Appendix 19C

Freshwater and Sediment Quality Data Summary Report

Appendix 19C

Freshwater and Sediment Quality Data Summary Report

Grays Bay Road and Port Project Freshwater and Sediment Quality Data Summary Report

Prepared for:

West Kitikmeot Resources Corp.

Prepared by:

Nunami Stantec Limited

March 2026

Project No.: 123514868

Sign-off

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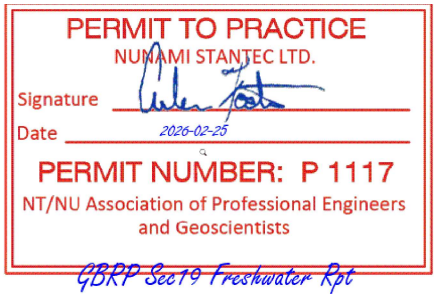

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Abbreviations

Baseline ..... freshwater and sediment quality baseline
$CaCO_3$ ..... calcium carbonate
CCME ..... Canadian Council of Ministers of the Environment
DO ..... dissolved oxygen
DOC ..... dissolved organic carbon
DWG ..... Health Canada Drinking Water Guidelines
FEQG ..... Federal Environmental Quality Guidelines
ICP ..... Izok Corridor Project
IK ..... Inuit Knowledge
IS ..... Impact Statement
ISQG ..... interim freshwater sediment quality guidelines
KN ..... Kennarctic
LAA ..... Local Assessment Area
LT ..... long-term
MMG ..... Minerals and Metals Group
NH_3 ..... un-ionized ammonia
NH_4^+ ..... ammonium ion
NIRB ..... Nunavut Impact Review Board
$NO_3^- + NO_2$ ..... total nitrate and nitrite
NT ..... Northwest Territories
NTU ..... Nephelometric Turbidity Unit
PAHs ..... polycyclic aromatic hydrocarbons
PDA ..... Project Development Area
PEL ..... the probably effect levels
Project, the ..... Grays Bay Road and Port Project
PWI ..... Potential Water Intake
QA/QC ..... quality assurance and quality control
RAA ..... Regional Assessment Area

TCWR..... Tibbitt to Contwoyto Winter Road
TDS ..... total dissolved solids
TKN ..... total Kjeldahl nitrogen
TOC..... total organic carbon
TSS ..... total suspended solids
VC ..... Valued Component
WKR..... West Kitikmeot Resources Corp.

Symbols and Units of Measure

% ..... percent
°C ..... Celsius
µS/cm ..... microsiemens per centimetre
cm..... centimetre
g/L ..... grams per litre
km..... kilometre
km^2 ..... kilometre squared
m ..... metre
mg/L ..... milligrams per litre
mm ..... millimetre
mV ..... millivolt

1 Introduction

West Kitikmeot Resources Corp. (WKR) is an Inuit-owned, Inuit-led company focused on the advancement of the Grays Bay Road and Port Project (the Project) in the Kitikmeot Region of Nunavut. WKR's largest shareholder is a wholly-owned subsidiary of the Kitikmeot Inuit Association. The Project is proposed as a multi-user, multi-use transportation infrastructure to be located on a combination of Inuit Owned Land and Crown Land in the Kitikmeot Region of western Nunavut. Subject to approval, the Project would result in the establishment of the first deep-water port in the Canadian Central Arctic at Grays Bay Port, as well as a 230 kilometre (km) all-season access road between Grays Bay Port (the Port) and Jericho station near Contwoyto Lake. The Project will connect to the already approved Tibbitt to Contwoyto Winter Road (TCWR). The multi-user, multi-use Project would allow for the establishment of shared infrastructure with many potential users including the federal and territorial governments, communities, community members, resource companies, and defense agencies. Grays Bay Port is approximately 180 km east of Kugluktuk, NU (Figure 1.1).

The objective of this freshwater and sediment quality baseline summary (Baseline) report is to provide a characterization of the regional freshwater and sediment quality baseline conditions in the PDA for the Water Resources Valued Component (VC) of the Impact Statement (IS). Analysis of existing freshwater quality and sediment quality data is used to improve the current understanding of freshwater and sediment quality conditions in the PDA. Since 1990, several baseline programs have been conducted in the Izok Lake and High Lake areas. Initial environmental studies focused on aquatic life and fish, while studies from 2012 onward included water quality and sediment characterizations. Stream water crossings for the current Project Development Area (PDA) have been identified in the Fish and Fish Habitat Baseline Report (Section 20, Appendix 20A of the application). The marine water and sediment quality baseline report is provided in Section 21, Appendix 21A of the application.

- Local Assessment Area (LAA)
- Regional Assessment Area (RAA)
- Grays Bay Port
- Tibbitt to Contwoyto Winter Road
- Watercourse

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WEST KITIKMEOT RESOURCES CORP

Notes
1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Government of Canada, Stantec, Earthstar Geographics

Project Location
West Kitikmeot Region
Nunavut

Prepared by SL on 2026-02-12
TR by EH on 2026-02-12

Client/Project
123514868_037

West Kitikmeot Resources Corp
Grays Bay Road and Port

Figure No.
1.1

Title
Water Resources Assessment Areas

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1.1 Inuit Knowledge, Traditional Knowledge, and Community Knowledge

A considerable number of Inuit Knowledge has been documented for the Project, which has substantially informed WKR's understanding of baseline environmental and socio-economic conditions in the PDA. For the purposes of the IS, focus is placed on Inuit of the Kitikmeot Region, or Kitikmiut. The Project is located wholly within the Kitikmeot Region; as such, the region and its people are where key Project interactions and effects are most likely to occur.

Verified Inuit Knowledge and perspectives considered and integrated in the IS were shared through two primary Project-specific sources.

1. **Naonaiyaotit Traditional Knowledge Project (NTKP):** The Kitikmeot Inuit Association maintains a repository of Inuit Knowledge for the Kitikmeot Region within a Geographic Information System (GIS)-based database called the NTKP. The NTKP contains the collective body of documented and verified Inuit Knowledge of the Kitikmeot Region, including but not limited to knowledge of birds, fish, terrestrial and marine mammals, water quality, travel routes, gathering places, and heritage. The Kitikmeot Inuit Association compiled a Project-specific report called Kitikmiut Knowledge of the Proposed Kogloktoakyok (Grays Bay) Port and Road Project (Banci and Spicker 2024) which provides the majority of the Inuit Knowledge shared and integrated in the IS.
2. **Inuit Advisory Group (IAG):** Initiated in 2018 by the previous Project proponent, WKR re-initiated the IAG in 2025. Through a series of IAG workshops, WKR and Inuit land users, Elders, and Knowledge Holders have met to discuss and document feedback and advice about the Project, including but not limited to dialogue about wildlife, fisheries, land use, archaeology, water, air quality, and access management. Through the IAG, multiple perspectives have been shared, allowing for the integration of knowledge systems (both Inuit Knowledge and western science), resulting in a more informed and sustainable Project. At the time of filing, four IAG workshops had occurred (GBEEC 2018a, 2018b; IAG 2025a, 2025b), with additional workshops planned for the future.

Pertinent baseline information from these sources of Inuit Knowledge is not presented further here; rather, this information is provided in the above-noted reports themselves, the 'Baseline Conditions' sections of each assessment section, and integrated in the Assessment of Potential Effects on Water Resources sections where appropriate. The same process was applied when integrating baseline information associated with applicable Traditional Knowledge and Community Knowledge shared in publicly available literature and through the Project-specific engagement program.

1.2 Spatial Boundaries

Spatial boundaries are established for the assessment of the Project's environmental effects and cumulative environmental effects for each VC. The primary consideration used is the probable geographical extent of the environmental effects (i.e., the zone of influence) on the VC. Spatial boundaries may be different from one VC to another, depending on the characteristics of the VC. The spatial boundaries are referred to as the project development area (PDA), the local assessment area (LAA), and the regional assessment area (RAA) as shown on Figure 1.1. The following proposed spatial boundaries for assessing the Project and cumulative effects have been developed:

- The **Project Development Area** encompasses the physical footprint of all Project components, including both permanent and temporary disturbances (e.g., extent of Project infrastructure, planned clearing, and laydown areas). The PDA includes six sub-areas based on the types of components to be developed: the Port (which is further divided into marine and landside infrastructure), Road, Aerodrome, Jericho Station, and Winter Road PDAs. The boundaries of the PDAs were created by applying buffers around where the Project components will be sited, and varies by each of the sub-areas depending on necessary flexibility for final siting of certain Project components based on conditions on the ground. For the Road PDA and Winter Road PDA, a 75 m buffer was applied to the roads centreline, for the Port PDA and the Aerodrome PDA, the areas were subdivided based on the conceptual Project component locations and then buffered approximately 1,000 m for the landside Port PDA, approximately 300 m for the marine Port PDA, and 500 m for the Aerodrome PDA. The Jericho Station PDA was buffered based on the existing development from the old Jericho Mine site that will be used for the Project and the need for additional space to accommodate the Project components that will be developed as part of the Project for this location. The Winter Road PDA will only exist annually between the beginning of February and end of March, will be built on land where the existing Jericho Station road ends, at the southeastern portion of Jericho Station, to the shoreline of Contwoyto Lake where it will connect to the TCWR. For the purposes of the impact assessment, the PDA is the same as the Site Study Area identified in the IS Guidelines.
- **Local Assessment Areas** have been developed for each VC to represent the maximum area within which Project environmental effects, both direct and indirect, can be predicted or measured with a reasonable degree of accuracy and confidence. The LAA includes the PDA and adjacent areas where environmental effects may reasonably be expected to occur. The road PDA of the LAA includes the area extending 100 m upstream and downstream of the centerline (i.e., the Road Footprint plus 25 m); at larger, more sensitive watercourses, assessment will include areas up to 300 metres (m) downstream depending on site-specific conditions.
- **Regional Assessment Areas** have been developed to represent the areas that provide context to the changes occurring in the LAA for each VC. The Port portion of the RAA includes a 10 km land-based buffer around the Port and Aerodrome PDA. The road portion of the RAA includes a 10 km buffer on the PDA for southern watersheds, and the entirety of the Arctic and Kennarctic watersheds at the north end of the PDA. The Jericho Station portion of the RAA includes a 10 km buffer around the PDA.

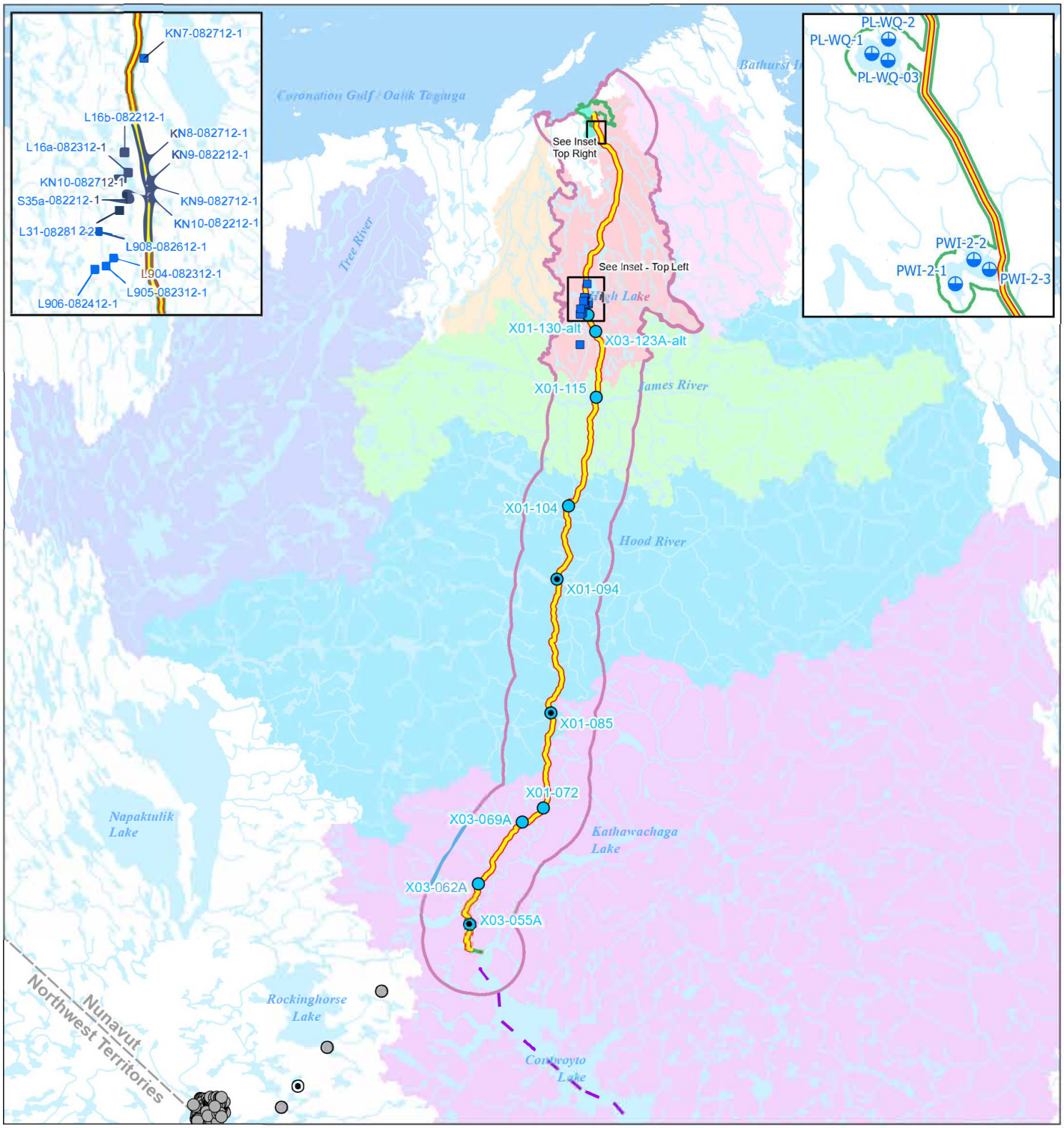
1.3 Regional Setting

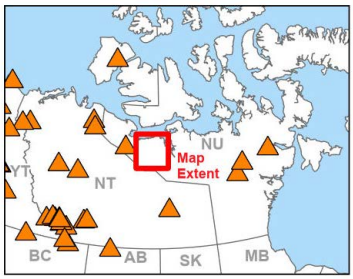
The Project lies within the tundra of the continuous permafrost zone of the Canadian Arctic. This region is characterized by long, cold winters and short, cool summers and a dry climate. During the summer, the active layer (the top layer of soil that undergoes thawing and refreezing in permafrost zones) is thin and allows for minor infiltration of precipitation. The topography of the region is generally undulating to moderately rugged. The treeless, barren tundra is sparsely covered with shrubs, lichen and herbs (Sabina 2015; Wolfden 2006).

1.3.1 Regional Watersheds

The Project crosses four main watersheds, each drains to the Arctic Ocean: the Burnside River, Hood River, James River, and Kennarctic River. Additional streams along the northern most portion of the proposed alignment flow directly into the Arctic Ocean (see Figure 1.2). From south to north, the watersheds are:

- *Burnside River*: The headwaters of the Burnside River originate at Contwoyto Lake near Jericho Station and generally flow northeast, ultimately draining into the Arctic Ocean at Bathurst Inlet. The Burnside River watershed encompasses the southern 65 km of the road, as well as the Tibbitt to Contwoyto Winter Road to the NT/NU border, with a total drainage area of approximately 25,000 kilometres squared (km²).
- *Hood River*: The Hood River watershed spans the middle 70 km of the road, with a drainage area of approximately 10,200 km². The river generally flows east for 200 km before meandering northward for 80 km near Bathurst Inlet and ultimately emptying into the Arctic Ocean.
- *James River*: James River watershed drains approximately 4,000 km² in the north-central 30 km, from approximately 135 km to 165 km along the road. James River flows easterly for approximately 200 km until its confluence with Hood River, where it flows a further 30 km north before reaching the Arctic Ocean.
- *Kennarctic River:* The Kennarctic River watershed drains the northern 65 km of the road with a total drainage area of 1,400 km². Kennarctic River flows north to the Arctic Ocean with a river length of approximately 150 km.
- *Arctic Ocean*: The northern 6 km of the road drains directly to the Arctic Ocean, with a drainage area of approximately 25 km².





Notes

1. Coordinate System: WGS 1984 UTM Zone 12N
2. Data Sources: Governments of Nunavut and Canada, Stantec

- Water Quality Site with Sediment Collected (2024)
- Water Quality Site (National Long-term)
- Water Quality Sample Site (High Lake Water Quality Field Report 2012)
- Sediment Collected
- Water and Sediment Sampling Station (Izok Water and Sediment Quality 2012 Field Data Report)
- Water and Sediment Sampling Station - Not Assessed (Izok Water and Sediment Quality 2012 Field Data Report)
- Grays Bay Road
- Grays Bay Winter Road
- Local Assessment Area (LAA)
- Regional Assessment Area (RAA)
- Territory Boundary
- Tibbitt to Contwoyto Winter Road
- Watercourse
- Ocean
- Waterbody

Watersheds

- Anialik River
- Arctic Ocean
- Burnside River
- Hood River
- James River
- Kennarctic River
- Tree River
- Wentzel River

0 10 20 Kilometres

(At original document size of 8.5x11) 1:1,350,000

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WEST KITIKMEOT RESOURCES CORP

Project Location
Kitikmeot Region, Nunavut

Prepared by BSPRY on 2025-12-05
TR by SLEMAY on 2025-12-05

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West Kitikmeot Resources Corp
Grays Bay Road and Port

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Figure No.
1.2

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Freshwater Surface and Sediment Water Quality Data Summary Report

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1.3.2 Regional Water Quality

Federal and federal-territorial water quality monitoring sites have not yet been established within the RAA. The closest federal site is the Coppermine River (site: NW10PC0019 in the Coppermine River watershed), located approximately 225 km west of the Project (see inset in Figure 1.2) and outside of the RAA; therefore, federal and territorial site monitoring data were not applicable and not assessed. A literature review was conducted, and the results are summarized here.

In the Canadian Arctic Archipelago, surface water quality is influenced by bedrock geology, seasonal hydrology, and landscape physiography (Brown et al. 2020). Specifically, Brown et al. (2020) observed that the Burnside River has lower dissolved ion concentrations compared to other rivers in the study; however, flow paths and residence times determine the geochemical loads. This study found that the geochemistry of small, coastal-draining rivers in the Canadian Arctic Archipelago differ from that of large rivers in the Arctic, which are influenced by extensive and diverse landscapes.

Elliott et al. (2021) described drinking water sources of communities in Nunavut and provided data for specific parameters, described herein. Drinking water in Nunavut is entirely supplied by surface water, mostly lakes; however, some communities source water from creeks, rivers, or glacial meltwater (Elliott et al. 2021). An example of unimpacted water quality monitoring data from drinking water sourced in Kugluktuk, a community 180 km west of the Port, showed that the water had a measured pH of 4, alkalinity of 2 (assumed mg/L as $CaCO_3$), nitrate (as N) of 6 (assumed mg/L), chloride of 4 (assumed mg/L), dissolved organic carbon of 3 (assumed mg/L), turbidity of 3 (assumed Nephelometric Turbidity Unit [NTU]), sulphate 4 (assumed mg/L); metals were not measured (Elliott et al. 2021). Drinking water sources identified by Inuit and Traditional Knowledge community members include: the Burnside River, most lakes and rivers - preferably large lakes and flowing rivers, rock crevasses, and “’aniloakhinik’, places where water was forced to the surface due to the pressure of the surrounding permafrost and ‘neelak’, locations of permanent ice” (Banci and Spicker 2024).

2 Methods

Descriptions of the data sources and the collection of samples used for the characterization of existing freshwater and sediment quality conditions are described in Sections 2.1 and 2.2, respectively.

2.1 Data Sources

Data and information used to characterize existing conditions (also referred to as the baseline conditions) were sourced from publicly available data and literature, and freshwater and sediment quality data collected in 2012 and 2024 within the RAA, the LAA, and far-field sites (sites outside of the RAA). Existing conditions refer to freshwater and sediment quality prior to Project-related construction activities. Depending on the watercourse and its location, these conditions may represent either natural ambient conditions or environments influenced by anthropogenic activities. Data sources are summarized in the following sections [note: Indigenous Knowledge and traditional use information were collected through literature review, consultation, and engagement and are summarized in Section 19, Sections 19.1.2, 19.2.2.1 of the application)].

2.1.1 Data Sources

Data and information for the characterization of existing freshwater quality and sediment quality were reviewed from the following sources (see Appendix A, Appendix B, Appendix C, Appendix D, and Section 20, Appendix 20A of the application):

- Izok Corridor Project access road: *Water and Sediment Quality – Izok Lake and Road – 2012 Field Data Report* (Golder 2013), (Appendix A). Samples within the RAA were included, as listed below.
- *High Lake Water Quality Field Report 2012* (RC Bio 2011) (Appendix B). Data from lake monitoring sites for the proposed High Lake mine were included in the characterization of existing conditions as the mine area is located within the RAA. One stream site (S35/S35a) was collected from the proposed High Lake mine area and was excluded from the characterization of existing conditions as it was determined to be very low flow and boggish and does not represent stream water quality.
- Izok Corridor Project (i.e., the Izok mine) (RC Bio 2011) (Appendix C): Monitoring sites for the proposed Izok mine are located in the Coppermine River watershed, which does not overlap with or flow into the RAA. For these reasons, baseline data from the proposed Izok mine were excluded from the characterization of existing conditions.
- *Community Water Quality Data Across Nunavut: An Introduction to Available Data for Community Water Supplies* (Elliott et al. 2021)
- *Geochemistry of Small Canadian Arctic Rivers with Diverse Geological and Hydrological Settings* (Brown et al. 2020)

The freshwater and sediment quality data was collected at monitoring locations within the RAA and LAA in 2024 (Appendix D; Section 20, Appendix 20A of the application).

2.1.2 Selected Monitoring Sites

Monitoring sites from the High Lake Mine, the Izok Corridor Project access road, and the Potential Water Intake study were mostly sampled once at multiple locations; however, some were sampled more than once. Data from the following monitoring sites were reviewed and incorporated into this analysis:

- The High Lake Mine (see Figure 1.2) 2012 baseline confirmation program's water quality data were reviewed and incorporated into this analysis. Specifically:
  - the Kennarctic River sites (KN7, KN8, KN9, and KN10)
  - lake sites (L908-T, L908-B, L904, L905, L906-B, L906-T, L16a-T, L16b-T(a), L16b-B(a), L16b-T(b), L16a-B, L16b-T(c), L16b-B(b), HLC3-T, HLC3-B, L31(a), and L31(b)).
- The Izok Corridor Project access road sites within the RAA (see Figure 1.2). Data from 2012 were also reviewed to provide stream surface water quality and sediment quality characteristics. Specifically:
  - Stream water quality sites X03-055A, X03-062A, X03-069A, X01-072, X01-085, X01-094, X01-104, X01-115, X03-123A, and X01-130-ALT.
  - Sediment quality sites X03-055A, X01-085, and X01-094
- Potential Water Intake Location (PWI-1) lake water quality and sediment quality sites PL-WQ-1, PL-WQ-2, and PL-WQ-03.
- Potential Water Intake Location (PWI-2) lake water quality sites PWI-2-1, PWI-2-2, and PWI-2-3

Data from the sampling sites described above were used to characterize baseline spatial and temporal variability in surface water quality and spatial variability in sediment quality along the proposed roadway (Table 2.1).

For the Kennarctic River sites, site KN10 serves as a reference site and is located upstream of known anthropogenic influences (i.e., High Lake Mine). The remaining sites (KN-7, KN-8, KN-9a, and KN-9 b) are downstream of potential anthropogenic influences (i.e., High Lake Mine) and are summarized together as they represent Baseline surface water conditions in the Kennarctic River watershed (Appendix B).

