sample collected as a composite of three sub-samples. All sampling locations, both within and among areas, are selected based on similar substrate characteristics, water depths and water velocity. To collect the sample, all substrate within the Hess sampler is scrubbed until the area is cleaned of organisms, with organisms washed into the collection net by the current. The three sub-samples within a station are combined to form a composite. Composite samples are preserved with 10% buffered formalin and sent to a taxonomist for identification to the “lowest practical level”.

Benthic invertebrate community monitoring under the EEM is currently undertaken using the Reference Condition Approach (RCA). Three stations in upper Minto Creek (the exposed area) are evaluated relative to the reference condition defined by ten RCA reference areas (chosen from reference sites evaluated in the previous EEM; Minnow 2015; Figure 2; Table 4) in accordance with the Canadian Aquatic Biomonitoring Network (CABIN) protocol for RCA studies (CABIN, 2012). Unlike the WUL benthic monitoring (a control-impact approach), only one sample is collected from each area (referred to as a site under CABIN). Samples are collected using a Hess sampler as described above.

Under both programs, benthic invertebrate community characteristics of Minto Creek are evaluated on the basis of summary metrics of invertebrate density (number of organisms per m2 calculated based on a sample area of 0.3 m2), number of taxa, Simpson’s Diversity, Simpson’s Evenness and Bray-Curtis Index

(Environment Canada, 2012), and the relative proportions of dominant taxon groups. Summary metrics are evaluated by statistical contrast of exposed (Minto Creek) and the reference areas (using either a control-impact contrast or an RCA model) and by comparison to previous benthic invertebrate community data to evaluate temporal change. Relationships between benthic invertebrate community condition and water chemistry are also evaluated.

6.3.4.1 Benthic Invertebrate Tissue

The objective of the benthic invertebrate tissue monitoring is to determine if the Minto Mine has influenced benthic invertebrate tissue quality of Minto Creek. Samples are collected from lower Minto Creek, lower Wolverine Creek (reference), and lower Big Creek (reference; Figure 6-1, Appendix 3) at five replicate stations. Benthic invertebrate tissue samples are collected by using the kick-and-sweep method (CABIN, 2012) or by hand until approximately 2.0 g of benthic invertebrate tissue is collected. Samples are collected from all five stations in each area (Figure 6-1, Appendix 3). Collected benthic invertebrate samples are frozen and then sent to a CALA accredited analytical laboratory for analysis of metal and metalloid concentrations (Table 6-4).

Benthic invertebrate tissue quality of Minto Creek is evaluated by statistical contrast of exposed (Minto Creek) and reference areas and by comparison to previous benthic invertebrate tissue quality data to evaluate temporal change. Relationships between benthic invertebrate tissue quality and water chemistry are also evaluated.

6.4 Fish Monitoring Program

The objective of the fish monitoring program is to monitor, assess and characterize fish usage of Minto Creek and to determine if the Minto Mine influences the health of a sentinel fish species of Minto Creek. Based on previous findings of fish use of Minto Creek, fish monitoring includes two elements: 1) ongoing characterization of fish use of lower Minto Creek; and 2) a mobile laboratory-based evaluation of the effects of exposure of juvenile Chinook salmon (*Oncorhynchus tshawytshca*) to Minto Mine effluent.

Ongoing characterization of the use of lower Minto Creek by fish is undertaken in lower Minto Creek, with lower Big Creek serving as a reference (Figure 6-1, Appendix 3). Although fish monitoring is only required under EEM, the *in-situ* fish monitoring is typically conducted annually to characterize fish usage of Minto Creek, with fishing conducted on several occasions during the open water season (typically conducted between July and September). In Minto Creek, fishing effort is restricted to the area downstream of a natural barrier located approximately 1.5 km upstream of the creek mouth. Fishing for the evaluation of fish usage is implemented using minnow traps baited with Yukon River origin Chinook salmon roe and set in areas of known juvenile Chinook salmon habitat. This typically includes eddies, pools and calm water with overhead cover and/or woody debris. The minnow traps are left for 24 hours and any fish caught are identified, enumerated, measured (fork or total length, mm) and any abnormalities are noted. Trap location information is recorded and catch per unit effort (CPUE) is calculated and used to quantify use of

Minto Creek. CPUE, fish size data and fish condition are evaluated by statistical contrast of exposed (Minto Creek) and the reference area and by comparison to previous data to evaluate temporal differences.