Stream sites selected from the Izok Corridor Project (Appendix A) were used to represent existing surface water quality conditions, and the results are summarized together:

- X03-055A, X03-062A, X03-069A, and X01-072 from the Burnside River watershed
- X01-085, X01-094, and X01-104 from the Hood River watershed
- X01-115 from the James River watershed
- X03-123A and X01-130-ALT from the Wentzel River watershed

Table 2.1 Number of Surface Water and Sediment Quality Samples Included in this Assessment

Sampling Area	Station Type	Water Quality			Sediment Quality	
		August 2012	August 2024	August 2025	August 2012	August 2024
Izok Corridor Project – Road[1]	Stream	10	-	-	3	-
High Lake Mine[2]	Kennarctic River	6	-	-	-	-
	Lake	15	-	-	-	-
	Reference Lake Site	2	-	-	-	-
Potential Water Intake (PWI-1 and PWI-2)[3]	Lake	-	6	6	-	3
Subtotals		**Water Quality: 45**			**Sediment Quality: 6**	

Notes:
"-" indicates no samples collected
[1] Golder (2013)
[2] RC Bio (2021)
[3] Nunami Stantec Limited (2024) and Section 20, Appendix 20A of the application

Lake water quality data collected in August 2012 are summarized for lakes within the proposed High Lake Mine area. Within this area, site HLC3 serves as a reference location. Lakes L904, L095, L906, and L908 are located within the proposed mine footprint near the planned explosives storage area. Sites L16a and L16b are located within High Lake, and lake L31 is approximately 500 m southwest of High Lake (Appendix B). Additional data were collected in August 2024 and July 2025 from two lakes near the proposed Port (referred to herein as PWI-1 and PWI-2; Figure 1.2), which may serve as a potential water intake location for the Project. PWI-1 was sampled at three locations (PL-WQ-01, PL-WQ-02, and PL-WQ-03) and PWI-2 within one lake was sampled at three locations (Section 20, Appendix 20A of the application) within another lake.

Sediment sites were selected from the Izok Corridor Project (X03-055A, X01-085, and X01-094; Appendix A) and from PWI-1 (sites PL-SQ-1, PL-SQ-2, and PL-SQ-03) as summarized in Appendix D). These sites are within the Wentzel River watershed, are summarized together as they represent existing sediment quality conditions.

2.2 Sample Collection and Laboratory Analyses

In 2012 (Golder 2013; RC Bio 2011, 2021), 2024 (Nunami Stantec Limited 2024), and 2025 (Section 20, Appendix 20A of the application) surface water quality grab samples, in situ measurements (i.e., temperature, pH, conductivity, dissolved oxygen), and sediment quality grab samples were collected from stream and lake sites within the RAA; detailed methods are described in Appendix A, Appendix B, Appendix C, Appendix D, and Section 20, Appendix 20A of the application are summarized here. Monitoring sites were sampled in July or August during the open water season and collected when water was present.

At stream sites, surface water quality samples were collected from the shoreline, in defined flow, and at depths of 5 to 15 centimetres (cm) below the water surface. Along the roadway, 10 sites were sampled for water quality, with 3 of these sites sampled for sediment quality.

At lake sites, samples were collected at depth using a non-metallic Kemmerer bottle or a Van Dorne water sample bottle. At lake stations, the number of samples collected depended on the total water depth. For lake sites less than 5 metres (m) deep, one sample was collected at 1 m below the water surface. For lake sites greater than 5 m deep, two samples were collected: 1) from 1 m below the top surface and 2) from 1 m above the lake bottom. Lake water depths were determined with the probe and measuring rope; bathymetric maps were not available at the time of this study.

In situ measurements, including temperature, pH, conductivity, turbidity, and dissolved oxygen, were collected using a YSI multimeter. Grab samples were submitted to ALS Laboratory in Edmonton, Alberta or Yellowknife, NT as soon as possible, using chain of custody forms to track shipment and receipt of samples. ALS Laboratory is accredited by the Canadian Association for Laboratory Accreditation Inc. Quality assurance and quality control field measures included the collection and analysis of field blanks and field replicates for each program and included a trip blank for the Potential Water Intake Study. Additional details on methods including quality assurance and quality control are found in Appendix A, Appendix B, Appendix C, and Section 20, Appendix 20A of the application.

Sediment samples were collected using an Ekman grab sampler, a petite Ponar sampler, or a push tube sampler, depending on the site. Parameters tested for sediment quality, the detection limits, and guidelines used to compare results are listed in Table 2.8 in Appendix A; Section 2.3.2 and Appendix A in Section 20, Appendix 20A of the application.

Water quality parameters and detection limits are listed in Table 2.3 in Appendix A, Table 1 in Appendix B, and Section 2.0 and Appendix A in Appendix D, and Section 3.0 of Section 20, Appendix 20A of the application.

2.3 Data Analysis

The surface quality results were compared to the Federal Environmental Quality Guidelines (FEQG) (GOC 2024), Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for Freshwater Aquatic Life (CCME 2025a), and Health Canada Drinking Water Guidelines (DWG) (Health Canada 2025). The variable guidelines were calculated based on a pH of 6.5, water temperature of 10 degrees Celsius, hardness of 11 mg/L as $CaCO_3$ as per methods described in Appendix A. Guidelines that are dependent on dissolved organic carbon (DOC) were calculated using a DOC of 1 mg/L. The sediment quality results were compared to the Sediment Quality Guidelines for the Protection of Aquatic Life, interim freshwater sediment quality guidelines (ISQG) and the probable effect levels (PEL) (CCME 2025b).

3 Results

This section provides an overview of the surface water quality results for the Kennarctic River (Section 3.1) as well as other stream sites (Section 3.2) and lake sites (Section 3.3). The surface water quality results include both natural background conditions and anthropogenically influenced conditions and are further described in the following sections. Sediment quality results are also summarized in Section 3.4.

3.1 Kennarctic River

Six samples were collected from the Kennarctic River in August 2012 as part of the High Lake Water Quality Field Report (RC Bio 2021) (Appendix B), with results summarized below. The laboratory results compared to guidelines (see Section 2.3) and summary statistics are provided in Appendix E, Table E.1. Site KN10 is a reference site and is upstream of anthropogenic influences (i.e., High Lake Mine). The remaining sites (KN-7, KN-8, KN9a, and KN9b) are downstream of potential anthropogenic influences (i.e., High Lake Mine) and are summarized together as they represent existing surface water conditions.

3.1.1 In Situ Parameters

Field-measured (in situ) parameters in the Kennarctic River showed the following ranges:

- Monitoring occurred in August 2012 and river temperatures ranged from 9.6 °C to 11.3 °C.
- Dissolved oxygen (DO) concentrations ranged from 91.8 % saturation to 132 % saturation.
- Conductivity measurements ranged from 48 microsiemens per centimetre (µS/cm) to 73 µS/cm.
- Field pH measurements ranged from 7.86 to 8.57.
- Total dissolved solids (TDS) ranged from 0.043 grams per litre (g/L) to 0.066 g/L and turbidity ranged from 0.22 NTU to 0.46 NTU.
- Oxygen reduction potential ranged from 111.0 millivolts (mV) to 132.0 mV.

Sample-by-sample in situ results are listed in Table 1 of Appendix B.

3.1.2 General Parameters, Anions, Cations, and Cyanide

General parameters in the Kennarctic River were measured in the following ranges:

- Total suspended solids (TSS) were below the detection limit (<3.0 mg/L),
- Water hardness ranged from 27.3 milligrams per litre (mg/L) to 31.4 mg/L as calcium carbonate ($CaCO_3$).
- Dominant cations were calcium and magnesium; however, at lower concentrations (<9 mg/L) compared to other sites, and bicarbonate was the dominant anion.
- Total alkalinity ranged from 23.0 mg/L to 25.4 mg/L as $CaCO_3$.

- Chloride concentrations ranged from 2.08 mg/L to 2.73 mg/L, fluoride concentrations were below the detection limit (<0.050 mg/L), and sulphate concentrations ranged from 8.11 mg/L to 9.19 mg/L.
- Total cyanide was consistently below the detection limit of <0.0020 mg/L.

3.1.3 Nutrients

Nutrients in the Kennarctic River showed the following ranges:

- Total ammonia (i.e., un-ionized ammonia [NH_3] + ammonium ion [NH_4^+]) was below detection limit (<0.0050 mg/L [as nitrogen]), total Kjeldahl nitrogen (TKN) ranged from <0.050 mg/L to 0.099 mg/L, total nitrate (as N; NO_3^-) ranged from 0.0292 to 0.0831 mg/L, and nitrite (as N; NO_2^-) was below the detection limit (<0.0020 mg/L as N).
- Total phosphorus ranged from 0.0014 to 0.0027 mg/L and dissolved orthophosphate was below detection limit (<0.0010 mg/L).
- Dissolved organic carbon (DOC) ranged from 1.2 mg/L to 1.7 mg/L and total organic carbon (TOC) ranged from 1.2 mg/L to 2.1 mg/L.

3.1.4 Metals

Metals were below the applicable guidelines except for dissolved copper:

- Dissolved copper concentrations were above the calculated FEQG of 0.0002 mg/L (i.e., the minimum possible value) in 6 of 6 samples and ranged from 0.00063 mg/L to 0.00112 mg/L (up to 5 times [x] the FEQG).

3.2 Other Streams

Water quality results are summarized for streams within the RAA located in the Burnside River, Hood River, James River, and Wentzel River watersheds, excluding the Kennarctic River watershed (Section 3.1). Water quality data selected for this assessment were collected in August 2012 as part of the Izok Corridor Project (Appendix A) and are summarized below. In situ results are listed in Table 5-1 of Appendix A and Table 4 of Appendix B. Laboratory results, compared to applicable guidelines, along with summary statistics, are provided in Appendix E, Table E.2.

3.2.1 In Situ Parameters

Field-measured (in situ) parameters in the stream sites showed the following ranges:

- Stream temperatures, measured at the surface, ranged from 10.2 °C to 13.8 °C.
- DO concentrations ranged from 9.2 mg/L to 13.3 mg/L and 85.7 percent (%) to 118.9 % saturation.
- Conductivity measurements ranged from 18 µS/cm to 102 µS/cm.
- Field pH measurements ranged from 5.6 to 7.0.

3.2.2 General Parameters, Anions, Cations, and Cyanide

General parameters in the stream sites showed the following ranges:

- Turbidity ranged from 0.3 to 1.0 NTU, TDS ranged from <10.0 to 61 mg/L.
- TSS was <3.0 mg/L for measured sites.
- Water hardness ranged from 6.0 mg/L to 40 mg/L as $CaCO_3$.
- Dominant cations were calcium and magnesium, and bicarbonate was the dominant anion.
- Total alkalinity ranged from <5.0 mg/L to 36 mg/L as $CaCO_3$.
- Chloride concentrations ranged from <0.50 mg/L to 2.0 mg/L, fluoride concentrations were below the detection limit (<0.050 mg/L), and sulphate concentrations ranged from 1.0 to 11 mg/L.
- Total cyanide was consistently below the detection limit of <0.0020 mg/L.

3.2.3 Nutrients

Nutrients in the stream sites showed the following ranges:

- Total ammonia (i.e., un-ionized ammonia [NH_3] + ammonium ion [NH_4^+]) was below detection limit (<0.0050 mg/L [as nitrogen]), total Kjeldahl nitrogen (TKN) ranged from <0.050 mg/L to 0.500 mg/L, total nitrate (as N; NO_3^-) ranged from <0.0060 to 0.148 mg/L (as nitrogen [N]), and nitrite (as N; NO_2^-) was below detection limit of 0.0020 mg/L as N.
- Total phosphorus ranged from 0.001 to 0.008 mg/L and dissolved orthophosphate was below detection limit (<0.0010 mg/L).
- Dissolved organic carbon (DOC) ranged from 2 mg/L to 10 mg/L and total organic carbon (TOC) ranged from 1.3 mg/L to 9.5 mg/L.

3.2.4 Metals

Metals were below the applicable guidelines (see Appendix E, Table E.2) except for:

- Total aluminum (1 of 10 sites, approximately 1.3x the FEQG of 0.057 mg/L)
- Dissolved copper (10 of 10 sites; up to 9x the FEQG of 0.0002 mg/L; total copper marginally exceeded the CCME guideline of 0.002 mg/L once)
- Total iron (1 of 10 sites, 3.2x the Health Canada DWQG aesthetic objective; note that exceedance of aesthetic objectives does not imply a risk to human health).

3.3 Lakes

Water quality results are summarized for lakes within the RAA, including those in the general area of the proposed High Lake Mine (sampled in August 2012), and for the potential water intake locations (PWI-1 and PWI-2) within the LAA near the Port site of the Project (sampled in August 2024 and in July 2025). The in situ results are listed in Appendix C.3 of Section 20, Appendix 20A of the application.
The laboratory results, comparison to applicable guidelines, and summary statistics are provided in Appendix E, Table E.3 and are summarized below.

3.3.1 Physical Limnology

The depths of selected lakes ranged from approximately 1 m to > 30 m. The shallow lakes (<5 m) included L904, L905, and L31; lakes between 5 m and 11 m included L908, L906, HCL3, and PL-WQ-1/ PWI-2; and one lake site, L16, was >30 m.

3.3.2 In Situ Parameters

Field-measured (in situ) parameters in the lake sites showed the following ranges:

- Lake temperature profiles, measured in July or August, ranged from 9.7°C to 14°C at surface and 5.0°C to 12.1°C at depths (up to 30 metres). Temperatures cooled with depth.
- DO concentrations ranged 90.8 percent (%) to 105.7 % saturation
- Field pH measurements ranged from 6.8 to 7.9.
- In situ conductivity at surface measured from 36 µS/cm to 184.4 µS/cm.

3.3.3 General Parameters, Anions, Cations, and Cyanide

General parameters in the lake sites showed the following ranges:

- Laboratory conductivity measurements ranged from 50 to 221 µS/cm.
- Laboratory pH measurements ranged from 6.7 to 7.7.
- TDS ranged from 49 to 52 mg/L, TSS ranged from 4.0 to 5.2 mg/L, and turbidity ranged from 0.4 to 2.7 NTU.
- Water hardness ranged from 13 to 89 mg/L (as $CaCO_3$).
- Total alkalinity ranged from 7 mg/L to 38 mg/L (as $CaCO_3$).
- Chloride ranged from less than 2 mg/L to 48.0 mg/L, fluoride ranged from below the detection limit of <0.02 mg/L to 0.03 mg/L, and sulphate ranged from 2 mg/L to 28 mg/L.
- Total cyanide was consistently below the detection limit of < 0.002 mg/L.

3.3.4 Nutrients

Nutrients in the lake sites showed the following ranges:

- Total ammonia ranged from < 0.005 mg/L to 0.411 mg/L (as nitrogen), TKN ranged from < 0.05 mg/L to 0.1 mg/L, total nitrate (as N) ranged from <0.0050 mg/L to 0.03 mg/L, and nitrite (as N) ranged from < 0.0010 mg/L to 0.003 mg/L (as N).
- Total phosphorus ranged from < 0.001 mg/L to 0.02 mg/L and dissolved orthophosphate was consistently below the detection limit of < 0.001 mg/L where measured.
- DOC ranged from 2 mg/L to 6 mg/L and TOC ranged from 2 mg/L to 5 mg/L.

3.3.5 Metals

Metals were below the applicable guidelines (see Appendix E, Table E.3), except for:

- Total aluminum (13 of 29 sites, up to 1.4x the FEQG of 0.057 mg/L)
- Total cobalt (7 of 29 sites, up to 10x FEQG of 0.0004 mg/L)
- Total cadmium (7 of 29 sites, up to 53x the long-term CCME guideline of 0.00004 mg/L)
- Dissolved copper (all 29 sites, up to 995x the FEQG of 0.0002 mg/L)
- Total copper (15 of 29 sites, up to 163x the long-term CCME guideline of 0.002 mg/L)
- Dissolved zinc (7 of 29 sites, up to 49x the CCME ST and 69x the long-term CCME guideline of0.01 mg/L)
- Total iron (2 of 29 sites, up to 1.4x the Health Canada DWQG aesthetic objective; note that exceedance of aesthetic objectives does not imply a risk to human health).

3.4 Sediment Quality

Sediment quality samples were collected from stream sites from the Izok Corridor Project (sites X03-055A, X01-085, X01-094; Appendix A) and from lake sites from the Potential Water Intake Study (sites PL-SQ-01, PL-SQ-02, PL-SQ-03; Appendix D). These data were used to represent existing sediment quality conditions. Site X03-055A was collected from the Burnside River watershed, sites X01-085 and X01-094 were from the Hood River watershed, and sites PL-SQ-01, PL-SQ-02, and PL-SQ-03 were from the Wentzel Lake watershed. Sediment quality results for streams along the Project alignment are summarized for each monitoring site in Appendix E, Table E.4. General results are summarized across multiple stream sites (Section 3.4.1) and lake sites (Section 3.4.2).

3.4.1 Stream Sediment Quality

Stream sediment quality is summarized for samples collected at sites X03-055A, X01-085, X01-094 in August 2012. Key sediment quality results across stream sample locations were as follows:

- Coarse sand was the dominant substrate in stream sediments and silt, or fine sand were the sub-dominant substrates.
- pH ranged from 5.39 to 5.60
- Organic matter ranged from <1.0% to 2.4%
- Concentrations of total metals were below CCME guidelines

3.4.2 Lake Sediment Quality

Lake sediment quality is summarized for samples collected at sites PL-SQ-01, PL-SQ-02, and PL-SQ-03 in August 2024. Key sediment quality results across lake sample locations were as follows:

- Silt was the dominant substrate, and clay was the sub-dominant substrate.
- pH ranged from 5.76 to 6.05
- Total organic carbon ranged from 3.67 % to 4.38 %
- Concentrations of total metals were above applicable guidelines, including:
  - Arsenic (3 of 3 sites, up to 2x CCME ISQG)
  - Chromium (3 of 3 sites, up to 2x CCME ISQG)
  - Copper (3 of 3 sites, up to 1.3x CCME ISQG)
  - Iron (3 of 3 sites, up to 3x CCME ISQG, up to 1.2x CCME PEL)
  - Manganese (1 of 3 sites, up to 1.1x CCME ISQG)
  - Nickel (3 of 3 sites, up to 3x CCME ISQG)
- Concentrations of polycyclic aromatic hydrocarbons (PAHs) were above applicable guidelines, including (see Table E.3 in Appendix E):
  - Acenaphthene (3 of 3 sites, up to 2x CCME ISQG)
  - Acenaphthylene (3 of 3 sites, up to 2x CCME ISQG)
  - Dibenz(a,h) anthracene (3 of 3 sites, up to 4x CCME ISQG)
  - Naphthalene (1 of 3 sites, 1x CCME ISQG)

4 Summary

Freshwater and sediment quality data were collected in the summer months of 2012, 2024, and 2025 along the roadway, at High Lake Mine, and near the Port to provide reliable information for characterizing existing conditions and developing the IS for the Project. Monitoring data were collected across multiple watersheds, including the Burnside River, Hood River, James River, the Kennarctic River, and the Arctic Ocean. A total of 6 samples were collected from the Kennarctic River, 10 samples were collected from streams along the roadway, 29 samples were collected from lakes near the High Lake Mine and near the Port (some sites have multiple samples per site), and 6 samples of sediment were collected along the roadway and near the Port.

Water quality across rivers, streams, and lakes was generally good, with clear, well-oxygenated waters and low nutrient levels. The Kennarctic River showed cool temperatures (9.6–11.3 °C), slightly alkaline pH, and minimal turbidity, with most parameters below applicable guidelines. Total dissolved solids were 43–66 mg/L, hardness moderate (27–31 mg/L), and chloride and sulphate low. Nutrients were largely undetectable, with total phosphorus between 0.0014 and 0.0027 mg/L, and organic carbon minimal (1.2–2.1 mg/L). Metals were below guidelines except dissolved copper, which exceeded the federal guideline by up to five times.

Streams in the Burnside, Hood, James, and Wentzel watersheds had similar conditions, though pH ranged from acidic to neutral and hardness was very low in places. Nutrients remained low, and organic carbon ranged from 1.3 to 10 mg/L. Metals were generally below guidelines, but dissolved copper exceeded the federal guideline at all sites (up to nine times), aluminum was elevated at one site, and total iron exceeded the aesthetic objective at one site.

Lakes near the High Lake Mine were cool, well-oxygenated, and low in turbidity, with soft to moderately hard water and minimal nutrients, indicating low eutrophication potential. Most parameters were below guidelines; however, these lakes exhibited significant metal exceedances. Dissolved copper was the most notable, reaching extreme levels—up to 995 times the federal guideline—with total copper up to 163 times. Other exceedances included cobalt (up to 10×), cadmium (up to 53×), and zinc (up to 69×). The reference lake (HLC3) also showed copper above guidelines. Lakes near the Port site (potential water intake locations PWI-1 and PWI-2) generally had similar physical and chemical characteristics—soft to moderately hard water, low turbidity, and minimal nutrients—but metals such as aluminum, iron, and copper were above guidelines at both sites.

Sediment in streams consisted mainly of coarse sand with low organic matter (<1–2.4%) and metals below guidelines. In contrast, lake sediments at the potential intake site contained silt and clay and showed multiple metal exceedances, including arsenic, chromium, copper, iron, manganese, and nickel, with iron surpassing the Probable Effect Level. Organic carbon ranged from 3.67% to 4.38%. Several polycyclic aromatic hydrocarbons also exceeded guidelines, notably dibenz (a,h) anthracene at up to four times the limit.

The results of the Baseline will be used to support the refinement of engineering designs and Project footprints, and to develop mitigation measures for use during the Project Construction, and Operation and Maintenance phases.

5 References

Banci, V., & Spicker, R. 2024. *Kitikmiut Knowledge of the Proposed Kogloktoakyok (Grays Bay) Port and Road Project.* Kugluktuk NU: Naonaiyaotit Inuit Knowledge Project (NTKP), Kitikmeot Inuit Association.

Brown, K. A., Williams, W. J., Carmack, E. C., Fiske, G., François, R., McLennan, D., & Peucker-Ehrenbrink, B. 2020. *Geochemistry of small Canadian Arctic Rivers with diverse geological and hydrological settings.* Journal of Geophysical Research: Biogeosciences, 125(1). Retrieved from https://doi.org/10.1029/2019JG005414

CCME (Canadian Council of Ministers of the Environment). 2025a. *Canadian Water Quality Guidelines for Protection of Aquatic Life.* https://ccme.ca/en/summary-table.

CCME. 2025b. *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life Freshwater.* Retrieved from https://ccme.ca/en/summary-table

Elliott, J., Clayden, M., Clouter, K., Collins, S., Tremblay, T., & LeBlanc-Havard, M. 2021. *Community water quality data across Nunavut: an introduction to available data for community water supplies.* Geoscience for infrastructure. Iqaliut: Canada-Nunavut Geoscience. Retrieved from https://cngo.ca/summary-of-activities/2021/

GBEEC (Grays Bay Engineering and Environmental Consultants). 2018a. *Grays Bay Road and Port Project Proposal*. Prepared for Nunavut Planning Commission and the Nunavut Impact Review Board.

GBEEC. 2018b. *Grays Bay Road and Port Project – Fisheries Technical Data Report.* Prepared for Nunavut Resources Corporation and Government of Nunavut.

GOC (Government of Canada). 2024. *Federal Environmental Quality Guidelines (FEQG)*. Retrieved from https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/federal-environmental-quality-guidelines.html

Golder. 2013. *Water and Sediment Quality – Izok Lake and Road – 2012 Field Data Report.*

Health Canada. 2025. *Guidelines for Canadian Drinking Water Quality—Summary Tables.* Ottawa: Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada.

IAG (Inuit Advisory Group). 2025a. *Grays Bay Road and Port Project What We Heard Report: Inuit Advisory Group Workshop #1 Summary – Inuit Knowledge Integration Methods and Mitigation Strategies. March 2025. Report on file.*

IAG. 2025b. *Grays Bay Road and Port Project What We Heard Report: Inuit Advisory Group Workshop #2 Summary – Understanding and Protecting Caribou. September 2025. Report on file.*

Nunami Stantec Limited. 2024. *Potential Water Intake Location (PWI-1) Memorandum.*

RC Bio (RC BioSolutions Ltd.). 2011. Izok Project – *Addendum Technical Report for Fisheries Baseline Studies 2008.*

RC Bio. 2021. *High Lake Water Quality Field Report 2012*. Prepared for: MMG.

Sabina (Sabina Gold & Silver Corp.). 2015. Sabina Gold & Silver Corp. Back River Project, F*inal Environmental Impact Statement Supporting Volume 6: Freshwater Environment. Submitted to Nunavut Impact Review Board*, November 2015.

Wolfden (Wolfden Resources Inc.). 2006. *High Lake Project, Hydrology, Volume 5, Section 1.* Submitted to Nunavut Impact Review Board, September 2006.

Appendix A Izok Lake and Road – 2012 Water and Sediment Quality

January 17, 2013

IZOK CORRIDOR PROJECT

Water and Sediment Quality - Izok Lake and Road - 2012 Field Data Report

Submitted to:
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REPORT

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Golder Associates

Executive Summary

The Izok Corridor Project (the Project) is a proposed zinc mine development in the Kitikmeot Region of Nunavut, approximately 350 km north of Yellowknife and 70 km west of the Lupin mine site. The project consists of a proposed mine at Izok Lake and High Lake, a port at Grays Bay, and an all-weather road to connect the three project areas. A field program was conducted in 2012 to collect water quality and sediment quality samples from selected locations near the proposed Izok Mine and from streams along the optimum road alignment. Samples were collected to document baseline spatial and temporal variability in water quality, and spatial variability in sediment quality.