Previous studies of the usage of Minto Creek by fish has documented that the most consistent use of lower Minto Creek is by juvenile Chinook salmon, which typically use lower Minto Creek between June and October. Individual fish spend only short periods of time in the creek (typically less than two weeks) during out-migration along the Yukon River from upstream spawning areas and Chinook salmon do not spawn in Minto Creek (Access and Minnow, 2014). Several other fish species have been observed to use lower Minto Creek less frequently and at much lower abundance than juvenile Chinook, including slimy sculpin (*Cottus cognatus*), arctic grayling (*Thymallus arcticus*) and round whitefish (*Prosopium cylindraceum*; Access and Minnow, 2014).

Based on the current understanding of fish use of Minto Creek, the potential effects of Minto Mine effluent on survival and growth of juvenile Chinook salmon are evaluated every three years under EEM. Due to often limited fish captures in situ, a mobile laboratory exposure is set up to evaluate fish survival and growth using hatchery-sourced juvenile Chinook salmon. The mobile laboratory exposure system set up consists of three large tanks (approximately 4,000 liters) with 150 juvenile Chinook salmon per tank. Two Minto Mine effluent concentrations (1:3 and 1:6) and a Minto Creek control are evaluated. Growth and condition are monitored prior to exposure and in all exposures at two-week intervals to six weeks of exposure. At each monitoring, all fish are measured for length, weight and abnormalities.

Effluent-exposed juvenile chinook salmon are evaluated on the basis of endpoints of growth (length-frequency distribution), energy use (length and weight) and energy storage or condition (weight-at-length) by statistical contrast of Minto Creek results against those of the control group in accordance with technical guidance for non-lethal EEM fish populations surveys (Environment Canada, 2012) and by comparison to previous results to evaluate temporal differences. Relationships between juvenile Chinook salmon health endpoints and water chemistry are also evaluated.

6.4.1 Supporting Measurements

To support the chemical and biological monitoring components outlined in previous sections, water chemistry and other supporting measures are collected (Figure 6-1 and Figure 6-2; Appendix 3). At each monitoring location, GPS coordinates and water quality meter measurements (dissolved oxygen, pH, temperature and conductivity) are recorded, and water quality samples are collected (Appendix 3). To support sediment quality monitoring in the lower reaches, depth at all stations and penetration depth of all hand corer samples are recorded (Appendix 3). Photographs are taken of all core and petite ponar samples, as well as substrate type (Appendix 3). To support periphyton monitoring, the area scraped for chlorophyll α and community samples is recorded. Photographs of the rocks collected for periphyton samples are also taken (Appendix 3).

To support benthic invertebrate community monitoring during both the WUL (annual basis) and EEM (every three years), depth and velocity at every Hess sampler location is recorded (Appendix 3). Photographs and a 100 pebble count (CABIN, 2012) are conducted at every station. At one station per area (except for upper Minto Creek during EEM where all three stations are sampled) a habitat assessment is also conducted (Appendix 3). To support in situ fish monitoring, the following additional supporting measures are collected at every station: weather, photographs and trap location with a description of the station (Appendix 3).

Quantitative supporting measurement data (e.g., water quality meter measurements, water depth, water velocity and water chemistry) are evaluated by statistical contrast of exposed (Minto Creek) and reference areas. They are also used to investigate potential causes of any observed biological effects by correlation analysis.

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. The Invasive Plant Species Monitoring Program includes invasive plant mitigation, monitoring and reporting.