In the Izok Lake area, water quality samples were collected from streams (11 samples total), small lakes (23 samples), and large lakes (63 samples), and sediment quality samples were collected from small lakes (6 samples) and large lakes (10 samples). In the road corridor area, water quality samples (14) and sediment samples (4) were collected from streams.

Water and sediment quality data were compared to aquatic life guidelines and drinking water guidelines. In the water quality samples, cadmium most often exceeded aquatic life guidelines, followed by copper, aluminum, and pH. Water quality in the streams was mostly below the aquatic life guidelines. In the larger lakes, cadmium concentration exceeded guidelines in most samples. In the smaller lakes, with low pH, concentrations of metals (aluminum, cadmium, copper, iron, manganese, nickel, and zinc) were above guidelines. In the sediment quality samples, arsenic most often exceeded aquatic life guidelines, followed by cadmium, copper, and chromium.

List of Acronyms

ALS	ALS Environmental
CCME	Canadian Council of Ministers of the Environment
CWQG	Canadian Water Quality Guidelines
DO	Dissolved oxygen
DOC	Dissolved organic carbon
Golder	Golder Associates Ltd.
ISQG	Interim sediment quality guidelines
MDL	Method detection limit
MMG	Minerals and Metals Group
NIRB	Nunavut Impact Review Board
N/A	Not applicable
PEL	Probable effect level
Project	Izok Corridor Project
PQL	Practical Quantitation Limit
QA	Quality assurance
QC	Quality control
QA/QC	Quality assurance/quality control
RPD	Relative percent difference
TC	Total carbon
TDP	Total dissolved phosphorus
TDS	Total dissolved solids
TIC	Total inorganic carbon
TKN	Total Kjeldahl nitrogen
TOC	Total organic carbon
TP	Total phosphorus
TSS	Total suspended solids
UTM	Universal Transverse Mercator

Units and Symbols

°	Degree
°C	Degrees Celsius
%	Percent
>	Greater than
≥	Greater than or equal to
<	Less than
≤	Less than or equal to
cm	Centimetre
g	Gram
km	Kilometre
m	Metre
mg	Milligram
mg/L	Milligrams per litre
mg N/L	Milligrams per litre as nitrogen
mL	Millilitre
pH	Measure of the acidity or basicity of a solution
µg	Microgram
µg/L	Micrograms per litre
µS/cm	MicroSiemens per centimetre

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APPENDICES

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Quality Assurance and Quality Control

APPENDIX B
Field Data

APPENDIX C
Water Quality Data

APPENDIX D
Sediment Quality Data

1.0 INTRODUCTION

1.1 Background

The Izok Corridor Project (the Project) is a proposed zinc mine development in the Kitikmeot Region of Nunavut, approximately 350 km north of Yellowknife and 70 km west of the Lupin mine site (Figure 1-1). The Project consists of a mine site at Izok Lake and at High Lake, an all-season access road, and a port facility.

Minerals and Metals Group (MMG) is an Australian based metal mining company, based in Melbourne with Canadian headquarters in Vancouver, British Columbia. MMG is a wholly owned subsidiary of Minmetals Resources Limited (Minmetals) group of companies. MMG submitted a proposal to the Nunavut Impact Review Board (NIRB) to initiate the process to permit the Project.

1.2 Objectives

The objective of this report is to provide a summary of water and sediment quality data collected in 2012 from the Izok Lake area and the all-season road area. The sampling program for 2012 was based on the sampling programs used for the 2007 (GLL 2008) and 2008 (Golder 2011) water and sediment quality programs, plus updates on the proposed Project design.

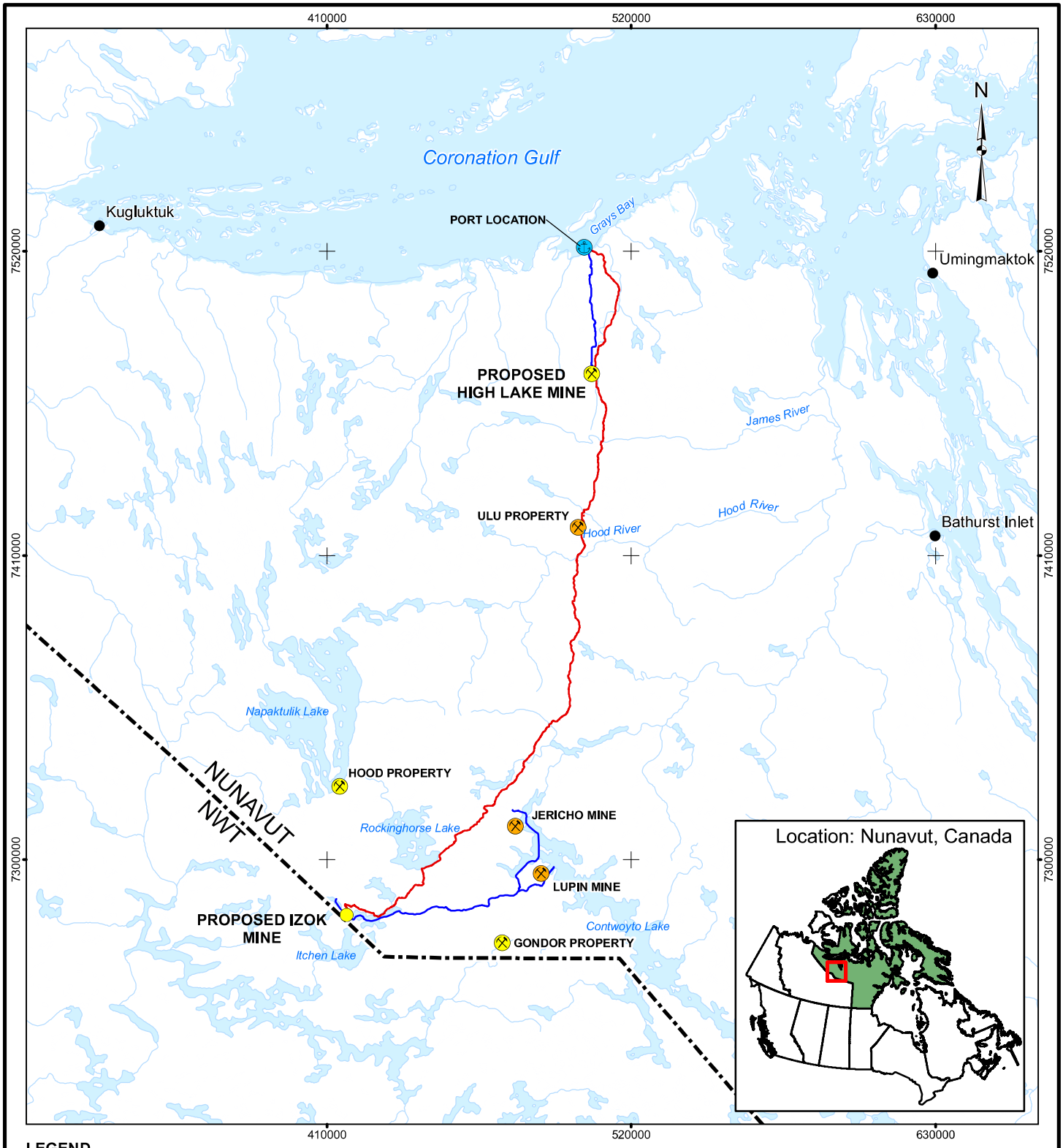
The 2012 field program for the Izok mine area consisted of under-ice water sampling of lakes (May) and open water sampling of lakes and streams (July and August). The field program for the road corridor consisted of one sampling campaign in August of selected streams crossed by the proposed road.

1.3 Study Areas

Two study areas were sampled during the 2012 water and sediment quality field program. These areas are defined as follows:

- Mine: Proposed Izok Mine and related infrastructure (Figure 1-2a and b)
- All-season access road: Proposed optimum road corridor from Izok to High Lake (Figure 1-3a and b)

The sampling locations were selected based on an understanding of the Project, and sampling programs conducted in 2007 and 2008.



LEGEND

- MMG MINING PROPERTY
- OTHER MINING PROPERTY
- PORT LOCATION
- PROPOSED IZOK MINE
- COMMUNITY
- OPTIMUM ROAD ALIGNMENT (2012)
- WINTER ROAD ALIGNMENT (2012)
- WATERCOURSE
- WATERBODY
- TERRITORIAL BOUNDARY

REFERENCE

HYDROLOGY DATASET IS FROM ATLAS OF CANADA FRAMEWORK THAT IS AVAILABLE FROM GEOGRATIS.
DATUM: NAD83 PROJECTION: UTM ZONE 12

PROJECT

MMG | MINERALS AND METALS GROUP

IZOK CORRIDOR PROJECT

TITLE

PROJECT LOCATION

Golder Associates

PROJECT		12-1373-0020	FILE No.	
DESIGN	CP	01 Sep. 2011	SCALE AS SHOWN	REV. 0
GIS	SK	23 Nov. 2012		
CHECK	CP	23 Nov. 2012		
REVIEW	ZK	23 Nov. 2012		

FIGURE: 1-1

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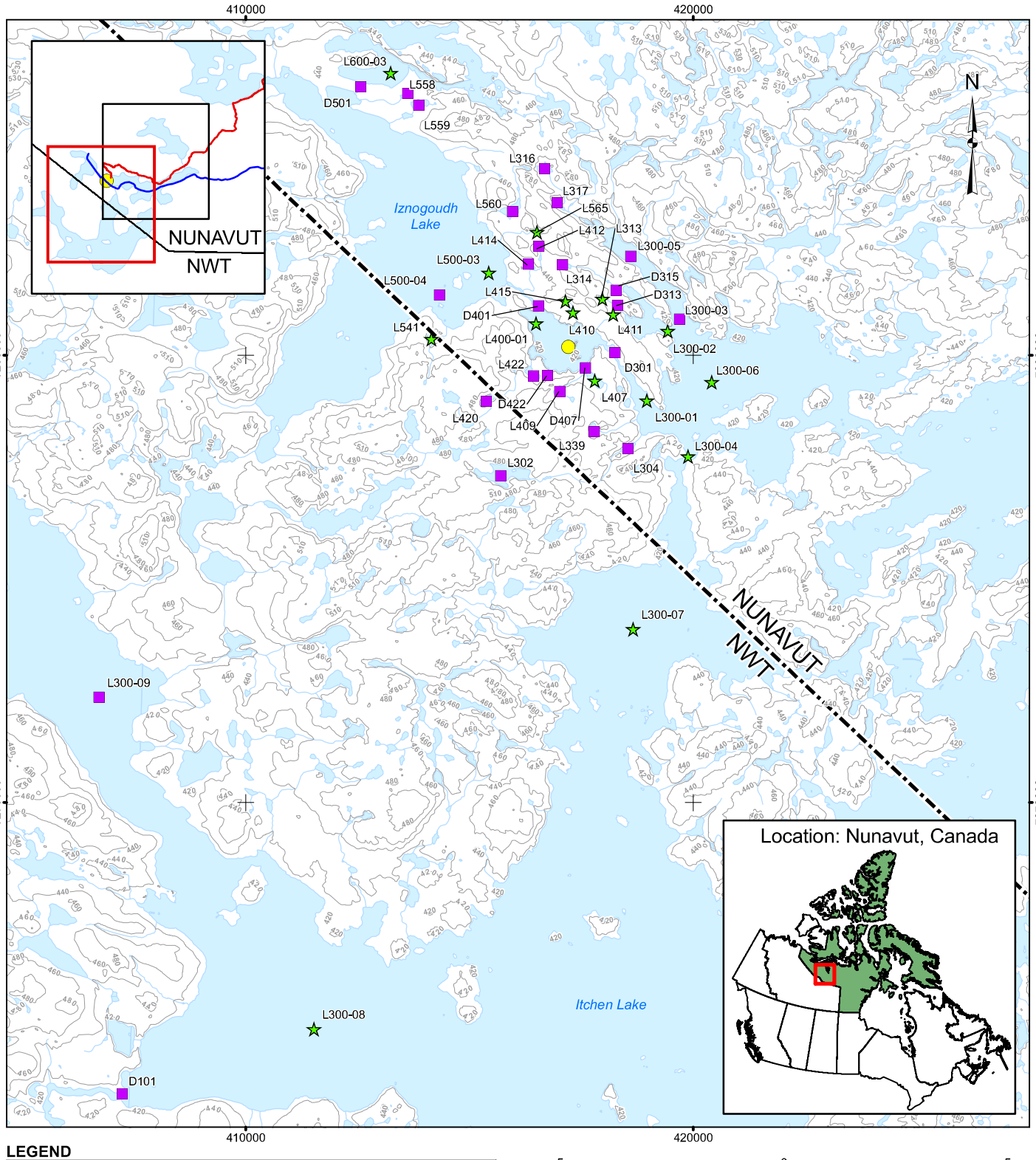

LEGEND

- PROPOSED IZOK MINE

SAMPLING STATIONS

- WATER QUALITY
- WATER AND SEDIMENT QUALITY
- CONTOURS 20 m
- WATERCOURSE
- WATERBODY
- TERRITORIAL BOUNDARY

REFERENCE

HYDROGRAPHY AND CONTOUR DATA FROM NATIONAL TOPOGRAPHIC DATABASE (NTDB) PROVIDED BY THE GOVERNMENT OF CANADA.
DATUM: NAD83 PROJECTION: UTM ZONE 12

PROJECT
MMG | MINERAL AND METALS GROUP

IZOK CORRIDOR PROJECT

TITLE
WATER AND SEDIMENT QUALITY SAMPLING STATIONS AT IZOK MINE AREA

Golder Associates

PROJECT		12-1373-0020	FILE No.	
DESIGN	CP	01 Sep. 2011	SCALE AS SHOWN	REV. 0
GIS	SK	23 Nov. 2012		
CHECK	CP	23 Nov. 2012		
REVIEW	ZK	23 Nov. 2012		

FIGURE: 1-2A

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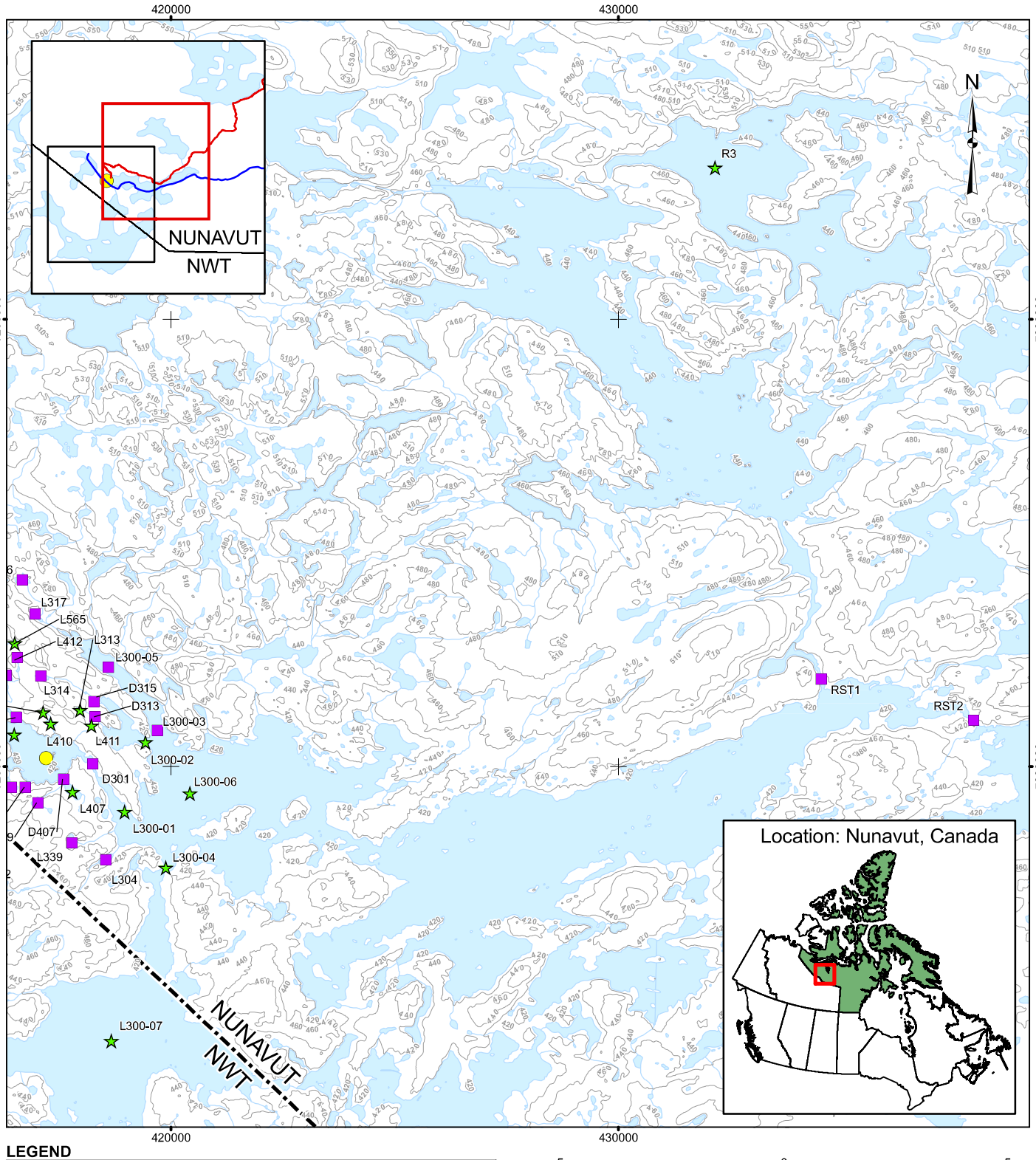

LEGEND

- PROPOSED IZOK MINE

SAMPLING STATIONS

- WATER QUALITY
- WATER AND SEDIMENT QUALITY
- CONTOURS 20 m
- WATERCOURSE
- WATERBODY
- TERRITORIAL BOUNDARY

5 0 5

SCALE 1:125,000 KILOMETRES

REFERENCE

HYDROGRAPHY AND CONTOUR DATA FROM NATIONAL TOPOGRAPHIC DATABASE (NTDB) PROVIDED BY THE GOVERNMENT OF CANADA.
DATUM: NAD83 PROJECTION: UTM ZONE 12

PROJECT

MMG | MINERAL AND METALS GROUP

IZOK CORRIDOR PROJECT

TITLE

WATER AND SEDIMENT QUALITY SAMPLING STATIONS AT IZOK MINE AREA

Golder Associates

PROJECT		12-1373-0020	FILE No.	
DESIGN	CP	01 Sep. 2011	SCALE AS SHOWN	REV. 0
GIS	SK	23 Nov. 2012		
CHECK	CP	23 Nov. 2012		
REVIEW	ZK	23 Nov. 2012		

FIGURE: 1-2B

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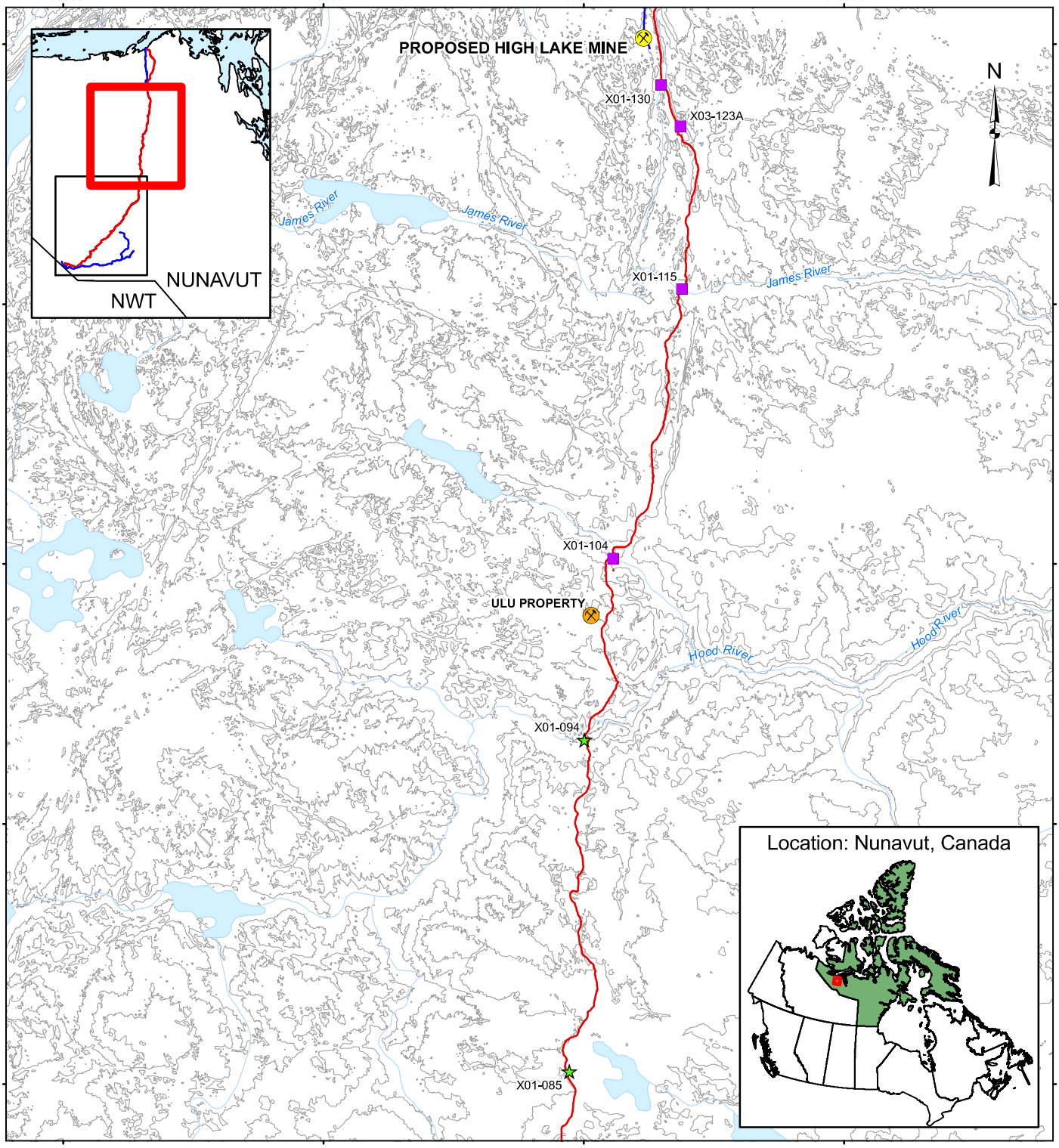

LEGEND

- MMG MINING PROPERTY
- OTHER MINING PROPERTY
- PROPOSED IZOK MINE

SAMPLING STATIONS

- WATER QUALITY
- WATER AND SEDIMENT QUALITY
- OPTIMUM ROAD ALIGNMENT (2012)
- WINTER ROAD ALIGNMENT (2012)
- CONTOURS 50 m
- WATERCOURSE
- WATERBODY
- TERRITORIAL BOUNDARY

15 0 15

SCALE 1:550,000 KILOMETRES

REFERENCE

HYDROGRAPHY AND CONTOUR DATA FROM NATIONAL TOPOGRAPHIC DATABASE (NTDB) PROVIDED BY THE GOVERNMENT OF CANADA.
DATUM: NAD83 PROJECTION: UTM ZONE 12

PROJECT
MMG | MINERALS AND METALS GROUP

IZOK CORRIDOR PROJECT

TITLE
WATER AND SEDIMENT QUALITY SAMPLING STATIONS ON IZOK ROAD CORRIDOR

Golder Associates

PROJECT		12-1373-0020	FILE No.	
DESIGN	CP	30 Apr. 2012	SCALE AS SHOWN	REV. 0
GIS	SK	23 Nov. 2012		
CHECK	CP	23 Nov. 2012		
REVIEW	ZK	23 Nov. 2012		

FIGURE: 1-3A

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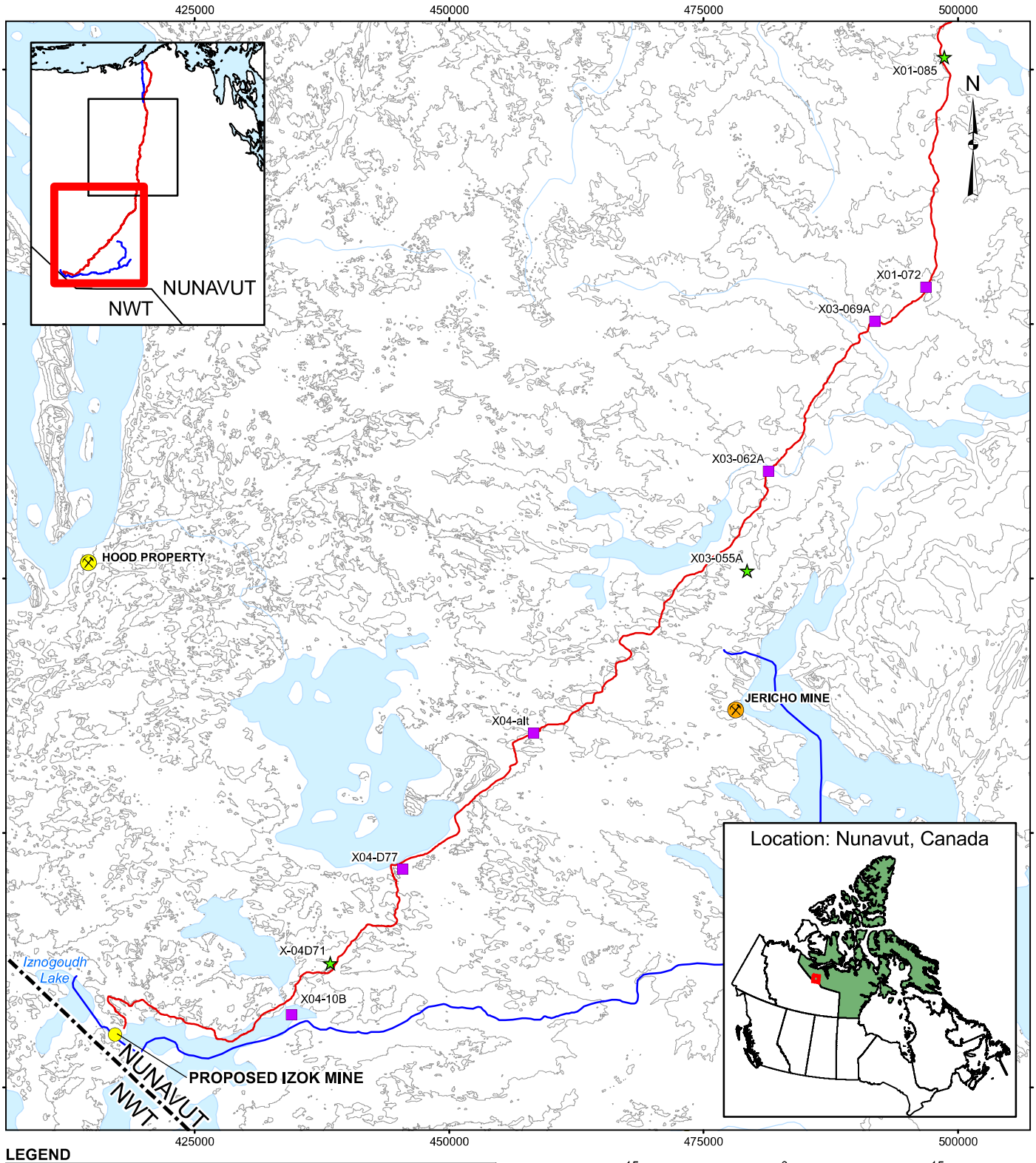

LEGEND

- MMG MINING PROPERTY
- OTHER MINING PROPERTY
- PROPOSED IZOK MINE

SAMPLING STATIONS

- WATER QUALITY
- WATER AND SEDIMENT QUALITY
- OPTIMUM ROAD ALIGNMENT (2012)
- WINTER ROAD ALIGNMENT (2012)
- CONTOURS 50 m
- WATERCOURSE
- WATERBODY
- TERRITORIAL BOUNDARY

15 0 15

SCALE 1:550,000 KILOMETRES

REFERENCE

HYDROGRAPHY AND CONTOUR DATA FROM NATIONAL TOPOGRAPHIC DATABASE (NTDB) PROVIDED BY THE GOVERNMENT OF CANADA.
DATUM: NAD83 PROJECTION: UTM ZONE 12

PROJECT
MMG | MINERALS AND METALS GROUP

IZOK CORRIDOR PROJECT

TITLE
WATER AND SEDIMENT QUALITY SAMPLING STATIONS ON IZOK ROAD CORRIDOR

Golder Associates

PROJECT		12-1373-0020	FILE No.	
DESIGN	CP	30 Apr. 2012	SCALE AS SHOWN	REV. 0
GIS	SK	23 Nov. 2012		
CHECK	CP	23 Nov. 2012		
REVIEW	ZK	23 Nov. 2012		

FIGURE: 1-3B

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2.0 METHODS

Maps of the study area, in relation to changes in the proposed footprint, were reviewed before designing the field sampling program. Access to the mine area sampling stations was via helicopter and boat from the Ham Lake camp. Access to the watercourse crossings along the road corridor was via helicopter from Ham Lake and High Lake camps.

2.1 Izok Mine Lakes and Streams

Various lakes and streams in the vicinity of the proposed Izok Mine were sampled to collect information about spatial and temporal variability in water quality and spatial variability in sediment quality. The study was designed to collect water samples from lakes during winter/under-ice conditions (May 2012), spring/open-water conditions (July 2012), and summer/open-water conditions (August 2012). Not all lakes were sampled during all months. Streams were sampled during two open-water periods (July and August). Not all streams were sampled during both months. Lakes and streams were sampled for sediments in one open-water month (August 2012). The stations sampled in 2012, along with coordinates and samples collected are listed by watershed in Table 2-1.

Table 2-1: Water and Sediment Quality Sampling Stations at Izok

Watershed	Station Type	Station Number	NAD 83, 12W		Water Quality			Sediment Quality
			Easting (m)	Northing (m)	May-12	Jul-12	Aug-12	Aug-12
Itchen	Stream	D101	407246	7263491	-	Surface	Surface	Not collected[a]
		D301	418260	7280067	-	Surface	Surface	Not collected[a]
		D313	418313	7281129	-	Dry	-	-
		D315	418278	7281462	-	Dry	-	-
Izok		D401	416545	7281113	-	Surface	Surface	Not collected[a]
		D407	417599	7279732	-	Surface	-	-
		D422	416746	7279555	-	Surface	-	-
Iznogoudh		D501	412580	7286016	-	Surface	-	-
Reference Stream 1		RST1	434537	7281959	-	-	Surface	
Reference Stream 2		RST2	437940	7281040	-	-	Surface	
Itchen	Lake	L300-01	418968	7278998	Top, bottom	Top, bottom	Top, bottom	Surface[b]
		L300-02	419429	7280554	-	Top, bottom	Top, bottom	Surface
		L300-03	419696	7280817	Top, bottom	-	-	-
		L300-04	419888	7277748	Top, bottom	Top, bottom	Top, bottom	Surface
		L300-05	418605	7282229	Profile only	Top, bottom	-	-
		L300-06	420422	7279413	Top, bottom	Top, bottom	Top, bottom	Surface
		L300-07	418665	7273883	-	Top, bottom	Top, bottom	Surface
		L300-08	411531	7264940	Top, bottom	Top, bottom	Top, bottom	Surface

Table 2-1: Water and Sediment Quality Sampling Stations at Izok (cont.)

Watershed	Station Type	Station Number	NAD 83, 12W		Water Quality			Sediment Quality
			Easting (m)	Northing (m)	May-12	Jul-12	Aug-12	Aug-12
Itchen	Lake	L300-09	406725	7272360	Top, bottom	-	-	-
		L302	415695	7277314	-	Top	Top	-
		L304	418544	7277923	-	Top	-	-
		L313	417972	7281276	-	-	Top	Surface
		L314	417087	7282042	-	Top	-	-
		L316	416682	7284183	-	Top	-	-
		L317	416968	7283421	-	Top	-	-
		L339	417794	7278302	-	Top	-	-
Izok	Lake	L400-01	416496	7280722	Top, bottom	Top, bottom	Top, bottom	Surface
		L407	417805	7279442	-	Top	Top	Surface
		L409	417024	7279204	-	Top	-	-
		L410	417313	7280966	Frozen to bottom	Top	Top	Surface
		L411	418222	7280922	-	Top	Top	Surface
		L412	416560	7282445	Profile only	Top	-	-
		L414	416318	7282044	Frozen to bottom	Top	-	-
		L415	417143	7281224	Unsafe ice conditions	Top	Top	Surface
		L420	415377	7278977	-	Top	-	-
		L422	416437	7279552	-	Top	-	-
Iznogoudh		L500-03	415433	7281855	Top, bottom	Top, bottom	Top, bottom	Surface
		L500-04	414337	7281360	Top, bottom	Top, bottom	-	-
		L541	414148	7280373	-	-	Top	Surface
		L558	413623	7285866	Profile only	-	-	-
		L559	413868	7285598	Profile only	-	-	-
		L560	415965	7283223	Frozen to bottom	Top	-	-
Ham		L600-03	413245	7286323	Top	Top	Top	Surface
Reference Lake 3		R3	432168	7293404	Top, bottom	Top, bottom	Top, bottom	Surface[c]
-	QC	Blank	-	-	Yes (1)	Yes (2)	Yes (2)	-
-		Replicate	-	-	Yes (2)	Yes (4)	Yes (4)	Yes (2)

Note:
"-" = no sample collected; "D" = drainage or tributary; "L" = lake; "Top" = water sample collected at 1 m below the surface of the water; "Bottom" = water sample collected 1 m above the sediments.
[a] unable to collect sediments.
[b] surface sediments collected at 3.5 m and 11.5 m water depth.
[c] surface sediments collected at 3.5 m and 13 m water depth.
QC = quality control; number in parentheses indicates the number of QC samples collected during the particular sampling month.

2.1.1 Water Quality

At each sampling station, in situ measurements were taken for pH (pH units), specific conductivity (µS/cm, hereafter "conductivity"), dissolved oxygen (mg/L and % saturation), and temperature (°C) using a YSI multimeter. At the stream stations, readings were taken 10 cm below the water surface. At the lake stations, readings were taken as profiles through the water column. At lake stations less than 5 m deep, readings were taken at 0.5 m intervals, and at stations more than 5 m deep, readings were taken at 1 m intervals.

One water sample was collected at each of the tributary sampling stations. Water samples were collected at 10 cm below the water surface, directly in the bottles provided by the lab.

The number of water samples collected at each lake station depended on water depth. At lake stations less than 5 m deep, one sample was collected at 1 m below the water surface. At lake stations more than 5 m deep, two samples were collected: the top sample (T) was collected at 1 m below the water surface and the bottom sample (B) was collected at 1 m above the sediments. These samples were analyzed separately. A Kemmerer bottle with a length calibrated rope was used to collect the water samples. At each station, the Kemmerer was triple-rinsed with lake water and then lowered to the required depth, returned to the surface, and then used to fill the lab supplied sample bottles. The procedure was repeated until all required sample bottles were filled.

Water samples were submitted to ALS Environmental in Edmonton as soon as possible after collection for analysis of parameters. Parameters are discussed in more detail in Section 2.3.

2.1.1.1 Under-Ice Sampling

The procedures followed for under-ice sampling were similar to those used during the open water programs. A gas powered ice auger was used to drill holes through the ice and a slotted spoon was used to remove ice from the sampling hole. Water column profiles were measured before collecting water samples. The depth of the sampling station was measured as the distance from the top of the ice to the sediments. Water column profile measurements taken using a YSI multimeter were recorded at 1 m intervals, starting at 1 m below the ice surface. Streams were not sampled during this program because they were assumed to be frozen to the substrate.

A Kemmerer bottle was used to collect water samples at specific depths. At lake stations less than 5 m deep, one sample was collected at 1 m below the water surface. At lake stations more than 5 m deep, two samples were collected: the top sample (T) was collected at 1 m below the water surface and the bottom sample (B) was collected at 1 m above the sediments. These samples were analyzed separately. Samples were submitted to ALS Environmental in Edmonton as soon as possible after collection.

2.1.2 Sediment Quality

Bottom sediment samples were collected with an Ekman grab. Sediment was removed from the grab with a plastic trowel, taking care to remove sediment from the centre to avoid contamination from the metal sides of the grab. Sediment was placed in Whirl-Pak bags and frozen upon returning to camp. Sediments were submitted to ALS Environmental in Edmonton as soon as possible after collection. Parameters are discussed in more detail in Section 2.3.

2.2 Road Corridor Streams

Along the road corridor, 106 streams were identified, of which 10 were sampled for water quality, and four were sampled for water and sediment quality (Table 2-2). Procedures followed for measurement of in situ parameters and collection of water quality samples was the same as those used for sampling streams in the mine area. The streams along the proposed road were only sampled in August. At each sampling location, in situ measurements were taken and surficial sediment samples were collected using a push tube. Samples were submitted to ALS Environmental in Edmonton as soon as possible after collection. Parameters are discussed in more detail in Section 2.3.

Table 2-2: Water and Sediment Sampling Stations Along the Road Corridor

Station	Easting	Northing	Water and Sediment	Water only
X03-055A	479288	7325814	Yes	-
X03-062A	481366	7335568	-	Yes
X03-069A	491809	7350282	-	Yes
X01-072	496819	7353643	-	Yes
X01-085	498621	7376284	Yes	-
X01-094	500069	7408148	Yes	-
X01-104	502819	7425586	-	Yes
X01-115	509408	7451467	-	Yes
X03-123A-alt	509279	7467151	-	Yes
X01-130-alt	507439	7471091	-	Yes
X04-alt	458322	7309817	-	Yes
X-04D71	438346	7287245	Yes	-
X04-D77	445444	7296446	-	Yes
X04-10B	434503	7282161	-	Yes
QC-blank	-	-	-	Yes
QC-duplicate	-	-	-	Yes

2.3 Parameters

2.3.1 Water Quality

Samples collected from the Izok Lake and the road corridor areas were analyzed for a common set of parameters and results were compared to Canadian Council of Ministers of the Environment (CCME) guidelines for protection of aquatic life and Health Canada drinking water guidelines (Table 2-3).

Table 2-3: Water Quality Parameters, Detection Limits, and Guidelines

Parameter	Units	Detection Limit	Aquatic Life-Acute	Aquatic Life-Chronic	Drinking Water
			CCME[a]	CCME[a]	HC[b]
Field Measured					
pH	-	-	-	6.5 - 9.0	6.5 - 8.5
Conductivity	µS/cm	-	-	-	-
Dissolved oxygen	mg/L	-	-	6.5 – 9.5[c]	-
Dissolved oxygen	%	-	-	-	-
Conventional Parameters					
Conductivity	µS/cm	0.20	-	-	-
pH	-	0.10	-	6.5 - 9.0	6.5 - 8.5
Total alkalinity	mg/L	5.0	-	-	-
Gran alkalinity (as H+)	meq/L	0.10	-	-	-
Hardness ($CaCO_3$)	mg/L	-	-	-	-
Total dissolved solids	mg/L	3.0	-	-	500
Total suspended solids	mg/L	10	-	Narrative	-
Turbidity	NTU	0.10	-	-	-
Major Ions					
Bicarbonate	mg/L	5.0	-	-	-
Calcium	mg/L	0.5	-	-	-
Carbonate	mg/L	5.0	-	-	-
Chloride	mg/L	0.50	640	120	250
Fluoride	mg/L	0.050	-	0.12	1.5
Hydroxide	mg/L	5.0	-	-	-
Magnesium	mg/L	0.1	-	-	-
Potassium	mg/L	0.1	-	-	-
Sodium	mg/L	1	-	-	200
Sulphate	mg/L	0.050	-	-	500
Nutrients and Biological Indicators					
Nitrate + nitrite	mg-N/L	0.0060	-	-	-
Nitrate	mg-N/L	0.0060	124	2.93	10
Nitrite	mg-N/L	0.0020	-	0.06	1
Nitrogen - ammonia	mg-N/L	0.0050	-	26.33[d]	-
Nitrogen - Kjeldahl	mg-N/L	0.050	-	-	-
Phosphorus - total	mg-P/L	0.0010	-	-	-
Phosphorus - dissolved	mg-P/L	0.0010	-	-	-
Phosphorus - ortho (PO_4)	mg-P/L	0.0010	-	-	-
Silicon (as SiO_2)	mg/L	0.21	-	-	-
Dissolved organic carbon	mg/L	1.0	-	-	-

Table 2-3: Water Quality Parameters, Detection Limits, and Guidelines (cont.)

Parameter	Units	Detection Limit	Aquatic Life-Acute	Aquatic Life-Chronic	Drinking Water
Total organic carbon	mg/L	1.0	-	-	-
Coliforms					
Fecal coliforms	CFU/mL	1	-	-	-
Cyanide					
Cyanide	mg/L	0.0020	-	0.005	0.2
Total Metals					
Aluminum	mg/L	0.00030	-	0.1[d]	0.1
Antimony	mg/L	0.000020	-	-	0.006
Arsenic	mg/L	0.000020	-	0.005	0.01
Barium	mg/L	0.000050	-	-	1
Beryllium	mg/L	0.000010	-	-	-
Bismuth	mg/L	0.000010	-	-	-
Boron	mg/L	0.0010	29	1.5	5
Cadmium	mg/L	0.0000050	-	0.000005[d]	0.005
Calcium	mg/L	0.020	-	-	-
Chromium	mg/L	0.000060	-	0.001	0.05
Cobalt	mg/L	0.000010	-	-	-
Copper	mg/L	0.00010	-	0.002[d]	1
Iron	mg/L	0.0010	-	0.3	0.3
Lead	mg/L	0.000010	-	0.001[d]	0.01
Lithium	mg/L	0.00050	-	-	-
Magnesium	mg/L	0.0040	-	-	-
Manganese	mg/L	0.000050	-	-	0.05
Mercury	mg/L	0.000020	-	0.000026	0.001
Molybdenum	mg/L	0.000050	-	0.073	-
Nickel	mg/L	0.000060	-	0.025[d]	-
Potassium	mg/L	0.020	-	-	-
Selenium	mg/L	0.000040	-	0.001	0.01
Silver	mg/L	0.0000050	-	0.0001	-
Sodium	mg/L	0.0050	-	-	-
Strontium	mg/L	0.000050	-	-	-
Thallium	mg/L	0.000010	-	0.0008	-
Tin	mg/L	0.000050	-	-	-
Titanium	mg/L	0.00010	-	-	-
Uranium	mg/L	0.000010	0.033	0.015	0.02
Vanadium	mg/L	0.000050	-	-	-
Zinc	mg/L	0.00080	-	0.03	5

Table 2-3: Water Quality Parameters, Detection Limits, and Guidelines (cont.)

Parameter	Units	Detection Limit	Aquatic Life-Acute	Aquatic Life-Chronic	Drinking Water
Dissolved Metals					
Aluminum	mg/L	0.00030	-	-	-
Antimony	mg/L	0.000020	-	-	-
Arsenic	mg/L	0.000020	-	-	-
Barium	mg/L	0.000050	-	-	-
Beryllium	mg/L	0.000010	-	-	-
Bismuth	mg/L	0.000010	-	-	-
Boron	mg/L	0.0010	-	-	-
Cadmium	mg/L	0.0000050	-	-	-
Calcium	mg/L	0.020	-	-	-
Chromium	mg/L	0.000060	-	-	-
Cobalt	mg/L	0.000010	-	-	-
Copper	mg/L	0.00010	-	-	-
Iron	mg/L	0.0010	-	-	-
Lead	mg/L	0.000010	-	-	-
Lithium	mg/L	0.00050	-	-	-
Magnesium	mg/L	0.0040	-	-	-
Manganese	mg/L	0.000050	-	-	-
Mercury	mg/L	0.000020	-	-	-
Molybdenum	mg/L	0.000050	-	-	-
Nickel	mg/L	0.000060	-	-	-
Potassium	mg/L	0.020	-	-	-
Selenium	mg/L	0.000040	-	-	-
Silicon	mg/L	0.100000	-	-	-
Silver	mg/L	0.0000050	-	-	-
Sodium	mg/L	0.0050	-	-	-
Strontium	mg/L	0.000050	-	-	-
Thallium	mg/L	0.000010	-	-	-
Tin	mg/L	0.000050	-	-	-
Titanium	mg/L	0.00010	-	-	-
Uranium	mg/L	0.000010	-	-	-
Vanadium	mg/L	0.000050	-	-	-
Zinc	mg/L	0.00080	-	-	-

Note:
"-" = not available.
[a] CCME (2012a).
[b] Health Canada (2012).
[c] For cold-water species: minimum value of 6.5 mg/L for life stage other than early and 9.5 mg/L for early life stages.
[d] Guidelines based on pH of 6.5, water temperature of 10, and water hardness of 11 mg/L.

Hardness is a measure of the sum of cations present in the water, mostly calcium and magnesium, and is expressed as mg/L equivalent of calcium carbonate ($CaCO_3$). Hardness is important because the calcium ion plays an important physiological role in the toxicity of metals: toxicity usually increases as hardness decreases. A qualitative scale of water hardness is provided in Table 2-4. This scale was used to describe hardness of surface water in the study area. The hardness value of each water sample was used to compare concentration of select metals (e.g., cadmium, copper) to the CCME guideline.

Table 2-4: Water Hardness Scale

Hardness scale	Hardness (mg $CaCO_3$/L)
Very soft	0-30
Soft	31-60
Moderately soft	61-120
Hard	121-180
Very hard	>180

After McNeely et al (1979).

Alkalinity of water is a measure of the water's ability to neutralize acids, and it is closely related to water hardness. If alkalinity is high, pH will remain constant despite the addition of acid, while if alkalinity is low, pH will be sensitive to the addition of acid. Alkalinity can also influence the form, or speciation, or trace metals in water, which may alter their toxicities. The three major ions that contribute to alkalinity include bicarbonate (HCO_3^-), carbonate (CO_3^{2-}) and hydroxide (OH^-). Relative scales of acid sensitivities for lakes (Table 2-5) and streams (Table 2-6) were used to evaluate surface water in the study area.

Table 2-5: Lake Acid Sensitivity Scale

Acid Sensitivity	Alkalinity (mg $CaCO_3$/L)
High	0-10
Moderate	10-20
Low	20-40
Least	>40

After Safran and Trew (1996).

Table 2-6: Stream Acid Sensitivity Scale

Acid Sensitivity	Alkalinity (mg $CaCO_3$/L)
Acidic	<0
Highly Sensitive	0-2.5
Sensitive	2.6-10
Not Sensitive	>10

After Boward et al. (1999).

Phosphorus is an important nutrient that influences aquatic productivity. Trophic classification of lakes and streams is usually related to total phosphorus concentration in the water. The relative scale in Table 2-7 was used to describe trophic status of surface waters in the study area.

Table 2-7: Trophic Classification of Lakes and Streams

Trophic Status	Total Phosphorus (mg/L)	
	Lakes[a]	Streams[b]
Ultra-oligotrophic (very nutrient poor)	<0.004	n/a
Oligotrophic (nutrient poor)	0.004-0.01	<0.025
Mesotrophic (containing a moderate level of nutrients)	0.01-0.02	0.025-0.075
Meso-eutrophic (containing moderate to high levels of nutrients)	0.02-0.035	n/a
Eutrophic (nutrient rich)	0.035-0.1	>0.075
Hypereutrophic (very nutrient rich)	>0.1	na

[a] CCME (2004).

[b] Dodds et al. (1998).

2.3.2 Sediment Quality

Samples collected from the Izok Lake and the road corridor areas were analyzed for a common set of parameters and results were compared to CCME sediment quality guidelines for the protection of aquatic life (Table 2-8).

Table 2-8: Sediment Quality Parameters, Detection Limits, and Guidelines

Parameter	Units (dry wt.)	Detection Limit	CCME ISQG[a]	CCME PEL[a]
Physical Tests				
Moisture	%	0.10	-	-
Organic Matter	%	1.0	-	-
Loss on Ignition at 375°C	%	1.0	-	-
Particle Size				
Gravel (>2 mm)	%	0.10	-	-
Course Sand (2.0 mm - 0.2 mm)	%	0.10	-	-
Fine Sand (0.2 mm - 0.063 mm)	%	0.10	-	-
Silt (0.063 mm - 4 µm)	%	0.10	-	-
Clay (<4 µm)	%	0.10	-	-
Saturated Paste Extractables				
pH	pH	0.10	-	-
Metals				
Aluminum	mg/kg	50	-	-
Antimony	mg/kg	0.10	-	-
Arsenic	mg/kg	0.10	5.9	17
Barium	mg/kg	1.0	-	-

Table 2-8: Sediment Quality Parameters, Detection Limits, and Guidelines (cont.)