7.1.1 Invasive Plants Mitigation

Invasive plant mitigation techniques at Minto include site access measures, appropriate plant selection, erosion control and soil salvage techniques.

7.1.1.1 Site access

The following site access mitigation measures aid in reducing the possibility of propagules spreading across Minto 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

The following plant selection measures will reduce the possibility invasive plants are utilized in reclamation at Minto:

- 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).
- Whenever possible, 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 so as to discourage the production of fugitive dust and colonization by invasive plant species. Techniques may include covers, dust suppressants, and temporary or permanent planting. Listed below are several erosion control techniques to discourage invasive plant colonization at Minto:

- Reduce the amount of seed that is 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 stripping activities will allow for a natural seed bank and reduce the need for imported seed mixes and fertilizers when reclamation is required. The following techniques will aid with soil salvage at Minto:

- 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

Invasive plant monitoring at Minto includes detailed vegetation surveys in areas of reclamation and coarse vegetation surveys in areas where there are invasive species pathways.

Detailed vegetation surveys were established in September 2012 on the Main Waste Dump (MWD). The detailed vegetation surveys identify vegetative cover and species types (within the dry land seed mix) and should invasive species be detected, the following information will be included in the survey:

- Location;
- Species Name;
- Health and size of the plant;
- Photos (for verification of plant and location); and
- Percent coverage in the area.

Coarse vegetation surveys typically take place in areas where there are invasive species pathways such as roads with high visitor traffic, recently exposed areas and areas that have been recently reclaimed. The meander or roadside method may be utilized to inventory invasive plants in pathways with high visitor traffic. High priority species as determined by the Yukon Invasive Species Council (YISC) will be identified, and the distribution and location of the plant will be recorded. Incidental surveys may also take place as field staff are routinely collecting data for various programs within the EMSRP; should an invasive plant be located the field staff will record its distribution and location. Data from the coarse vegetation surveys is entered into an invasive plant tracking record.

High priority plant species in the Yukon, as defined by YISC, are summarized in Table 7-1. A full list of invasive species found in the Yukon by taxonomy is provided in Appendix 4.

Table 7-1: Common and Scientific Names of High Priority Yukon Invasive Plant Species, as defined by YISC

Common Name	Latin Name
Bird vetch	*Vicia cracca*
Common tansy	*Tanacetum vulgare*
Creeping thistle	*Cirsium arvense*
Hawkweeds	*Crepis tectorum*
Leafy spurge	*Euphorbia esula*
Oxeye daisy	*Leucanthemum vulgare*
Perennial sow-thistle	*Sonchus arvensis*
Scentless chamomile	*Tripleurospermum perforata*
Spotted knapweed	*Centaurea stoebe*

7.1.3 Invasive Plants Reporting

Should any high priority invasive plant species listed by the YISC be encountered, Minto will report the findings to YISC through the YISC Spotters Network Program.

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 to the site. The *Wildlife Protection Plan* establishes the guidelines for the monitoring program in order 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 sightings around site are entered into a *Wildlife and Hazing Tracking Form* which is in a spreadsheet format (Table 7-4). Wildlife sightings from site personnel are collected either via a *Wildlife Sighting Log* form or through communication with the Environmental and Safety Departments. Any direct sighting by the Environmental Department are additionally entered into the *Wildlife and Hazing Tracking Form*.

An example *Wildlife Sighting Log* form is provided in Table 7-3. Wildlife Sighting Logs are posted at all main offices and around camp, and all staff are encouraged to record all wildlife observations. The logs are collected regularly and data entered into the Wildlife and Hazing Tracking Form spreadsheet, displayed in

Site personnel are encourage to immediately report all interactions with dangerous wildlife to the Environmental or Safety Department. Information gathered on dangerous wildlife includes hazing techniques applied, the animal response and previous hazing attempts (if known).