Parameter	Units (dry wt.)	Detection Limit	CCME ISQG[a]	CCME PEL[a]
Beryllium	mg/kg	0.50	-	-
Bismuth	mg/kg	1.0	-	-
Cadmium	mg/kg	0.10	0.6	3.5
Calcium	mg/kg	100	-	-
Chromium	mg/kg	0.50	37.3	90
Cobalt	mg/kg	1.0	-	-
Copper	mg/kg	1.0	35.7	197
Iron	mg/kg	50	-	-
Lead	mg/kg	1.0	35	91.3
Lithium	mg/kg	2.0	-	-
Magnesium	mg/kg	100	-	-
Manganese	mg/kg	1.0	-	-
Mercury	mg/kg	0.0050	0.17	0.486
Molybdenum	mg/kg	1.0	-	-
Nickel	mg/kg	1.0	-	-
Phosphorus	mg/kg	50	-	-
Potassium	mg/kg	100	-	-
Selenium	mg/kg	0.20	-	-
Silver	mg/kg	0.20	-	-
Sodium	mg/kg	100	-	-
Strontium	mg/kg	1.0	-	-
Thallium	mg/kg	0.10	-	-
Tin	mg/kg	2.0	-	-
Titanium	mg/kg	5.0	-	-
Uranium	mg/kg	0.10	-	-
Vanadium	mg/kg	1.0	-	-
Zinc	mg/kg	5.0	123	315

Note:
"-" = not available; "ISQG" = interim sediment quality guidelines; "PEL" – probable effect level.
[a] CCME (2012b).

3.0 QUALITY ASSURANCE AND QUALITY CONTROL

This section provides a review of quality control (QC) procedures; additional details of the QC program are provided in Appendix A.

Standard quality assurance/quality control (QA/QC) procedures were followed and included the following:

- using only laboratory supplied bottles;
- preserving samples (when required) with lab provided, pure, pre-measured preservatives;
- filtering samples (when required) in the lab in a clean area, minimizing dust;
- wearing nitrile gloves;
- collecting blank and replicate samples; and
- labelling, storing, and shipping samples according to relevant protocols.

3.1 Quality Control Results

This section provides a summary of QC results; additional details are provided in Appendix A.

3.1.1 Blanks

In total, five blank samples were collected in the mine study area, and one blank was collected in the road study area.

The blank data were reviewed for parameters with concentrations reported at more than or equal to five times the detection limit. Thirteen parameters were detected at least once in the six blank samples at concentrations more than five times the detection limit. Of those 13 parameters, concentrations of four parameters (total and dissolved boron, and total and dissolved tin) had the highest reported concentrations in the blank samples compared to the test samples. Contamination of lab provided distilled water is suspected. Results for these four parameters should be used with caution.

3.1.2 Replicates

In total, six sets of replicate samples were collected in the mine study area, and two sets of replicate samples were collected in the road study area.

Concentrations of total copper, total iron, total titanium, dissolved iron, dissolved manganese, and dissolved zinc were considered to be notably different in one replicate sample set each. Dissolved boron was considered to be notably different in two replicate sample sets. In total, seven parameters out of 91 were considered to be notably different. Overall, analytical precision is rated as high because less than 10% of parameters were notably different from one another.

4.0 RESULTS – IZOK

This section presents water and sediment quality results for lakes and streams in the Izok Lake study area. This section provides a summary of results; detailed results are provided in Appendix B (field data), Appendix C (water quality data), and Appendix D (sediment quality data).

4.1 Water Quality – Streams

Water quality results for streams in the mine study area are discussed together, rather than separated by watershed, to provide an understanding of stream water quality in the general mine study area. Results are discussed in relation to field parameters, general chemistry, nutrients and total metals, relative to qualitative ratings (e.g., hardness, productivity, as reviewed in the methods), and relative to water quality guidelines. Values that exceed guidelines are reviewed below, as well as any streams that appear different or unique. Field data are summarized in Section 4.1.1. Complete water quality analytical results for streams can be found in Appendix C, Table C-1. Sediment was not collected from the streams in the mine area.

4.1.1 Field Data – Streams

Field water quality results for the streams are provided in Table 4-1. All streams were sampled in both July and August except for the following:

- D407, D422, and D501 were sampled in July only for logistical reasons;
- RST1 and RST2 were sampled in August because they were not identified until after the July program; and
- D313 and D315 were not sampled in July because the watercourses were dry. They were not visited during the August program as it was assumed that they would still be dry.

Stream water was slightly warmer in August compared to July and pH was lower in August compared to July at site D401, but slightly higher at site D101 (Table 4-1). Field conductivity was very low and ranged from 11 to 31 µS/cm in the complete dataset, and was similar between months (e.g., D101 and D401; Table 4-1). Conductivity was similar between months at stations where data exist (e.g., D101, D401). Dissolved oxygen was high in all samples and was above the aquatic life guidelines, except for site D422, where it was below the guideline of 9.5 mg/L for the protection of early life stages for cold-water biota (CCME 2012a).

Table 4-1: Field Water Quality Data for Streams in the Izok Area (July and August 2012)

Stream	Temperature (°C)		pH		Conductivity (µS/cm)		Dissolved Oxygen (mg/L)[a]	
	Jul-12	Aug-12	Jul-12	Aug-12	Jul-12	Aug-12	Jul-12	Aug-12
D101	13.2	13.9	5.6	5.8	16	15	11.2	12.6
D301	17.6	17.5	5.7	5.6	12	12	10.6	11.7
D401	9.7	15.6	6.2	4.9	12	12	10.3	9.8
D407	16.8	-	6.0	-	31	-	9.8	-
D422	14.7	-	6.1	-	20	-	6.6	-
D501	19.0	-	5.8	-	11	-	9.8	-
RST1	-	11.4	-	5.0	-	20	-	9.6
RST2	-	11.3	-	5.8	-	14	-	11.0

Note:
"-" = not sampled.
[a] Dissolved oxygen guideline for cold water freshwater biota is 9.5 mg/L for early life stages and 6.5 mg/L for other life stages (CCME 2012a).

4.1.2 General Chemistry

Of the parameters included under general chemistry (physical parameters and major ions), only pH has a guideline. All streams had pH values less than 6.5 in July and August, indicating potential acidic stress to biota in these tributaries under baseline conditions (Table 4-1). From all stream samples (July and August combined), field pH ranged from 4.9 to 6.2 and averaged 5.8, and lab pH ranged from 6.5 to 6.9 and averaged 6.8. No month-to-month trends are discernible from these data.

Stream water was very soft, with hardness values ranging from 3.4 to 10.1 mg/L as $CaCO_3$ (average of 5.2 mg/L for all data). All streams are rated as acidic to acid sensitive, as none had detectable total alkalinity and only two had detectable Gran alkalinity (D401-August, and D422-July).

Cyanide was not detected in any samples, and average sulphate concentration was less than 3 mg/L.

The general chemistry in most of the tributaries was similar, with site D407 showing slightly higher conductivity.

4.1.3 Nutrients

The streams are rated as oligotrophic in both July and August. In most streams, the concentration of total phosphorus (TP) was very low (average of all samples was 0.004 mg/L), and approximately half of the TP was dissolved phosphorus (average of all samples was 0.002 mg/L); the remainder was particulate phosphorus (dissolved P + particulate P = total P).

Ammonia concentrations were low and did not exceed the guideline for un-ionized ammonia. The average values of ammonia and nitrite were less than the detection limit (<0.005 mg/L and <0.002 mg/L, respectively) in both July and August. Average nitrate was also low in both months, at less than 0.014 mg/L for all data. Total Kjeldahl nitrogen (TKN), a measure of organic nitrogen and ammonia, was also low (<0.2 mg/L in July and August). The highest concentrations of TKN (0.2 mg/L) were recorded in D407 (August) and D101 (August), whereas the highest concentration of nitrate (0.046 mg/L) was recorded in D422 (July).

Total organic carbon (TOC) and dissolved organic carbon (DOC) were, on average, low (<5 mg/L), except for site D407, which had higher concentrations (6 mg/L) compared to other stations.

4.1.4 Metals

Total and dissolved metals were analyzed in all samples. Concentrations of arsenic, chromium, lead, mercury, molybdenum, nickel, and silver in stream samples did not exceed aquatic life guidelines; however, guidelines were exceeded for cadmium (D422), copper (D422), and iron (D407).

Total cadmium exceeded the aquatic life guideline at D301 (both samples), D407, and D422. Most of the metal (90%) was in the dissolved form.

Total copper exceeded the aquatic life guideline at D422. Most of the copper (94%) was in the dissolved form.

The highest concentrations of many metals were restricted to the following two samples:

- D422 – aluminum, cadmium, copper, and zinc
- D407 – arsenic, barium, lead, iron, manganese, and strontium

4.2 Water Quality – Large Lakes

This section provides a review of water quality of the large lakes in the mine area. The results are reviewed by parameter group (i.e., field profiles, general chemistry, nutrients, and metals), to provide a summary of lake water quality for larger lakes in the general mine area. Results are reviewed in relation to qualitative ratings (e.g., hardness, productivity, as reviewed in the methods) and guidelines (Table 2-3). Values that exceed guidelines and lakes that appear different or unique are highlighted. Complete water quality analytical data are provided in Appendix C, Table C-2.

The lake sampling program included three campaigns in 2012: May (late winter/under-ice), July (spring/open-water), and August (summer/open-water). Due to minor changes before and during the various field campaigns, not all lakes were sampled during all three events (Table 2-1). The sampling effort is summarized as follows:

- lake stations that were sampled in May, July, and August include L300-01, L300-04, L300-06, L300-08, L400-01, L500-03, L600-03, and R3;
- lake station L500-04 was sampled in May and July;
- lake stations L300-02 and L300-07 were sampled in July and August; and
- lake stations L300-03, L300-05, and L300-09 were sampled once on an opportunistic basis.

4.2.1 Field Data

General physical measurements at each lake sampling station are provided in Table 4-2, and lake profile data are provided in Appendix B, Tables B-1 to B-5. Every attempt was made to sample at the same locations each time, but depending upon wind conditions, the boat could drift during the collection of water column profile data. As a result, final water depth at each station differed among sampling events.

Among all stations in the larger lakes, only the station in Ham Lake (L600-03) was less than 4 m deep (Table 4-2). The station at Ham Lake was 2.4 m deep, with approximately 1.5 m of ice. Ice thickness on the larger lakes ranged between 1.1 to 1.8 m.

In July and August, Secchi depth was recorded along with total depth to obtain an understanding of transparency or clarity of the water column (Table 4-2; Figure 4-1). Transparency as measured by Secchi depth was more than 80% of the total depth at many stations (e.g., L300-01, L330-04, L500-04, L600-03), and was less than 50% at stations where water depth was greater than 25 m (L300-06, L300-07, R3).

Table 4-2: Physical Measurements of the Larger Lakes in 2012

Lake	Station Code	May		July		August	
		Total Depth (m)[a]	Thickness of ice (m)	Total Depth (m)	Secchi Depth (m)	Total Depth (m)	Secchi Depth (m)
Itchen Lake	L300-01	10.2	1.4	7.5	7.2	10.0	8.5
Itchen Lake	L300-02	-	-	14.5	7.2	14.5	9.5
Itchen Lake	L300-03	13.9	1.6	-	-	-	-
Itchen Lake	L300-04	8.2	1.5	8.5	7.0	8.5	8.5
Itchen Lake	L300-05	13.8	1.7	10.0	7.0	-	-
Itchen Lake	L300-06	33.2	1.1	>30.0[c]	8.0	34.0	7.7
Itchen Lake	L300-07	-	-	>30.0[c]	9.0	34.0	10.0
Itchen Lake	L300-08	21.3	1.2	22.0	11.0	23.0	11.0
Itchen Lake	L300-09	18.0	1.1	-	-	-	-
Izok Lake	L400-01	13.3	1.5	14.0	[b]	14.0	7.0
Iznogoudh Lake	L500-03	9.7	1.2	13.5	7.8	11.0	8.0
Iznogoudh Lake	L500-04	7.3	1.2	8.5	8.5	-	-
Ham Lake	L600-03	2.4	1.5	3.0	3.0	3.2	3.2
Reference Lake	R3	25.2	1.8	25.0	10.2	27.0	9.0

Note:
"-" not sampled.
[a] Total depth was from ice surface to the top of the sediments.
[b] Not recorded.
[c] Total depth was not recorded but it was assumed to be more 30 m as based on profile readings, field notes, and total depth recorded in August.

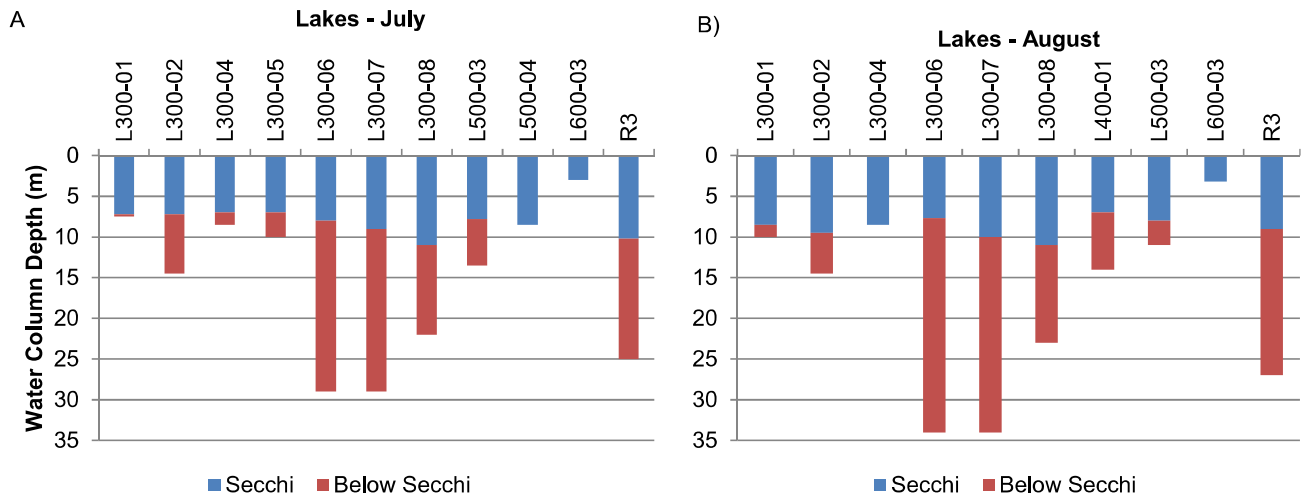

Figure 4-1: Water Column Depth and Secchi Depth in Large Lakes (July and August)

4.2.2 General Chemistry

Ham Lake

In Ham Lake, one water sample was collected at 1 m below the water surface from one station in both July and August, and just below the ice in May. Complete analytical results are in Appendix C, Table C-2. Field pH was below the guideline value of 6.5 at each sampling period, but lab measured pH was within the guideline. Conductivity and total dissolved solids (TDS) were higher in May (44 µS/cm and 30 mg/L, respectively) as compared to July and August. (conductivity of 9 to 12 µS/cm and TDS of 3 mg/L). Total suspended solids (TSS) and turbidity were higher in May (36 mg/L and 36 NTU, respectively), and not detectable (TSS) or near the detection limit (turbidity) during the summer. On a microequivalent basis of the measured cations and anions, calcium and magnesium were the dominant cations, and bicarbonate was the dominant anion.

Iznogoudh Lake

Two stations were sampled in Iznogoudh Lake. At station L500-03, a top sample and a bottom sample were collected in each of May, July, and August. At station L500-04, top and bottom samples were collected in May and July. Complete analytical data are in Appendix C, Table C-2. In total, 10 samples were collected from Iznogoudh Lake.

Field measured pH ranged from 4.7 to 6, while lab measured pH ranged from 6.7 to 7., Turbidity (0.1 to 0.4 NTU), TSS (<3 mg/L in all samples), alkalinity (<4 to 5 mg/L), and hardness (3.6 to 6.1 mg/L) were similar across all samples collected from this lake. The TDS concentration was higher in the May samples than in the July and August samples.

Iznogoudh Lake is a very soft water lake with high sensitivity to acid deposition. On a microequivalent basis of the measured cations and anions, calcium and magnesium were the dominant cations, and bicarbonate was the dominant anion. Chloride was not detected.

Izok Lake

One station was sampled in Izok Lake (L400-01), and samples were collected from the top and bottom in May, July, and August. Complete analytical data are presented in Appendix C, Table C-2. In total, there are six samples from Izok Lake.

Field measured pH varied by season, with lowest values in May, and highest values in July at the surface, and highest values in August at the bottom; lab measured pH ranged between 6.7 and 7 across all samples. Conductivity was low (maximum value of 14 µS/cm). TSS was not detected in any samples. Total alkalinity was not detected in the samples, but Gran alkalinity was detected in the surface sample from August. TDS were more variable in the top samples (3 to 21 mg/L) as compared to the bottom samples (<10 to 12 mg/L).

Izok Lake is a very soft water lake with high sensitivity to acid deposition. The dominant cations were calcium and magnesium (based on microequivalents). The only measureable anion was sulphate.

Itchen Lake

Nine stations were sampled in Itchen Lake, and top and bottom water samples were collected at all stations, for a total of 58 samples (Table 2-1). Complete analytical data are presented in Appendix C, Table C-2.

In all samples, field-measured pH was less than 6.5, but lab-measured pH was between 6.3 and 7.1. The pH generally increased throughout the year at all sites, with the lowest values usually measured under ice in May, and the highest usually measured in August. Across all stations, lab-measured conductivity was higher in May (average 26 µS/cm) as compared to July and August (average 14 µS/cm). There was little to no difference in TDS and TSS between top and bottom samples collected at any station. At most stations, conductivity and TDS were higher in both the top and bottom samples collected in July and August than in May. Turbidity was less than 0.5 NTU at all sites.

Lake water was very soft (hardness less than 10 mg/L), sensitive to acid deposition (alkalinity less than 10 mg/L), with very little seasonal variability in these parameters. The dominant cations were calcium and magnesium, and the dominant anion was sulphate, as bicarbonate and chloride were less than the detection limit in most samples (bicarbonate was detected in three samples from May [L300-01, L300-04, and L300-09]; chloride was detected in two samples from August [L300-06-T, L300-08-T]).

Reference Lake

One station was sampled on the reference lake (R3) where top and bottom water samples were collected in May, July, and August. Complete analytical data are presented in Appendix C, Table C-2.

The reference lake had general water chemistry very similar to the lakes in the Izok mine area. Conductivity was low (6 to 16 µS/cm), field-measured pH was acidic (4.7 to 6.1), lab-measured pH was close to neutral (6.6 to 7), and TDS, TSS and turbidity were low. The lake is classified as very soft, with high sensitivity to acid deposition. The dominant cations were calcium and magnesium, and the dominant anion was sulphate; bicarbonate was only detected in two of the bottom samples (May and August). There were very few and minor differences in water chemistry between the top and bottom samples, or between May, July, and August.

4.2.3 Nutrients

Ham Lake

Based on TP, Ham Lake is classified as oligotrophic, although it is classified as mesotrophic based on under ice concentrations (0.016 mg/L) (Appendix C, Table C-2). Less than half of the detectable phosphorus was in the dissolved form, and no inorganic phosphorus (i.e., ortho-phosphate) was detected. There were also no detectable concentrations of inorganic nitrogen (i.e., ammonia, nitrate, and nitrite) during the summer months, while ammonia was 0.436 mg/L under the ice in May. TKN was detected and was primarily organic nitrogen in summer, since ammonia was not recorded in the samples (<0.005 mg/L), while under ice, ammonia was a dominant portion of TKN (>50%). Total organic carbon was low (8 mg/L or less) and was primarily in the dissolved phase, as DOC was near equivalent to TOC.

Iznogoudh Lake

Iznogoudh Lake is ultra-oligotrophic, with less than half to all of the detectable phosphorus in the dissolved form and no detectable inorganic phosphorus in any samples (Appendix C, Table C-2). Ammonia was only detected in the under ice (May) samples, nitrate was detected in all samples, whereas nitrite was not detected. In the top and bottom samples collected in May, the concentration of ammonia was slightly higher at the surface than at depth; no trends are apparent for nitrate. Un-ionized ammonia was less than the aquatic life guideline in all samples.

No observable trends were apparent for TKN, as concentrations ranged from 0.09 to 0.2 mg/L across all samples. Total organic carbon and DOC were detected in all samples; DOC was the dominant form of the TOC.

Izok Lake

Izok Lake is classified as ultra-oligotrophic to oligotrophic (0.002 to 0.004 mg TP/L), with no detectable inorganic phosphorus, and total phosphorus split almost equally between the particulate and the dissolved fractions (Appendix C, Table C-2). Ammonia was detected in the May under-ice samples (both top and bottom) (0.014 to 0.027 mg/L), and was not detected in samples from July and August. Due to very low concentrations of total ammonia and low water temperatures, calculated un-ionized ammonia was less than the CCME guideline. Nitrate was detected in both May samples (0.03 to 0.06 mg/L) and the July bottom sample (0.02 mg/L); nitrate was not detected in any other samples. Nitrite was not detected in any samples. TKN was detected in all samples (0.09 to 0.4 mg/L) and was highest in May in the bottom sample. Dissolved organic carbon ranged from 3 to 6 mg/L in samples.

Itchen Lake

Itchen Lake is also ultra-oligotrophic (<0.001 to 0.004 mg TP/L), with no detectable concentrations of inorganic phosphorus (except one sample from L300-06-T-July), and non-detectable to detectable concentrations of dissolved phosphorus (<0.001 to 0.003 mg TDP/L) (Appendix C, Table C-2). Due to very low concentrations of TP, there are no discernible spatial (vertical and horizontal) or temporal trends in phosphorus concentrations.

Ammonia concentrations ranged from non-detectable (<0.005 mg/L) to 0.018 mg/L; ammonia was detected in the May samples (both top and bottom samples) at all stations, the July sample from L300-02-B, and the August sample from L300-06-B. At all stations, ammonia was higher in the top sample than in the bottom sample. Due to very low concentrations of total ammonia and low water temperatures, calculated un-ionized ammonia was less than the CCME guideline.

Nitrite was not detected in any sample, and nitrate ranged from <0.006 to 0.052 mg/L. Nitrate was detected in most of the May samples, plus in samples from L300-06, L300-07, and L300-08 in July and August. There were some spatial trends in the detectable concentrations of nitrate. Nitrate was detected in all months at L300-08 and L300-09, and in May and August in L300-07 and L300-05, with the highest concentrations generally observed in L300-06, L300-07, L300-08, and L300-09 (L300-06 had the highest single point concentration at 0.052 mg/L).

There were no apparent trends in TKN across sampling months (<0.05 to 0.7 mg/L). At some sites, TKN decreased over time (L300-02, L300-07), at other stations TKN increased (L300-08), and at some stations there were no changes in TKN (L300-01, L300-04, L300-06). TKN was highest (0.07 mg/L) at L300-07 (bottom sample, July) and lowest (<0.05 mg/L) at L300-04 (bottom sample, August).

Total organic carbon was low (maximum = 6 mg/L) and was predominantly in the dissolved form.

Reference Lake

The reference lake is generally ultra-oligotrophic to oligotrophic (0.002 to 0.007 mg TP/L) (Appendix C, Table C-2). There was no detectable inorganic phosphorus, and total phosphorus was generally dominated by particulate phosphorus, except for the top sample taken in August and the bottom sample taken in May. Ammonia and nitrate were only detectable in the samples from May, and nitrite was not detectable in any sample. Total Kjeldahl nitrogen ranged from 0.07 to 0.2 mg/L, and was highest in July. Organic carbon was low (maximum value was 4 mg/L), and was predominantly in the dissolved form.

4.2.4 Metals

Ham Lake

Parameters that exceeded guidelines in Ham Lake included arsenic, cadmium, and iron (aquatic chronic guideline), and iron and manganese (drinking water guideline) (Appendix C, Table C-2). All of these metals exceeded guidelines in May, and cadmium also exceeded the guideline in August. No metals exceeded guidelines in July. For other metals, the recorded concentrations were below the guidelines.

Iznogoudh Lake

Of the 10 samples collected from Iznogoudh Lake, cadmium exceeded the aquatic life guideline in four samples: L500-03-B in May, and L500-03-T, L500-03-B, and L500-04 in July. Concentrations of all other metals were below the guidelines (Appendix C, Table C-2).

Izok Lake

Cadmium exceeded the aquatic life guideline in all samples from Izok Lake except L400-01-B in July. Concentrations of all other metals were below the guidelines (Appendix C, Table C-2).

Itchen Lake

Cadmium exceeded the guidelines in many samples from Itchen Lake, as summarized below:

- May: L300-01-T, L300-01-B, L300-03-T, L300-04-T, L300-04-B, L300-06-T;
- July: L300-01-T, L300-02-B, L300-04-B, L300-07-T, L300-08-T, L300-08-B; and
- August: L300-02-T, L300-02-B, L300-06-T, L300-06-B, L300-07-B, L300-08-T, L300-08-B.

Cadmium did not exceed guidelines in any of the samples collected at L300-05 and L300-09. Concentrations of all other metals were below the guidelines (Appendix C, Table C-2).

Reference Lake

Cadmium exceeded the aquatic life guideline in two samples (R3-B in May and R3-T in July) and manganese exceeded the drinking water guideline in one sample (R3-B in May). Concentrations of all other metals were below the guidelines (Appendix C, Table C-2).

4.3 Water Quality – Small Lakes

This section provides a summary of water quality of the small lakes in the mine area. The results are reviewed by parameter group (i.e., field profiles, general chemistry, nutrients and metals) to provide a summary of lake water quality for smaller lakes in the general mine area. Results are reviewed in relation to qualitative ratings (e.g., hardness, productivity, as reviewed in the methods) and guidelines (Table 2-3). Values that exceed guidelines are highlighted and lakes that appear different form others or unique are identified.

The lake sampling program included three campaigns in 2012: May (late winter/under-ice), July (spring/open-water), and August (summer/open-water). Due to minor changes before and during the various field campaigns, not all lakes were sampled during all three events (Table 2-1). The sampling effort is summarized as follows:

- only profiles were recorded from the shallow lakes in May;
- lake stations L302, L407, L410, L411, and L415 were sampled in July and August; and
- lake stations L304, L313, L314, L316, L317, L339, L409, L412, L414, L420, L422, L541, and L560 were sampled once on an opportunistic basis.

4.3.1 Field Data

General physical measurements at each lake sampling station are provided in Table 4-3, and lake profile data are provided in Appendix B. Every attempt was made to sample at the same locations each time, but depending upon wind conditions, the boat could drift during the collection of water column profile data. As a result, final water depth at each station differed among sampling events.

The smaller lakes are variable in depth, with measured depth at the sampling stations ranging from 0.8 m (L559 in May) to 11.5 m (L304 in July). Lakes less than 2 m deep (L410, L414, L559, L560) were frozen to the bottom during the May late winter program. Water was found below the ice at L412 and L414. Total depth recorded at L560 is different between the May and July programs. During the May program, only the shallow portion of the lake was drilled, and as a result, no water below the ice was found. During the July open water field program, a deeper pool was selected for sampling.

Lake L410, was sampled in all three months, and total recorded depth was never more than 1.5 m. Lake L559 was only sampled in May and total depth was less than 1 m. Lake L414 was sampled in May and July, and a deeper station was selected for the July program. Since total depth recorded during July was more than 2 m, it is possible that portions of this lake do not freeze to the bottom during the winter.

In July and August, Secchi depth was recorded along with total depth to obtain an understanding of transparency or clarity of the water column (Table 4-3; Figure 4-2). The entire water column was transparent in most of the

smaller lakes. The depth of L317 was recorded as 6.5 m in July with a Secchi depth of 3.7 m. In contrast, the depth of L412 was recorded as 8.5 m in July and was transparent to the bottom.

Table 4-3: Physical Measurements at the Small Lake Sampling Locations in 2012

Watershed	Station Code	May		July		August	
		Total Depth (m)[a]	Thickness of ice (m)	Total Depth (m)	Secchi Depth (m)	Total Depth (m)	Secchi Depth (m)
Itchen	L302	-	-	3.0	3.0	3.5	[b]
	L304	-	-	11.5	8.5	-	-
	L313	-	-	-	-	2.0	2.0
	L314	-	-	1.1	1.1	-	-
	L316	-	-	4.5	4.5	-	-
	L317	-	-	6.5	3.7	-	-
	L339	-	-	4.0	4.0	-	-
Izok	L407	-	-	4.5	4.5	4.5	4.5
	L409	-	-	5.0	3.5	-	-
	L410	0.9	0.9	1.0	1.0	1.5	1.5
	L411	-	-	0.5	-[b]	1.0	1.0
	L412	7.8	1.5	8.5	8.5	-	-
	L414	1.1	1.1	3.0	3.0	-	-
	L415	3.3	0.8	3.5	3.5	4.0	4.0
	L420	-	-	9.5	4.8	-	-
	L422	-	-	3.0	3.0	-	-
Iznogoudh	L541	-	-	-	-	7.0	4.0
	L559	0.8[c]	0.8	-	-	-	-
	L560	1.4	1.4	7.0	6.0	-	-

Note:
"-" = not sampled.
[a] Total depth was from ice surface to the bottom.
[b] Not recorded.
[c] Stopped drilling at 0.8 m due to broken auger, so actual depth may be deeper.

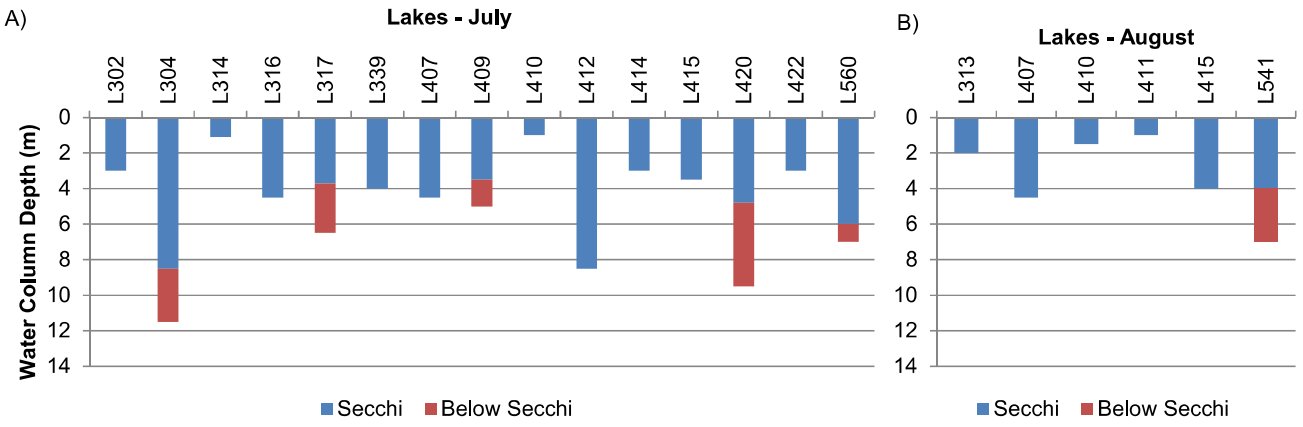

Figure 4-2: Water Column Depth and Secchi Depth in Small Lakes (July and August)

Field measured conductivity in July and August ranged from 14 to 457 µS/cm, with a mean of 86 µS/cm and median of 32 µS/cm. Temperatures were warm, ranging from 13.6 to 19.4°C (mean 17.0°C; median 17.2°C). The pH was very low at many sites (L313, L314, L412, L414, and L415), ranging from highly acidic 3.5 to near neutral 6.5, indicative of potential acid rock drainage. The mean pH was 5.4, and the median was 5.9. For the four sites sampled in both July and August (L407, L410, L411, and L415), there were no apparent trends for conductivity, temperature or pH.

Dissolved oxygen was high at all sites, ranging from 9.6 to 14.2 mg/L (mean 11.9 mg/L; median 11.9 mg/L). Water in these lakes was saturated or supersaturated with oxygen (99.2 to 146.6%; mean 122%; median 123%).

4.3.2 General Chemistry

Lab-measured conductivity in the small lakes (13 to 451 µS/cm) was higher than in the larger lakes (9 to 58 µS/cm). Total suspended solids concentrations were below detection limits at all sites, while TDS ranged from <10 mg/L to 287 mg/L. The highest concentrations of TDS were found at the sites with the lowest pH (i.e., pH <4.5). For example, in L313, lab pH was 3.8 and TDS was 287 mg/L, and in L314, lab pH was 4.4 and TDS was 113 mg/L. This indicates that the high acidity is leaching elements into the water. There were also samples with higher TDS (i.e., >70 mg/L) that had neutral pH.

Water at most lakes was very soft, while water at the highly acidic stations was soft (L314, L410, L412, and L414). Hardness at the most acidic station (L313, pH 3.5) was borderline between moderately soft and hard (hardness of 120 mg/L). Sixteen of the 18 lakes were highly sensitive to acid deposition, while two (L410, August sample; L411) were moderately sensitive.

The dominant cations were calcium and magnesium, and the dominant anion was sulphate. Bicarbonate was the dominant anion in only one sample (L411, July). The highest concentrations of sulphate were found at the stations with the lowest pH, confirming that sulphide oxidation (i.e., acid rock drainage) was the likely cause of the low pH. Fluoride exceeded guidelines at station L314 (0.24 mg/L).

4.3.3 Nutrients

Most lakes sampled were oligotrophic or ultra-oligotrophic (median TP was 0.004 mg/L). The exception was L410, which was mesotrophic (0.01 mg TP/L). There was no detectable inorganic phosphorus (ortho-phosphate)

at any station. Particulate phosphorus was the dominant form of TP (>50%) at all stations except L304 and L339, where TP was entirely in the dissolved phase. Ammonia and nitrate were not detected at most sites. Ammonia was detected at L313, L410 (August), and L411, and nitrate was detected at L314 and L410 (July). Nitrite was not detected at any station. TKN ranged from <0.05 to 0.6 mg/L (median equal to 0.2 mg/L), with the highest concentrations measured at L410 and L411.

Total organic carbon ranged from 2 to 12 mg/L (mean 5.3 mg/L; median 4.8 mg/L). DOC composed nearly all of the TOC at all sites except for L414, where it was two-thirds of the TOC.

4.3.4 Metals

Lab-measured pH values were used to determine the appropriate aluminum guideline to use for comparison to concentrations measured in the samples. Aluminum concentrations ranged from 0.0316 to 8.92 mg/L in the small lakes. Aluminum was above the guideline in the single samples collected from L304, L313, L314, and L412, and in both the July and August samples collected from L415 (Figure 4-3a). In all other samples, aluminum concentration was below the guideline.

Cadmium concentrations ranged from 0.000009 to 0.00187 mg/L (Figure 4-3b). Cadmium exceeded guidelines in all samples except at L411 in July. The cadmium guideline is dependent upon water hardness, and increases as water hardness increases. For each sample, exceedance of the guideline was calculated by comparing the measured cadmium concentration to a calculated guideline threshold using hardness measured in the same sample (CCME 2012a). Since water hardness in many lakes is very low, the cadmium guideline is also very low, and is close to the analytical detection limit.

Copper concentrations ranged from 0.0009 to 0.0353 mg/L, and the guideline was exceeded in most samples (Figure 4-3c). Copper did not exceed the guideline in the single samples from L316, L541, and L560, and in both July and August samples from L302. In L407, copper did not exceed the guideline in the August sample, but did exceed the guideline in the July sample. Iron ranged from 0.02 to 0.31 mg/L and exceeded the guideline in two samples: L313 and L541.

Lead concentrations ranged from <0.00001 to 0.0013 mg/L, and exceeded the guideline in one sample (L412) (Figure 4-3d). Manganese ranged from 0.0018 to 1.68 mg/L and exceeded the drinking water guideline in samples from L313, L314, L412, L414, and L415 (both July and August) (Figure 4-3e). Nickel concentrations ranged from 0.0005 to 0.128 mg/L and exceeded the guidelines in L313, L314, L412, and L414. Zinc exceeded guidelines at numerous sites (L313, L314, L412, L414, and L415) and ranged from <0.0008 to 1.07 mg/L (mean 0.125 mg/L; median 0.006 mg/L) (Figure 4-3f).

All other metals were below guidelines or below detection limits.

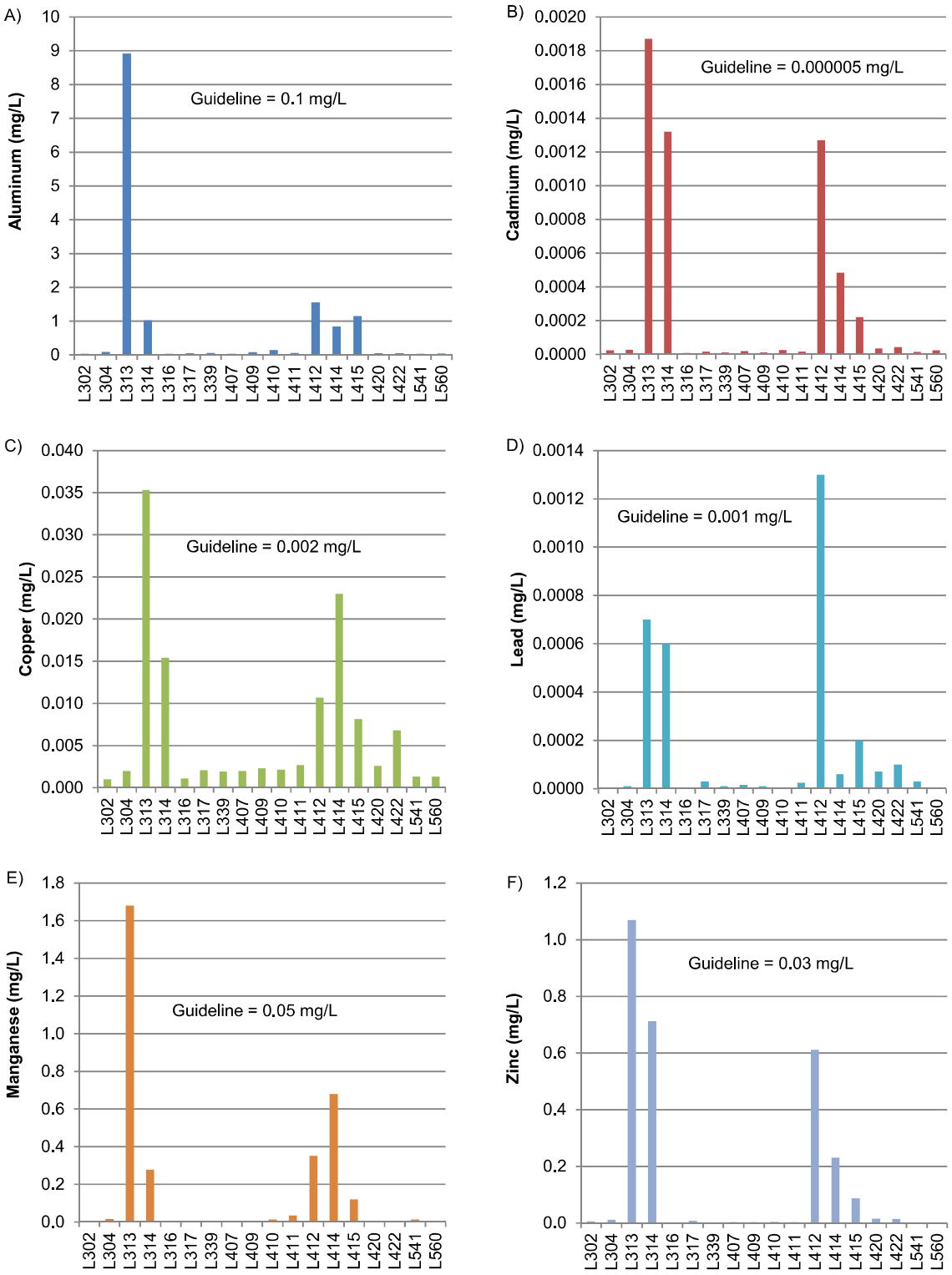

Figure 4-3: Concentrations of A) Aluminum, B) Cadmium, C) Copper, D) Lead, E) Manganese, and F) Zinc in Water in the Small Lakes

4.4 Sediment Quality – Lakes

Sediment quality results for the large and small lakes in the Izok mine study area are reviewed together. Complete results are provided in Appendix D, Table D-1 (large lakes) and Appendix D, Table D-2 (small lakes). Results are reported on a dry weight basis.

4.4.1 Physical Properties

Physical parameters of the sediments (moisture and organic matter) were similar in the large and small lakes, but on average, percent moisture and organic matter were higher in the small lakes compared to the larger lakes (Table 4-4). The dominant particle size in large and small lakes was silt, but in the small lakes, clay was the second most abundance particle size, while in the large lakes, fine sand and clay were equally abundant as the sub-dominant particle size.

Table 4-4: Sediment Quality (Physical Parameters and Particle Size) in Large and Small Lakes

Parameter	Large Lakes			Small Lakes		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Physical Tests						
Moisture (%)	76	83.2	79.7	81.5	89	85.7
Organic Matter (%)	4.8	23.1	10.4	13.8	21.6	18.3
Particle Size						
% Gravel (>2 mm)	0.6	0.7	0.6	0	0	0
% Course Sand (2.0 mm - 0.2 mm)	0.7	1.2	0.9	0.1	2.3	0.7
% Fine Sand (0.2 mm - 0.063 mm)	4.0	12.6	7.6	1.2	7.9	3.1
% Silt (0.063 mm - 4 um)	75.4	90.5	82.4	64.0	83.5	74.6
% Clay (<4 um)	2.9	13.1	7.2	6.8	32.5	22.1

Note:
"-" = not sampled.

4.4.2 Metals

Sediment pH was acidic at all lakes, ranging from 4.2 to 6.6 across large and small lakes.

Arsenic concentrations ranged from 6.75 to 165 mg/kg in the large lakes, and 4.55 to 26.8 mg/kg in the small lakes (Figure 4-4a). Concentrations exceeded the ISQG at every sampled lake except L313, where concentrations were less than the ISQG. In all other samples, arsenic concentrations either exceeded the ISQG or the PEL. Concentrations exceeded only the ISQG in four large lake samples (L300-01 at 3.5 m water depth, L300-04, R3 at both 3.5 m and 13 m water depths). In the small lakes, arsenic was above the ISQG but below the PEL in four samples: L410, L411, L415, and L541. There were eight samples from the large lakes, and one sample from the small lakes, where concentrations exceeded the PEL: L300-01 at 11 m water depth, L300-02, L300-06, L300-07, L300-08, L400-01, L500-03, L600-03, and L407.

Cadmium concentrations ranged from 0.11 to 0.55 mg/kg in the large lakes and 0.46 to 19.9 mg/kg in the small lakes (Figure 4-4b). All concentrations in the large lakes were below the ISQG. In the small lakes, concentrations in L407 and L541 were below the ISQG; concentrations in L410, L411, and L415 were above the ISQG but below PEL; and concentrations in L313 were above PEL.

Chromium concentrations ranged from 25.7 to 37.6 mg/kg in the large lakes and 14.3 to 62.4 mg/kg in the small lakes. None of the recorded concentrations exceeded the PEL. In the large lakes, concentrations were above the ISQG in samples from L300-06, L300-07, and L600-03. In all samples from the large lakes, concentrations were below the ISQG. In the small lakes, concentrations were above the ISQG in L410 and L541, and were below the ISQG in all other samples.

Copper concentrations ranged from 38.5 to 76.7 mg/kg in the large lakes and 90.0 to 352 mg/kg in the small lakes (Figure 4-4c). All recorded concentrations exceeded the ISQG, and the sample from L313 also exceeded the PEL. The sediment copper concentration in L313 was more than three times higher than concentrations in most of the small lakes. Copper concentration in the water sample from L313 was also the highest of all water samples.

Lead concentrations ranged from 4.3 to 66.5 mg/kg in the large lakes and 2.7 to 10.3 in the small lakes (Figure 4-4d). Concentrations were below the ISQG in the small lakes, and above the ISQG in L300-01 (both 3.5 m and 11 m water depth) and L400-01. In all other samples, concentrations were below the ISQG.

Mercury concentrations ranged from 0.015 to 0.3 mg/kg in the large lakes and 0.13 to 1.07 mg/kg in the small lakes (Figure 4-4e). In the large lakes, only the sample from L400-01 had concentrations above the ISQG. In the small lakes, mercury in L407 was below the ISQG, mercury in L313, L410, and L411 was above the ISQG but below the PEL, and mercury in L415 and L541 was above the PEL.

Zinc concentrations ranged from 50.2 to 120 mg/kg in the large lakes and 116 to 6,570 mg/kg in the small lakes (Figure 4-4f). Concentrations in the large lakes were below guidelines, while concentrations in all small lakes except L541 were above the ISQG or PEL. Concentrations in L407, L410, and L411 were above the ISQG but below the PEL, and concentrations in L415 and L313 were above the PEL. The concentration of zinc in the sediment of L313 was seven times higher than the concentration in L415.

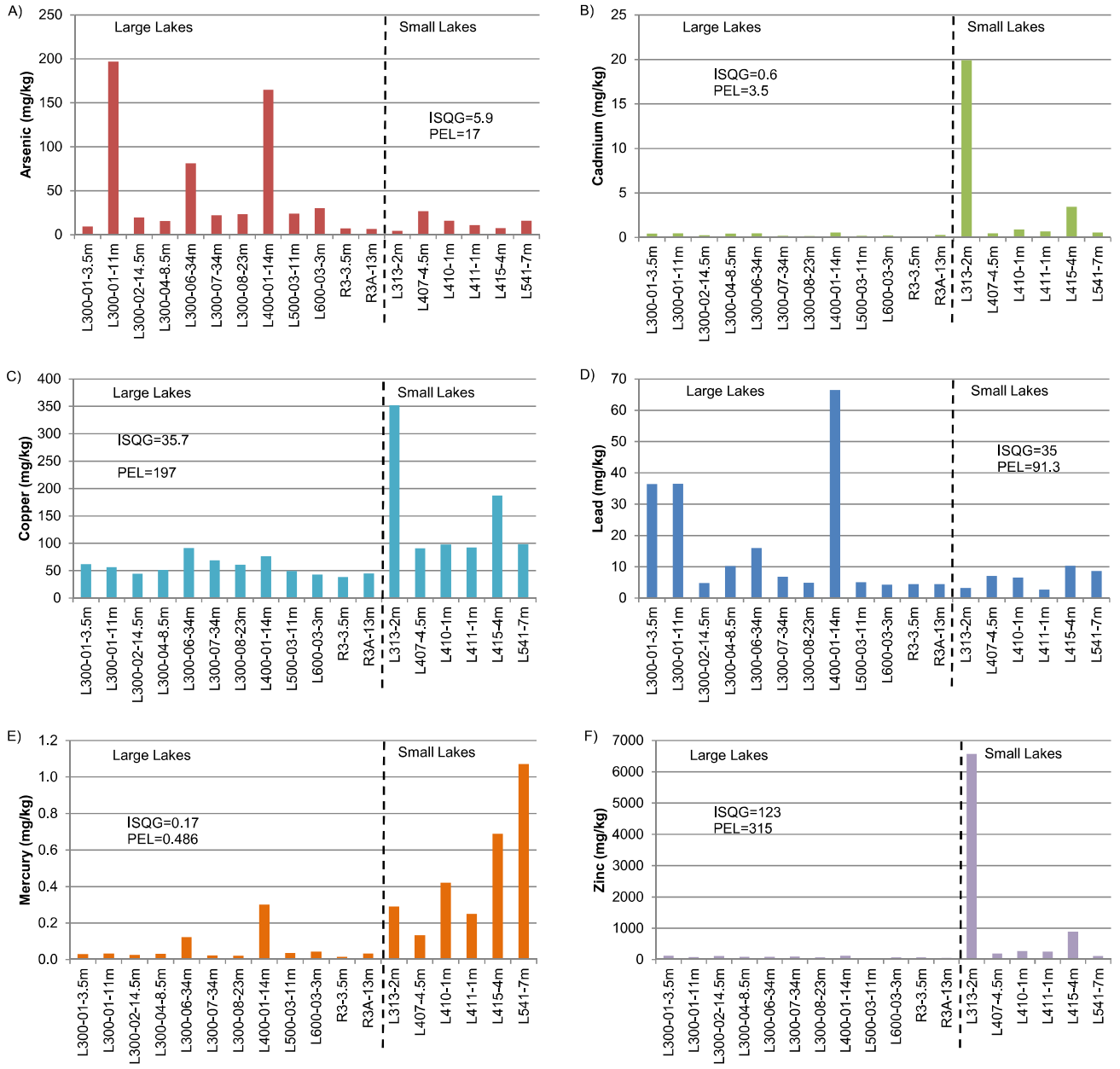

Figure 4-4: Concentrations of A) Arsenic, B) Cadmium, C) Copper, D) Lead, E) Mercury and F) Zinc in Sediments in Large and Small Lakes

5.0 RESULTS – ROAD CORRIDOR

This section presents water and sediment quality results for streams in the all-weather road study area. Detailed lab results are provided in Appendix C, Table C-4 (water quality data) and Appendix D, Table D-3 (sediment quality data).

5.1 Water Quality

5.1.1 Field Data

Based on estimated bankfull channel width, a selection of small streams and larger streams were sampled for water quality (Table 5-1). Streams were sampled in late August, and water temperature ranged from 10.2 to 13.8°C (Appendix C, Table C-4). The streams were well oxygenated with measured DO from 9.0 to 13.3 mg/L, which correspond to 85.7 to 118.9% saturation. Measured DO was above the cold-water aquatic life guideline for minimum DO in all streams, and was above the cold-water early life guideline for minimum DO in all streams except X03-069A, X04-D77, and X04-10B. Field measured conductivity had large variability and ranged from 15 to 102 µS/cm. The sites with highest conductivity were X03-123A and X01-130-ALT. Field-measured pH for most road samples (12 of 14 samples) was acidic, ranging from 5.1 to 7.0 (mean 5.9; median 5.8). The two sites that were near neutral (X03-123A and X01-130-ALT) were both close to the High Lake camp, and were the only ones not to exceed water quality guidelines (CCME 2012a). Algal cover in the streams was subjectively rated as none, low, moderate, and high.