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	• Wildlife monitoring consists of maintaining a wildlife observation log onsite and reporting wildlife encounters as per the Wildlife Act. • Environmental personnel on site will monitor project activities and modify operations to address wildlife concerns.	Ongoing
Migratory Birds	• Monitoring to determine if waterfowl and shorebirds settle on impacted water bodies, such as the Main or Area 2 Pits. • Environmental personnel on site will monitor project activities and modify operations to address wildlife concerns.	Seasonal during migratory periods

Area Monitored	Monitoring Activities	Frequency
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

Table 7-3: Wildlife Sighting Log

Wildlife Sighting Log

We are obliged to monitor wildlife in the mine area under the conditions of our Quartz Mining Licence.
Please help the Environment Department do this by recording any wildlife you see on this form.

Date	Time	Species	Number	Location	**Notes:** *(e.g. condition, behaviour, adult/young, weather conditions)*	Name

Table 7-4: Wildlife and Hazing Tracking Form

Date	Time	Type of Animal	Number of Animals	Location	Description: Size/Color/Markings and Additional Notes	Reported By (Name)	Was the animal hazed?	What hazing technique was used?	What was the animal's response?	Who performed the hazing?	Has this animal been hazed in 2015?	Reportable Incident (Yes/No)	Notes
6-Jan-15	14:30	Fox	1	Dyno Rd	Orange/ black	Helaina	no	N/a	N/a	N/a	n/a	No	Running away with rabbits foot in mouth
18-Jan-15	14:00	Fox	1	KM 1.5	Not too scared hazed down road	Ron	no	N/a	N/a	N/a	n/a	No	Not too scared hazed down road
23-Jan-15	16:00	Moose	2	Vent raise road	One cow and one calf	Dave	No	N/a	N/a	N/a	N/a	No	
9-Mar-15	5:00	Moose	1	In camp	Looking at me	Don	No	N/a	N/a	N/a	n/a	No	Looking at me
28-Mar-15	19:30	Hare	1	Km 3.5 Access Road	Dead hare on Access Road. Observed by a runner on road. Reported to Conservation Officer.	Rob	No	N/a	N/a	N/a	N/a	Yes	
28-Mar-15	19:00	Rabbit/Hare	1	3.5 Km	Dead hare on Access Road. Observed by a runner on road. Reported to Conservation Officer.	Rob	No	N/a	N/a	N/a	n/a	No	

7.3 Erosion and Sedimentation Monitoring Program

The *Minto Mine Sediment and Erosion Control Plan* (SECP), a requirement of the QML, details erosion and sediment monitoring strategies, sources and best management practices for control. The Erosion and Sedimentation Monitoring Program is derived from the SECP and monitoring activities are summarized in Table 7-5.

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 SECP.

Table 7-5: 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 [2]	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. Water quality monitoring locations and frequency described in detail in section 2.1. 2. Physical Monitoring Program details are described in section 5. 2Surface Water Surveillance Program

7.4 Vegetation Metal Uptake Program

The main objective of the Vegetation Metal Uptake Program is to monitor and measure metal uptake in vegetation on the mine site and surrounding areas. The *Vegetation Metal Uptake Monitoring Plan* (Appendix 5, (Minto, 2015)) describes the program in detail and employs the following components for program implementation:

- Utilizes previously established or documented conditions, monitoring results or predictive efforts, where appropriate and possible;
- Establishes a network of plots for monitoring both soil and vegetation metal concentrations; and
- Allows for an ongoing evaluation of the extent and degree that metals from mining activity is affecting vegetation in the proximity of the project site.

The Vegetation Monitoring Uptake program consists of a monitoring network of site (exposure) or control stations (Figure 7-1). Progression of the mine plan and analysis of the monitoring results may result in the creation of additional monitoring locations. For example, progressive reclamation of waste dumps may allow for areas that have been revegetated to be included into the monitoring network. Site sampling stations are located in areas anticipated to accumulate the most dust based on meteorological data collected at site.