Table 5-1: Field Data from Streams Along the Road Corridor

Station	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Conductivity (µS/cm)	pH	Benthic Algae (N/L/M/H)[a]	Bankfull Channel Width (m)	Wetted Channel Width (m)
X01-130-ALT	10.4	13.3	118.9	102	7.0	M	45	40
X03-123A	10.2	13.1	116.0	94	6.8	L	20	3.5
X01-115	13.6	11.7	112.3	28	5.9	H	40	30
X01-104	12.8	10.8	101.7	22	5.7	L	45	40
X01-094	11.3	11.7	106.8	18	5.6	M	-	-
X01-085	11.0	11.1	100.2	27	5.6	L	2	1.3
X01-072	11.3	9.6	87.3	28	6.0	L	3	3
X03-069A	13.8	9.2	89.3	31	6.1	M	0.8	0.8
X03-062A	12.7	9.7	91.5	19	5.8	L	80	80
X03-055A	11.4	9.6	87.6	16	5.6	M	20	20
X04-ALT	11.2	10.1	91.9	34	5.3	H	6	4
X04-D77	13.1	9.0	85.7	15	5.7	M	70	30
X04-D71	13.7	9.8	94.1	40	5.1	-	2.5	2.5
X04-10B	12.8	9.3	87.4	17	5.9	H	175	100

Note:
Stations are sorted from North to South as shown on Figure 1-3a and b.
"N"=none.
"L"=low (<25% cover).
"M"=moderate (25-75% cover).
"H"=high (>75% cover).

5.1.2 General Chemistry

Turbidity was low at all sites, ranging from 0.3 to 1.2 NTU (mean 0.5 NTU; median 0.4 NTU), as was TSS (below the detection limit at all sites). TDS was also low, ranging from <10 to 61 mg/L (mean 30 NTU). Lab measured conductivity ranged from 5.8 to 98.7 µS/cm.

Hardness of the water samples ranged from 4.9 to 40 mg $CaCO_3$/L (mean = 13 mg/L). As based on hardness, the streams on the road corridor are rated as very soft to soft. They are rated as ranging from sensitive to not sensitive to acid deposition (Table 2-6).

The dominant cations were calcium and magnesium, and the dominant anion was bicarbonate. The highest concentrations of calcium, magnesium, bicarbonate, and sulphate were from samples at X03-123A and X01-130-ALT indicating that the neutral pH was due to buffering by calcium carbonate and calcium sulphate rocks.

5.1.3 Nutrients

All tributaries along the road route are classified as oligotrophic (TP <0.025 mg/L; Table 2-7) (Appendix C, Table C-4). Concentrations of TP ranged from <0.0010 to 0.0122 mg/L (mean 0.0045 mg/L; median 0.0038 mg/L). Inorganic phosphorus was not detected at any site, and dissolved phosphorus generally ranged from 30 to 70% of TP, averaging about 50%. Ammonia and nitrite were not detected in any samples. Nitrate concentration ranged from <0.006 mg/L to 0.148 mg/L (X01-130-Alt). Total organic carbon was low to moderate, ranging from 1.3 to 9.5 mg/L (mean 3.3 mg/L; median 2.6 mg/L) and was predominantly found as DOC.

Reference streams were similar to the other tributaries for most nutrients (N, P), or fell within the low end of the range (silicon), although station RST-2 was above average in DOC/TOC.

5.1.4 Metals

All metal data for the road samples are in Appendix C, Table C-4. Lab-measured pH was used to determine the appropriate aluminum guideline to use for comparisons to concentrations measured in the samples. Aluminum concentrations ranged from 0.00163 to 0.0792 mg/L. Aluminum was above the guideline in the samples from X04-10B and X04-072. In all other samples, aluminum concentration was below the guideline.

Cadmium concentrations exceeded guidelines at X04-10B, X04-D71, and X04-ALT, and detection limits were above guidelines for all other sites except X03-069A and X01-072. Copper exceeded guidelines at X03-069A and X04-ALT, iron exceeded guidelines at X03-069A and X04-D71, and zinc exceeded guidelines at X04-ALT. All other metals were below detection limits and/or below relevant guidelines.

5.2 Sediment Quality

This section provides a summary of laboratory sediment quality results for streams. Sediments were collected from four of the 14 stream crossings (Table 2-2). Complete sediment quality data are provided in Appendix D, Table D-3.

The dominant particle size in three of the streams was sand, while the dominant particle size in the fourth stream was silt (Table 5-2).

Table 5-2: Sediment Particle Size in Streams on the Road Corridor

Particle	Units	X04-D71	X03-055A	X01-085	X01-094
Gravel (>2 mm)	%	<0.1	7.1	39.3	<0.1
Course Sand (2.0 mm - 0.2 mm)	%	3.5	51.2	46.7	45.4
Fine Sand (0.2 mm - 0.063 mm)	%	8.2	15.9	6.9	48.9
Silt (0.063 mm - 4 µm)	%	83.4	24.5	6.3	5.4
Clay (<4 µm)	%	4.8	1.4	0.8	0.6

Sediment pH was acidic in all streams, ranging from 5.39 to 5.60. Concentrations of metals in stream sediments were lower than those in the lake sediment samples. The concentrations of arsenic and copper were above the ISQG in the sample from X04-D71. Concentrations of all other metals were below the respective ISQG values.

6.0 SUMMARY

For the Izok Mine study area, a water quality field program was conducted in May, July and August, and a sediment quality field program was conducted in August (Table 6-1). In the mine area, streams, small lakes, and large lakes were sampled. In the road study area, a water and sediment quality field program of streams was conducted in August. Quality control samples (blanks and replicates) were collected during each field program (i.e., May, July, August-mine, August-road). In total, 129 water samples were collected: 97 in the mine study area, 14 in the road study area, and 18 QC samples. In total, 22 sediment samples were collected: 16 in the mine area, four in the road area, and two QC samples.

Table 6-1: Water and Sediment Quality Sampling Effort in 2012

Sampling Area	Station Type	Water Quality			Sediment Quality
		May	July	August	August
Izok Mine	Streams	0	6	5	0
	Small Lakes	0	16	7	6
	Large Lakes	21	23	19	10
Road	Streams	0	0	14	4
Quality Control	Blanks and Replicates	3	6	9	2
Total		**24**	**51**	**54**	**22**

The water and sediment quality data collected in 2012 were compared to aquatic life guidelines, drinking water guidelines, and additional classification categories (e.g., trophic status, water hardness). For water quality, cadmium concentrations exceeded guidelines most often, followed by copper, aluminum, and pH (Table 6-2). For sediment quality, arsenic concentrations exceeded guidelines most often, followed by cadmium, copper, and chromium.

Water quality in most of the streams was less than the aquatic life water quality guidelines. Streams with parameters above guidelines included D301 (cadmium), D407 (cadmium and iron), D422 (cadmium and copper), X04-10B (pH, aluminum, and cadmium), and X04-D71 (pH, aluminum, cadmium, and copper). In most of the samples from the larger lakes, cadmium concentrations were above aquatic life guidelines. In the smaller lakes with low pH, metals (aluminum, cadmium, copper, iron, manganese, nickel, zinc) were above guidelines and at the highest recorded concentrations for the dataset (e.g., L313 and L314). In addition, sediments in the small

lakes had higher concentrations of metals such as cadmium, copper, mercury, and zinc, while metals such as arsenic and lead were higher in the larger lakes.

Table 6-2: Summary of Water and Sediment Quality Data

Watershed	Station Number	Water and Sediment Collected	Water Collected	WQ Parameters Above Guidelines	SQ Parameters Above Guidelines
Itchen	D101	-	Yes	No parameters above guidelines	-
	D301	-	Yes	Cadmium	-
Izok	D401	-	Yes	No parameters above guidelines	-
	D407	-	Yes	Cadmium, iron	-
	D422	-	Yes	Cadmium, copper	-
Iznogoudh	D501	-	Yes	No parameters above guidelines	-
Reference Stream 1	RST1	-	Yes	No parameters above guidelines	-
Reference Stream 2	RST2	-	Yes	pH (low)	-
Itchen	L300-01	Yes	-	Cadmium	Arsenic, copper, lead
	L300-02	Yes	-	Cadmium	Arsenic, copper
	L300-03	-	Yes	Cadmium	-
	L300-04	Yes	-	Cadmium	Arsenic, copper
	L300-05	-	Yes	No parameters above guidelines	-
	L300-06	Yes	-	Cadmium	Arsenic, chromium, copper
	L300-07	Yes	-	Cadmium	Arsenic, chromium, copper
	L300-08	Yes	-	Cadmium	Arsenic, copper
	L300-09	-	Yes	No parameters above guidelines	-
	L302	-	Yes	Cadmium	-
	L304	-	Yes	pH (low), aluminum, cadmium, copper	-
	L313	Yes	-	pH (low), fluoride, aluminum, cadmium, copper, iron, manganese, nickel, zinc	Cadmium, copper, mercury, zinc
	L314	-	Yes	pH (low), aluminum, cadmium, copper, manganese, nickel, zinc	-
	L316	-	Yes	Cadmium	-
	L317	-	Yes	Cadmium, copper	-
	L339	-	Yes	Cadmium	-

Table 6-2: Summary of Water and Sediment Quality Data (cont.)

Watershed	Station Number	Water and Sediment Collected	Water Collected	WQ Parameters Above Guidelines	SQ Parameters Above Guidelines
Izok	L400-01	Yes	-	Cadmium	Arsenic, copper, lead, mercury
	L407	Yes	-	Cadmium, copper	Arsenic, copper, zinc
	L409	-	Yes	Cadmium, copper	-
	L410	Yes	-	Cadmium, copper	Arsenic, cadmium, chromium, copper, mercury, zinc
	L411	Yes	-	Cadmium, copper	Arsenic, cadmium, copper, mercury, zinc
	L412	-	Yes	pH (low), aluminum, cadmium, copper, lead, manganese, nickel, zinc	-
	L414	-	Yes	pH (low), aluminum, cadmium, copper, manganese, nickel, zinc	-
	L415	Yes	-	pH (low), aluminum, cadmium, copper, manganese, zinc	Arsenic, cadmium, copper, mercury, zinc
	L420	-	Yes	Cadmium, copper	-
	L422	-	Yes	Cadmium, copper	-
Iznogoudh	L500-03	Yes	-	Aluminum, cadmium	Arsenic, copper
	L500-04	-	Yes	Aluminum, cadmium	-
	L541	Yes	-	Cadmium, iron	Arsenic, chromium, copper, mercury
	L560	-	Yes	Cadmium	-
Ham	L600-03	Yes	-	Aluminum, arsenic, iron, manganese	Arsenic, chromium, copper
Reference 3	R3	Yes	-	Cadmium	Arsenic, copper
Streams on the Road Corridor	X03-055A	Yes	-	No parameters above guidelines	No parameters above guidelines
	X03-062A	-	Yes	No parameters above guidelines	-
	X03-069A	-	Yes	Copper, iron	-
	X01-072	-	Yes	No parameters above guidelines	-
	X01-085	Yes	-	No parameters above guidelines	No parameters above guidelines
	X01-094	Yes	-	No parameters above guidelines	No parameters above guidelines
	X01-104	-	Yes	No parameters above guidelines	-

Table 6-2: Summary of Water and Sediment Quality Data (cont.)

Watershed	Station Number	Water and Sediment Collected	Water Collected	WQ Parameters Above Guidelines	SQ Parameters Above Guidelines
	X01-115	-	Yes	No parameters above guidelines	-
	X03-123A-alt	-	Yes	No parameters above guidelines	-
	X01-130-alt	-	Yes	No parameters above guidelines	-
	X04-alt	-	Yes	Cadmium, copper, zinc	-
	X-04D71	Yes	-	pH, aluminum, cadmium, copper	Arsenic, copper
	X04-D77	-	Yes	No parameters above guidelines	-
	X04-10B	-	Yes	pH, aluminum, cadmium	-

Note:

"-" = no sample collected.

7.0 REFERENCES

Boward, D., P. Kayzak, S. Stranko, M. Hurd, and A. Prochaska. 1999. From the Mountains to the Sea: The State of Maryland's Freshwater Streams. Maryland Department of Natural Resources.

CCME. (Canadian Council of Ministers of the Environment). 2004. Canadian Council of Ministers of the Envrionment. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Phosphorus: Canadian Guidance Framework for the Management of Freshwater Systems. In: Canadian Environmental Quality Guidelines, 2004. Canadian Council of Ministers of the Environment, Winnipeg.

CCME. 2012a. *Canadian Water Quality Guidelines: Summary Table*. In Canadian Council of Ministers of the Environment. *Canadian Environmental Quality Guidelines, 1999* with updates to 2012. Winnipeg, MB. Accessed October 2012. Available at: http://st-ts.ccme.ca/

CCME. 2012b. *Canadian Sediment Quality Guidelines: Summary Table.* In Canadian Council of Ministers of the Environment. *Canadian Environmental Quality Guidelines, 1999 with updates to 2012.* Winnipeg, MB. Accessed October 2012. Available at: http://st-ts.ccme.ca/

Dodds, W.K., J.R. Jones, and E.B. Welch. 1998. Suggested Classification of Stream Trophic State: Distribution of Temperate Stream Types by Chlorophyll, Total Nitrogen and Phosphorus. J. Water Resources. 32:1455-1462.

GLL (Gartner Lee Limited). 2008. Izok Project: 2007 Water and Sediment Quality Field Report. Prepared for Zinifex Canada Inc. May 2008.

Golder (Golder Associates Ltd.). 2011. Izok Project: Water Quality Field Report – 2008 Data. Prepared for MMG Limited. October 2011.

Health Canada. 2012. Summary of Guidelines for Canadian Drinking Water Quality. Prepared by the Federal-Provincial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Environmental and Occupational Health.

McNeely, R.N., V.P. Neimanis, and L. Dwyer. 1979. Water Quality Sourcebook – A Guide to Water Quality Parameters. Inland Waters Directorate, Water Quality Branch, Minister of Supply and Services Canada.

Saffran, K.A., and D.O. Trew. 1996. Sensitivity of Alberta Lakes to Acidifying Deposition: An Update of Maps with Emphasis on 109 Northern Lakes. Water Management Division. Alberta Environmental Protection. W9603.

Report Signature Page

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APPENDIX A

Quality Assurance and Quality Control

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1.0 INTRODUCTION

Quality assurance and quality control (QA/QC) practices determine data integrity and are relevant to all aspects of a study, from sample collection to data analysis and reporting. Quality assurance encompasses management and technical practices designed to ensure that the data generated are of consistent high quality. Quality control is an aspect of QA and includes the procedures used to measure and evaluate data quality, and the corrective actions to be taken when data quality objectives are not met. This appendix describes QA/QC practices applied during this study, evaluates QC data, and describes the implications of QC results to the interpretation of study results.

2.0 QUALITY ASSURANCE

QA applicable to this study cover three areas of internal and external management, as described below.

2.1 Field Staff Training and Operations

Golder field staff are trained to be proficient in standardized field sampling procedures, data recording and equipment operations applicable to water and sediment quality sampling. Field work was completed according to approved specific work instructions (SWIs) and established Golder technical procedures (TPs). SWIs are standardized forms that describe exact sampling locations and provide specific sampling instructions, equipment needs and calibration requirements, required technical procedures, sample labelling and shipping protocols and laboratory contacts. They also provide specific guidelines for field record keeping and sample tracking. Technical procedures are consistent with standard field methods described in the relevant scientific literature (e.g., EC 1993; APHA 2005), and outline sample collection, preservation, handling, storage and shipping protocols.

Field work was preceded by a pre-field meeting attended by the field crew and the project/task manager, during which the purpose of the field program was discussed, roles of crew members were specified, questions regarding the SWI were addressed, and equipment needs, field logistics and contingency plans were discussed. During field work, field data were recorded on standardized field data sheets or in a bound field book, according to established field record-keeping procedures. In addition, field crews checked-in with task managers regularly to provide an update on work completed. Samples were documented and tracked using chain-of-custody forms and receipt of samples by the analytical laboratory was confirmed.

One field crew member was responsible for managing the sample shipping process to ensure that:

- all required samples were collected;
- chain-of-custody and analytical request forms were completed and correct; and
- proper labelling and documentation procedures were followed.

2.2 Laboratory

One member of the project team was designated as the lab liaison. To ensure that high quality data were generated, laboratories used for the sample analysis are accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA). Under CALA's accreditation program, performance evaluation assessments are conducted annually for laboratory procedures, methods and internal quality control.

2.3 Office Operations

Office-related QA included use of appropriately trained personnel for each task and senior review of work products at appropriate milestones, use of standardized data manipulation/summary tools, filing of data and project information according to standardized protocols and establishment of a data management system to ensure an organized consistent system of data storage, QC and retrieval.

3.0 QUALITY CONTROL

3.1 Field Control Procedures

The water quality field QC program consisted of the collection and analysis of field blank and field replicate split samples. Each QC sample type is described below:

- Field blanks consist of de-ionized water provided by the analytical laboratory, which is exposed to the sampling environment at the sample site and handled in the same manner as the surface water samples collected during the field program (e.g., preserved, filtered). Field blanks are used to detect potential sample contamination during sample collection, handling, shipping and analysis.
- Replicate samples are additional samples collected at the same time and location as surface water or sediment samples collected during a field program, using the sample sampling methods. They are used to check within-site variation, and the precision of field sampling methods and laboratory analysis.

Quality control samples collected during the field program accounted for approximately 10% of the total number of samples submitted for analysis. These samples were handled, stored and shipped along with field-collected surface water samples, and were submitted “blind” to the analytical laboratories. Quality control samples were analyzed for the same set of parameters as the samples collected from surface waters.

3.2 Office Quality Control Procedures

Relevant elements of office-based QC included the following:

- saving unaltered lab files in the project directory;
- comparing sample data entered into the project database against final laboratory reports to ensure data accuracy;
- creating backup files before each major operation as data were being manipulated;
- checking the data in the Project database against the raw data obtained from databases or analytical laboratories; and
- verifying the accuracy of calculations performed to generate summary statistics.

3.3 Initial Laboratory Data Screening

Upon receipt of water and sediment quality data from the analytical laboratory, a series of standard checks were performed to screen for potential data quality issues. These allowed potential re-analysis of samples to verify questionable data, or generate data for missing parameters. The following data checks were performed:

- verification that all required parameters and samples were analyzed;

- verification that data are reported using the appropriate units;
- verification that analyses were done with the appropriate detection limit;
- field versus laboratory data comparisons for parameters with parallel field and laboratory data (pH, conductivity); if large discrepancies were found, then laboratory data were considered correct;
- logic checks: presence of zero values, comparisons of TDS and conductivity, hardness and alkalinity, total and dissolved phosphorus, total and dissolved organic carbon, total and dissolved metals, measured and calculated TDS;
- checking for outliers;
- checking blanks for evidence of contamination (see next section);
- checking replicate samples for evidence of unacceptable variation (see next section);
- checking laboratory QC data (sample temperature and integrity of containers upon receipt, review laboratory qualifiers, holding times, internal duplicates, ion balance, % recovery of spiked analytes); and
- checking field-collected data for completeness, and unexpected values and trends.

If results of initial data screening indicated that there were deficiencies or potential data quality issues, the analytical laboratory was contacted and re-analysis of the parameters in question in the affected samples was requested. If data were verified by the analytical laboratory, but remained questionable based on the above evaluation, qualifiers were added to affected concentrations in the project data set for consideration during data summary and analysis, or data were excluded from further analysis (and identified in the report as excluded, with the corresponding reasons).

3.4 Field Quality Control Data Evaluation

3.4.1 Field Blanks

Concentrations in field blanks were considered notable if they were greater than or equal to five times the corresponding detection limit (DL). This threshold is based on the Practical Quantitation Limit (PQL) defined by the United States Environmental Protection Agency (U.S. EPA 2000; AENV 2006), and takes into account the potential for reduced accuracy when concentrations approach or are below DLs. This criterion was not applied to pH, which is expected to be above the laboratory-reported DL in the deionized water used to prepare blanks.

The implications of notable results in blanks to data quality were evaluated relative to concentrations observed in surface waters sampled during the field program. The aim of this evaluation was to determine (1) whether contamination was limited to a blank or was apparent in the corresponding water samples as well, (2) whether it resulted in a consistent bias, and (3) whether it was severe enough to warrant invalidating the affected data. To address these questions, notable concentrations in blanks were interpreted as follows:

- If the blank had a detectable concentration of a parameter that was higher than those in the corresponding surface water samples, it was assumed that the concentration in the blank was the result of an isolated field or lab error. In this case, the corresponding water samples were considered uncontaminated.

- If the detectable concentration in the blank was less than 10% of the typical surface water concentration, the data for the corresponding water samples were considered acceptable for the parameter in question and were included in further analysis.
- If the detectable concentration in a single blank was greater than 10% of the typical surface water concentration, but below those in the corresponding water samples, the water samples were considered potentially contaminated and were qualified in the data tables and the project database. Affected data were excluded from further analysis.
- If two or more blanks had similar notable concentrations of a parameter, which was greater than 10% of the typical surface water concentration, but below those in the corresponding water samples, the results were considered to indicate a consistent analytical bias for that parameter. In this case, the data for the corresponding water samples were adjusted by subtracting the mean concentration in the blanks and the analytical laboratory was contacted to request development of corrective actions.

3.4.2 Replicate Samples

Differences between concentrations measured in replicate water samples were calculated as the relative percent difference (RPD) for each parameter. Before calculating the RPD, concentrations below the DL were replaced with the DL value in cases when only one of the concentrations for a given parameter was detectable. The RPD was calculated using the following formula:

RPD = (|difference in concentration between two of the replicate samples| / mean concentration) x 100

The RPD value for a given parameter was considered notable if:

- it was greater than 20%; and
- concentrations in one or both samples were greater than or equal to five times the DL.

These criteria are consistent with those used by analytical laboratories as part of internal QC procedures for duplicate samples.

When three or more replicate samples were collected, the relative standard deviation (RSD) was calculated using the following formula:

RSD = (standard deviation / mean concentration) x 100

The RSD value for a given parameter was considered notable if:

- it was greater than 20% for three to five replicates (10% for six or more replicates); and
- concentrations in one or more samples were greater than or equal to five times the DL.

Differences between concentrations measured in replicate sediment samples, expressed as the RPD, were considered notable if they were:

- greater than 20% for all other parameters; and
- greater than or equal to five times the reported DL.

The number of parameters with exceedances of the assessment criteria was compared with the total number of parameters analyzed to evaluate analytical precision. Analytical precision was rated as follows:

- high, if less than 10% of the total number of parameters were notably different from one another;
- moderate, if 10 to 30% of the total number of parameters were notably different from one another; or
- low, if more than 30% of the total number of parameters were notably different from one another.

3.5 Quality Control Results

3.5.1 Field and Lab Measured Parameters

There were noted discrepancies between field-measured pH and lab-measured pH. In particular, lab-measured pH was above field-measured pH for every sample (Figure 3-1). The differences were greater when pH was greater than 5, similar to a recent comprehensive study by the USGS (Latysh and Gordon 2004). Two factors appear to play important roles: (1) water temperature in the field; and (2) hold time prior to analysis in the lab. There was a moderately strong, statistically significant negative correlation (r = -0.751, p < 0.01) between water temperature in the field and the lab:field pH ratio (Figure 3-2). However, when the temperature dropped below 5°C (i.e., the May under-ice water samples), this effect was pronounced. For hold time, there was a weaker correlation between the delay between analysis in the lab and in the field (r = 0.433, p < 0.01), indicating that the pH increased by approximately 2% with each day of delay in analysis (Figure 3-3).