The following procedures are performed at each monitoring network site:

- Selection of an appropriate microsite in the vicinity of the station identified on the map;
- Generation of a station ID and documentation of relevant ecological attributes of the station area;
- Soil sampling; and
- Vegetation sampling.

Soil and vegetation samples will be sent to an accredited laboratory for the following analysis: metals, pH, texture and cation exchange capacity. The initial study will take place in July or August any given year before seasonal desiccation of vegetative material occurs. Continued monitoring should occur every three years after initial study, to determine any changes in dust dispersal and vegetation metal uptake.

Figure 7-1: Vegetation Metal Uptake Program Monitoring Stations

8 Progressive Reclamation Effectiveness Monitoring Program

The Progressive Reclamation Effectiveness Monitoring Program is a requirement of the EMSRP, and is required to monitor the effectiveness of progressive reclamation and post closure reclamation at the Minto Mine. Progressive reclamation activities at Minto 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; while 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 RCP.

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. Monitoring areas included the Main Waste Dump (MWD) vegetation study plots in 2013-2014. Test pitting and soil modeling for cover material characterization was also completed in 2013-2014. The first four phases (i.e. information gathering, conceptual design, pilot scale, and demonstration scale) of developing a constructed wetland treatment system have also been implemented with the first three phases being completed in 2013-2014.

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 Programs

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 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 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. Results and interpretations of the QA/QC programs are detailed in the WUL Annual Report.

9.1 Quality Assurance

Quality assurance protocols help ensure that the programs as described in the EMSRP are quantifiable and able to produce quality data. Minto 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 staff on a monthly and annual basis. For example, the data associated with the Water Monitoring Program (Section 2) is reviewed by cross checking the Minto Water Quality Database with the sample tracking and log spreadsheet. The database is frequently audited by Minto personnel and a professional consultant on an annual basis. If inconsistences are found, further investigation is performed using field notes, Chain of Custody, 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

Hydrology, meteorology and hydrogeology program QA/QC is discussed in Sections 9.3.1 to 9.3.3.

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 Creek watershed. Minto Mine currently 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 generally conducted at the same location to minimize variability. Typically, field staff perform quality control on 10% of the manual measurements by performing duplicate flow measurements during the same monitoring event.

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 Campbell Scientific station is located approximately 100m northeast of the airstrip and has been operating since 2010. 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 either field duplicate, trip blank or field blank samples that are collected at a frequency of one QA/QC sample per ten groundwater monitoring samples (10%).

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.

The external laboratory utilized for water monitoring programs such as the Surface Water Surveillance Program is accredited under the International Organization for Standardization ISO/IC 17025:2005 standard. This accreditation includes both the laboratory and the tests that are performed at the laboratory.

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 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.

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 form the basis of the on-site 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 effluent quality standards 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 on-site laboratory and accredited external labs. Two external, CALA or ISO/IEC 17025 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 on-site 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 and Dissolved 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 Total Suspended Solids (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

Ongoing verification of the external and on-site laboratory results occurs on a monthly basis with monthly comparison of results detailed in the monthly WUL reports.

9.6 Field Instrumentation QA/QC

Field instrumentation are maintained according to manufacturers' specifications. Equipment that exhibits performance problems are not utilized to collect data; rather, the equipment is repaired according to the manufacturer's specifications. Certain field equipment, such as the YSI in-situ multi parameter meter and a Eutech (Oakton) PCTestr 35 handheld meter require calibration; calibration is conducted by field staff according to manufacturers' specifications and Minto SOPs. An example calibration log is presented in Figure 9-1.

Date of Calibration: **Technician:** **Unit:** **Cable:** **Battery Power:**

Record the following calibration values (for full calibration of YSI please follow the order on the sheet below):

	Unit Temp	Thermometer Temp	Unit Temp Result +/- from Thermometer Temp	Unit Temp Result should not be more than +/- 0.5c from Thermometer Temp.
Thermometer				

	Pre-Cal	[Calibration Value]	After Calibration	Acceptable "after calibration" Ranges
Barometer kPA				Range of 2013 True BP values at Minto: 87.3 – 93.6 kPA. Average: 90.8.
Specific Conductivity us/cm		[1413]		Calibration value is always 1413 us/cm. Do NOT use Temp chart with standard
DO%				~ 89-93 DO%. ** To verify the after calibration value see DO% -Barometric pressure verification chart for DO% to confirm the value
Salinity (value only; found under DO%)				Salinity range should be 0-0.5 ppt. Do not proceed with DO calibration if salinity is out of this range.

	Pre-Cal	Calibrant Temperature	[Calibration Value] ** To enter a value see pH -temperature compensation chart	After Calibration	pH mV value	mV Range	Acceptable mV Value or Range
pH 7							Value +/- 50 mv.
pH 10							Range -165 to -180 mV from Buffer 7 value. -177 ideal.
pH 4 (for 3 pt calibration)							Range +165 to +180 mV from Buffer 7 Value. 177 ideal.

	Pre-Cal	Calibrant Temperature	[Calibration Value] ** To enter a value see ORP-temperature compensation chart	After Calibration
ORP mV				

Record the following diagnostic numbers after calibration by viewing the GLP file: (UNDER THE FILE BUTTON)	
pH Slope:	(~ 55 to 60 mV/pH; 59 is ideal)
pH Slope % of Ideal:	
DO Sensor Value: Minto average 4.14 uA (min. 2.88 uA, max. 4.88 uA).	
Conductivity Cal Cell Constant:	Range: 5.0 +/- 1.0 acceptable

Figure 9-1: In-situ Field Parameters Calibration Log

10 Data Evaluation and Reporting

EMSRP data evaluation and reporting will be conducted in accordance with the WUL and QML.

The QML requires that the Licensee provide, as part of the annual report, "*a summary of the programs undertaken for environmental monitoring and surveillance as outlined in the Environmental Monitoring, Surveillance and Reporting 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, the WUL requires that the Licensee "shall *collect and submit each month's requires EMSRP data…to the board as part of the Monthly Report*" and "*as part of the annual Report*".

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.

EMSRP reporting requirements are summarized in Table 10-1.

Table 10-1: EMSRP Monitoring Program Reporting Requirements

Monitoring Program	Reporting Requirements		
	External Reporting Requirements		
	Monthly Report	Annual Report	Other
Water Monitoring Program			
Surface Water Surveillance Program	Monthly Report	Annual Report	
Groundwater Monitoring Program		Annual Report	
Seepage Monitoring Program		Annual Report	
Geochemical Monitoring Program			
Acid Base Accounting (ABA) Monitoring Program	Monthly Report	Annual Report	
Waste Rock Management Verification Program		Annual Report	
Meteorological Monitoring Program			
Climate Monitoring Program	Monthly Report	Annual Report	
Snow Survey Program		Annual Report	

Monitoring Program	Reporting Requirements		
	External Reporting Requirements		
	Monthly Report	Annual Report	Other
Physical Monitoring Program	Monthly Report	Annual Report	Semi-Annual Site-wide Geotechnical Inspection Report (Spring and Fall)
Aquatic Environmental Monitoring Program			
Metal Mine Effluent Regulations Monitoring Programs		Annual Report	MMER
Sediment Quality and Toxicity Monitoring		Annual Report	
Periphyton and Benthic Invertebrate Tissue Monitoring		Annual Report	MMER
Fish Monitoring Program		Annual Report	MMER
Terrestrial Environment Monitoring Program			
Invasive Plant Species Monitoring Program		Annual Report	YISC
Wildlife Monitoring Program		Annual Report	Environment Yukon
Erosion and Sedimentation Monitoring Program		Annual Report	
Vegetation Metal Uptake Program		Annual Report	
Progressive Reclamation Effectiveness Monitoring Program		Annual Report	
Quality Assurance and Quality Control Programs		Annual Report	

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