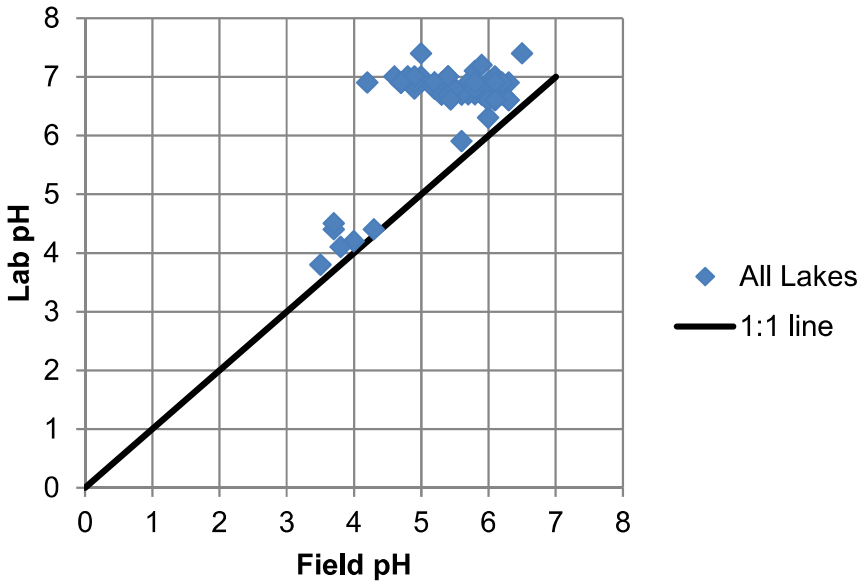

Figure 3-1. Relationship Between Field and Lab-measured pH for all Samples Collected in 2012

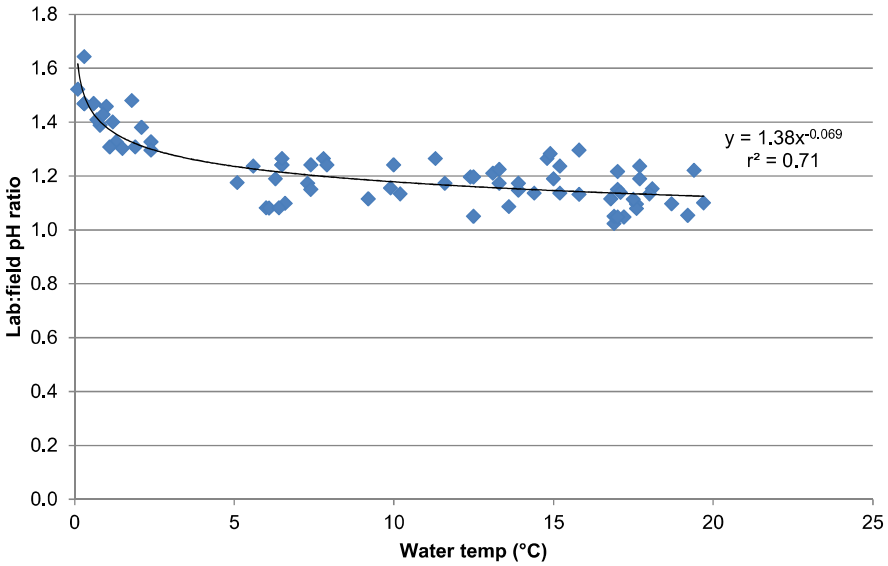

Figure 3-2. Relationship Between Water Temperature at Time of Sampling and Lab to Field pH Ratio

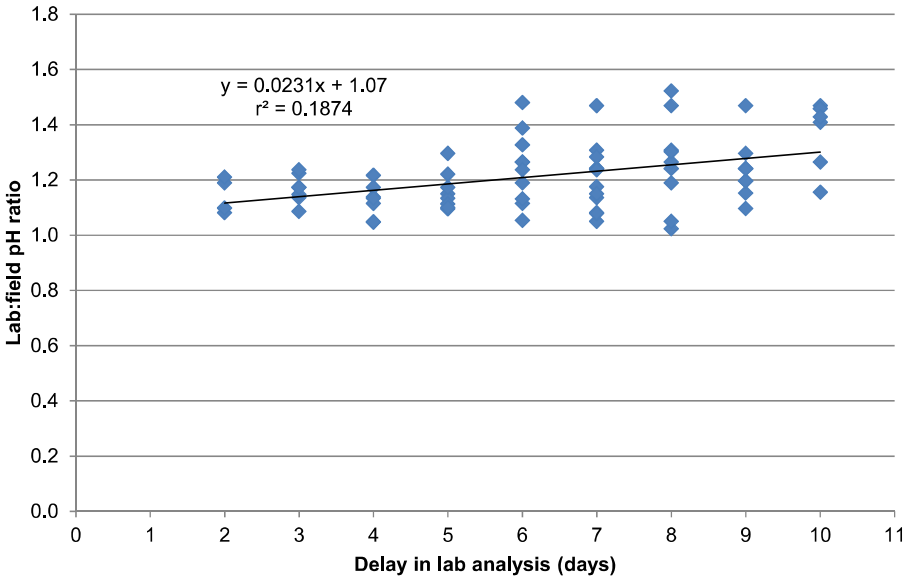

Figure 3-3. Relationship Between Delay in Lab Analysis and Lab to Field pH Ratio

3.5.2 Field Blanks

Through the course of the water quality program for the Izok and road study areas, six blank samples were collected and analyzed. The blank data were reviewed for parameters with concentrations reported at more than or equal to five times the detection limit. Thirteen parameters were detected at least once in the six blank samples with concentrations more than five times the detection limit (Table 3-1). Of those 13 parameters, seven parameters detected in the blank samples had the highest concentration in the corresponding lab report. Finally, concentrations of those seven parameters were compared to concentrations reported across all test samples (n=111) to evaluate if the concentration reported for the blank sample was the highest across the entire dataset, or within the range reported for test samples. From this last screening, it was determined that four parameters (total and dissolved boron, and total and dissolved tin) had the highest reported concentrations in the blank samples. Thus, results for boron and tin for the entire dataset are to be used with caution.

Complete results for the blank samples are provided in Table 4-1.

Table 3-1: Summary of Blank Samples with Detectable Concentrations

Parameters	Concentration more than 5xDL	Number of Lab Files where Concentration in the Blank Sample was the Highest in the Individual Lab Report	Is Concentration in Blank Sample(s) the Highest in the Entire Dataset?
Anions and Nutrients			
Gran Alkalinity	1	1	No
Conductivity	2	0	-
Total Metals			
Boron	3	3	Yes
Sodium	6	1	No
Tin	6	6	Yes
Dissolved Metals			
Aluminum	1	0	-
Boron	5	5	Yes
Calcium	4	0	-
Magnesium	4	0	-
Potassium	1	0	-
Sodium	4	1	No
Strontium	1	0	-
Tin	5	3	Yes

3.5.3 Replicate Water Samples

Complete replicate results are provided in Table 4-2.

For this program, duplicate and replicate samples were collected as follows:

- May
  - Triplicate from R3-Top
- July
  - Duplicate from L300-02-Top
  - Duplicate from D301
  - Triplicate from L420
- August
  - Triplicate from L300-02-Top
  - Triplicate from R3-Top
  - Duplicate from X01-05
  - Duplicate from X130-Alt

RSD was calculated for triplicate sample sets, and RPD was calculated for duplicate sample sets.

If concentrations in replicate samples were less than 20%, samples were considered similar. If concentrations in replicate samples were more than 20%, but concentrations in one or more samples was less than five times the detection limit, the percent difference between samples (RSD or RPD) was considered acceptable. If concentrations in replicate samples were more than five times the detection limit, and the percent difference between samples (RSD or RPD) was more than 20%, the difference was noted as a “fail”. These calculations were completed for all parameters (see Table 4-2). A summary of the RSD and RPD calculations are provided in Table 3-2 along with a statement if the differences between the samples are more 20% and concentrations are more than five times the detection limit (“fail” the QC evaluation).

Concentrations of total copper, total and dissolved iron, total titanium, dissolved manganese and dissolved zinc were considered to be notably different in one replicate sample set. Dissolved boron was considered to be notably different in two replicate sample sets. In total, seven parameters out of 91 were considered to be notably different. Overall, analytical precision is rated as high, as less than 10% of parameters were notably different from one another.

Table 3-2: Summary of Comparison Between Replicate Results

Sample Month	May		July						August							
Sample Station	R3-T		L300-02-T		D301		L420		L300-02-T		R3-T		X01-085		X01-130-Alt	
	RSD	Result[a]	RPD	Result[a]	RPD	Result[a]	RSD	Result[a]	RSD	Result[a]	RSD	Result[a]	RPD	Result[a]	RPD	Result[a]
Physical Tests																
Total Dissolved Solids	13%	-	13%	-	**26%**	-	20%	-	**42%**	-	6%	-	17%	-	1%	-
Anions and Nutrients																
Gran Alkalinity (as H+)	6%	-	0%	-	0%	-	0%	-	0%	-	**43%**	-	0%	-	1%	-
Nitrate and Nitrite (as N)	**23%**	-	0%	-	11%	-	0%	-	0%	-	0%	-	1%	-	1%	-
Nitrate (as N)	**23%**	-	0%	-	11%	-	0%	-	0%	-	0%	-	1%	-	1%	-
Total Kjeldahl Nitrogen	**34%**	-	5%	-	**33%**	-	17%	-	10%	-	**35%**	-	6%	-	-	-
Phosphorus (P)-Total Dissolved	0%	-	0%	-	**104%**	-	3%	-	3%	-	**23%**	-	2%	-	-	-
Phosphorus (P)-Total	**23%**	-	10%	-	16%	-	**35%**	-	7%	-	2%	-	2%	-	-	-
Total Metals																
Cadmium	0%	-	0%	-	**25%**	-	1%	-	**23%**	-	0%	-	0%	-	0%	-
Chromium	0%	-	5%	-	14%	-	5%	-	**23%**	-	17%	-	0%	-	0%	-
Cobalt	18%	-	1%	-	**24%**	-	3%	-	15%	-	6%	-	2%	-	0%	-
Copper	7%	-	**154%**	**fail**	0%	-	2%	-	6%	-	8%	-	2%	-	2%	-
Iron	**21%**	-	**46%**	**fail**	2%	-	1%	-	9%	-	2%	-	1%	-	9%	-
Lead	0%	-	0%		7%	-	1%	-	**34%**	-	16%	-	0%	-	0%	-
Titanium	18%	-	**171%**	**fail**	**26%**	-	9%	-	**101%**	-	**25%**	-	0%	-	0%	-
Zinc	**20%**	-	**52%**	-	**33%**	-	7%	-	12%	-	10%	-	2%	-	0%	-
Dissolved Metals																
Boron	2%	-	**40%**	**fail**	**34%**	**fail**	2%	-	2%	-	4%	-	19%	-	8%	-
Cadmium	0%	-	0%	-	0%	-	8%	-	**66%**	-	0%	-	0%	-	4%	-
Cobalt	**74%**	-	4%	-	19%	-	3%	-	11%	-	15%	-	2%	-	0%	-
Iron	6%	-	0%	-	**23%**	**fail**	1%	-	**20%**	-	14%	-	1%	-	2%	-
Lead	0%	-	0%	-	20%	-	4%	-	**24%**	-	**26%**	-	7%	-	0%	-
Manganese	**99%**	**fail**	2%	-	16%	-	0%	-	11%	-	6%	-	0%	-	1%	-
Titanium	0%	-	0%	-	0%	-	**25%**	-	0%	-	0%	-	0%	-	0%	-
Zinc	**23%**	-	**22%**	-	**71%**	-	3%	-	**62%**	-	20%	-	25%	**fail**	8%	-

[a] a difference between replicate samples of more than 20% was noted as a "fail" when at least one reported concentration was more than five times the detection limit.

Table 4-1: Summary of Blank Samples

RESULTS OF ANALYSIS	Units	DL	QC-Blank	QC-Blank	QC-Blank	QC-Blank	QC-Blank	QC-Blank
Date Sampled			07-MAY-12	06-JUL-12	16-JUL-12	08-AUG-12	11-AUG-12	28-AUG-12
ALS Sample ID			L1145577-9	L1177320-11	L1181227-18	L1191540-5	L1192736-11	L1202453-2
Physical Tests								
Total Suspended Solids	mg/L	3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Total Dissolved Solids	mg/L	10	<10	<10	<10	<10	<10	<10
Turbidity	NTU	0.10	0.18	<0.10	<0.10	<0.10	<0.10	<0.10
Anions and Nutrients								
Gran Alkalinity (as H+)	meq/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.16
Alkalinity, Total (as CaCO3)	mg/L	5.0	<5.0	<5.0	<5.0		<5.0	<5.0
Ammonia, Total (as N)	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bicarbonate (HCO3)	mg/L	5.0	<5.0	<5.0	<5.0		<5.0	<5.0
Carbonate (CO3)	mg/L	5.0	<5.0	<5.0	<5.0		<5.0	<5.0
Chloride (Cl)	mg/L	0.50	<0.50	<0.50	<0.50		<0.50	<0.50
Conductivity (EC)	µS/cm	0.20	1.23	1.23	0.90		0.94	<0.20
Fluoride (F)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Hardness (as CaCO3)	mg/L	-	<1.0	<1.0	<1.0		<1.0	<1.0
Hydroxide (OH)	mg/L	5.0	<5.0	<5.0	<5.0		<5.0	<5.0
Ion Balance	%	-	Low TDS	Low TDS	Low TDS		Low TDS	Low TDS
Nitrate and Nitrite (as N)	mg-N/L	0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060
Nitrate (as N)	mg-N/L	0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060
Nitrite (as N)	mg-N/L	0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Total Kjeldahl Nitrogen	mg-N/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
pH	-	0.10	6.10	6.31	6.20		6.21	5.73
Orthophosphate-Dissolved (as P)	mg-P/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total Dissolved	mg-P/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total	mg-P/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
TDS (Calculated)	mg/L	-	<1.0	<1.0	<1.0		<1.0	<1.0
Sulfate (SO4)	mg/L	0.050	0.068	<0.050	<0.050	<0.050	<0.050	<0.050
Cyanides								
Cyanide, Total	mg/L	0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020

Table 4-1: Summary of Blank Samples

RESULTS OF ANALYSIS	Units	DL	QC-Blank	QC-Blank	QC-Blank	QC-Blank	QC-Blank	QC-Blank
Date Sampled			07-MAY-12	06-JUL-12	16-JUL-12	08-AUG-12	11-AUG-12	28-AUG-12
ALS Sample ID			L1145577-9	L1177320-11	L1181227-18	L1191540-5	L1192736-11	L1202453-2
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L	1.0	<1.0	<1.0	<1.0	<1.0	1.0	<1.0
Total Organic Carbon	mg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Inorganic Parameters								
Silicon (as SiO2)-Dissolved	mg/L	0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Total Metals								
Mercury (Hg)-Total	mg/L	0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Total Metals (Undigested)								
Aluminum (Al)-Total	mg/L	0.00030	0.00032	<0.00030	<0.00030	0.00073	<0.00030	<0.00030
Antimony (Sb)-Total	mg/L	0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Arsenic (As)-Total	mg/L	0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Barium (Ba)-Total	mg/L	0.000050	0.000106	<0.000050	0.000105	<0.000050	<0.000050	<0.000050
Beryllium (Be)-Total	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Bismuth (Bi)-Total	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Boron (B)-Total	mg/L	0.0010	0.0027	0.0107	<0.0010	0.0053	0.0055	0.0026
Cadmium (Cd)-Total	mg/L	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Total	mg/L	0.020	0.022	<0.020	0.063	0.038	0.043	<0.020
Chromium (Cr)-Total	mg/L	0.000060	<0.000060	<0.000060	<0.000060	0.000103	<0.000060	<0.000060
Cobalt (Co)-Total	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Copper (Cu)-Total	mg/L	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Iron (Fe)-Total	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0017	<0.0010
Lead (Pb)-Total	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Lithium (Li)-Total	mg/L	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium (Mg)-Total	mg/L	0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040	<0.0040
Manganese (Mn)-Total	mg/L	0.000050	<0.000050	<0.000050	0.000089	0.000114	0.000135	<0.000050
Molybdenum (Mo)-Total	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Nickel (Ni)-Total	mg/L	0.000060	<0.000060	<0.000060	<0.000060	<0.000060	<0.000060	<0.000060
Potassium (K)-Total	mg/L	0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Selenium (Se)-Total	mg/L	0.000040	<0.000040	<0.000040	<0.000040	<0.000040	<0.000040	<0.000040
Silver (Ag)-Total	mg/L	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050

Table 4-1: Summary of Blank Samples

RESULTS OF ANALYSIS	Units	DL	QC-Blank	QC-Blank	QC-Blank	QC-Blank	QC-Blank	QC-Blank
Date Sampled			**07-MAY-12**	**06-JUL-12**	**16-JUL-12**	**08-AUG-12**	**11-AUG-12**	**28-AUG-12**
ALS Sample ID			**L1145577-9**	**L1177320-11**	**L1181227-18**	**L1191540-5**	**L1192736-11**	**L1202453-2**
Sodium (Na)-Total	mg/L	0.0050	0.0563	0.137	0.120	0.110	0.188	0.0503
Strontium (Sr)-Total	mg/L	0.000050	0.000090	<0.000050	0.000077	0.000052	0.000058	<0.000050
Thallium (Tl)-Total	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	mg/L	0.000050	0.00280	0.000743	0.000339	0.00244	0.00136	0.000062
Titanium (Ti)-Total	mg/L	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Total	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Vanadium (V)-Total	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Zinc (Zn)-Total	mg/L	0.00080	<0.00080	<0.00080	<0.00080	<0.00080	<0.00080	<0.00080
Dissolved Metals								
Aluminum (Al)-Dissolved	mg/L	0.00030	0.00042	<0.00030	<0.00030	0.00057	0.00047	0.00051
Antimony (Sb)-Dissolved	mg/L	0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Arsenic (As)-Dissolved	mg/L	0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Barium (Ba)-Dissolved	mg/L	0.000050	0.000177	<0.000050	0.000134	<0.000050	0.000071	<0.000050
Beryllium (Be)-Dissolved	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Bismuth (Bi)-Dissolved	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Boron (B)-Dissolved	mg/L	0.0010	0.0070	0.0130	<0.0010	0.0080	0.0083	0.0013
Cadmium (Cd)-Dissolved	mg/L	0.0000050	<0.0000050	<0.0000050	0.0000141	0.0000055	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	mg/L	0.020	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium (Cr)-Dissolved	mg/L	0.000060	<0.000060	<0.000060	<0.000060	0.000096	0.000163	<0.000060
Cobalt (Co)-Dissolved	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Copper (Cu)-Dissolved	mg/L	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00019	<0.00010
Iron (Fe)-Dissolved	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Lead (Pb)-Dissolved	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Lithium (Li)-Dissolved	mg/L	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium (Mg)-Dissolved	mg/L	0.0040	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (Mn)-Dissolved	mg/L	0.000050	0.000057	0.000071	0.000084	0.000109	0.000105	<0.000050
Mercury (Hg)-Dissolved	mg/L	0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Molybdenum (Mo)-Dissolved	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Nickel (Ni)-Dissolved	mg/L	0.000060	0.000060	<0.000060	<0.000060	<0.000060	<0.000060	<0.000060
Potassium (K)-Dissolved	mg/L	0.020	0.14	<0.1	<0.10	<0.10	<0.10	<0.10

Table 4-1: Summary of Blank Samples

RESULTS OF ANALYSIS	Units	DL	QC-Blank	QC-Blank	QC-Blank	QC-Blank	QC-Blank	QC-Blank
Date Sampled			07-MAY-12	06-JUL-12	16-JUL-12	08-AUG-12	11-AUG-12	28-AUG-12
ALS Sample ID			L1145577-9	L1177320-11	L1181227-18	L1191540-5	L1192736-11	L1202453-2
Selenium (Se)-Dissolved	mg/L	0.000040	<0.000040	<0.000040	<0.000040	<0.000040	<0.000040	<0.000040
Silicon (Si)-Dissolved	mg/L		<0.10		<0.10	<0.10		<0.10
Silver (Ag)-Dissolved	mg/L	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)-Dissolved	mg/L	0.0050	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Strontium (Sr)-Dissolved	mg/L	0.000050	0.000350	<0.000050	0.000069	0.000058	0.000067	<0.000050
Thallium (Tl)-Dissolved	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	0.000050	0.00115	0.000628	0.000243	0.00210	0.00114	0.000074
Titanium (Ti)-Dissolved	mg/L	0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Dissolved	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Vanadium (V)-Dissolved	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Zinc (Zn)-Dissolved	mg/L	0.00080	<0.00080	<0.00080	<0.00080	0.00170	0.00123	<0.00080

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data				May	May
Sample ID			R3-T	R3-T-Dup1	R3-T-Dup2	SD	RSD (R3-Top)	QC Statement
ALS Sample ID			L1145577-5	L1145577-7	L1145577-8			
Physical Tests								
Total Suspended Solids	mg/L	3.0	3	3	3	0	0%	-
Total Dissolved Solids	mg/L	10	12	13	10	1.527525232	13%	-
Turbidity	NTU	0.10	0.18	0.18	0.20	0.011547005	6%	-
Anions and Nutrients								
Gran Alkalinity (as H+)	meq/L	0.10	0.1	0.1	0.11	0.005773503	6%	-
Alkalinity, Total (as CaCO3)	mg/L	5.0	5	5	5	0	0%	-
Ammonia, Total (as N)	mg/L	0.0050	0.0084	0.0107	0.0100	0.001178983	12%	-
Bicarbonate (HCO3)	mg/L	5.0	5	5	5.1	0.057735027	1%	-
Carbonate (CO3)	mg/L	5.0	5	5	5	0	0%	-
Chloride (Cl)	mg/L	0.50	0.5	0.5	0.5	0	0%	-
Conductivity (EC)	µS/cm	0.20	37.6	34.1	25.1	6.448514041	20%	-
Fluoride (F)	mg/L	0.050	0.05	0.05	0.05	8.49837E-18	0%	-
Hardness (as CaCO3)	mg/L	-	5.4	6.5	6.2	0.56862407	9%	-
Hydroxide (OH)	mg/L	5.0	5	5	5	0	0%	-
Nitrate and Nitrite (as N)	mg-N/L	0.0060	0.0088	0.006	0.006	0.001616581	**23%**	-
Nitrate (as N)	mg-N/L	0.0060	0.0088	0.006	0.006	0.001616581	**23%**	-
Nitrite (as N)	mg-N/L	0.0020	0.002	0.002	0.002	0	0%	-
Total Kjeldahl Nitrogen	mg-N/L	0.050	0.061	0.091	0.123	0.031005376	**34%**	-
pH	-	0.10	6.88	6.94	6.96	0.04163332	1%	-
Orthophosphate-Dissolved (as P)	mg-P/L	0.0010	0.001	0.001	0.001	0	0%	-
Phosphorus (P)-Total Dissolved	mg-P/L	0.0010	0.001	0.001	0.001	0	0%	-
Phosphorus (P)-Total	mg-P/L	0.0010	0.0019	0.0015	0.0012	0.000351188	**23%**	-
TDS (Calculated)	mg/L	-	5.0	5.6	5.4	0.305505046	6%	-
Sulfate (SO4)	mg/L	0.050	2.27	2.46	2.39	0.096090235	4%	-
Cyanides								
Cyanide, Total	mg/L	0.0020	0.002	0.002	0.002	0	0%	-
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L	1.0	3.1	4.0	3.9	0.493288286	13%	-
Total Organic Carbon	mg/L	1.0	3.2	3.1	3.2	0.057735027	2%	-
Inorganic Parameters								

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data				May	May
Sample ID			R3-T	R3-T-Dup1	R3-T-Dup2	SD	RSD (R3-Top)	QC Statement
ALS Sample ID			L1145577-5	L1145577-7	L1145577-8			
Silicon (as SiO2)-Dissolved	mg/L	0.21	0.62	0.69	0.69	0.040414519	6%	-
Total Metals								
Mercury (Hg)-Total	mg/L	0.000020	0.00002	0.00002	0.00002	0	0%	-
Total Metals (Undigested)								
Aluminum (Al)-Total	mg/L	0.00030	0.0108	0.0104	0.00873	0.001098013	11%	-
Antimony (Sb)-Total	mg/L	0.000020	0.00002	0.00002	0.00002	0	0%	-
Arsenic (As)-Total	mg/L	0.000020	0.000209	0.000213	0.000204	4.50925E-06	2%	-
Barium (Ba)-Total	mg/L	0.000050	0.00220	0.00232	0.00216	8.32666E-05	4%	-
Beryllium (Be)-Total	mg/L	0.000010	0.00001	0.00001	0.00001	0	0%	-
Bismuth (Bi)-Total	mg/L	0.000010	0.00001	0.00001	0.00001	0	0%	-
Boron (B)-Total	mg/L	0.0010	0.0015	0.0016	0.0016	5.7735E-05	4%	-
Cadmium (Cd)-Total	mg/L	0.0000050	0.000005	0.000005	0.000005	0	0%	-
Calcium (Ca)-Total	mg/L	0.020	1.28	1.39	1.27	0.066583281	5%	-
Chromium (Cr)-Total	mg/L	0.000060	0.00006	0.00006	0.00006	0	0%	-
Cobalt (Co)-Total	mg/L	0.000010	0.000016	0.000011	0.000014	2.51661E-06	18%	-
Copper (Cu)-Total	mg/L	0.00010	0.00057	0.00064	0.00064	4.04145E-05	7%	-
Iron (Fe)-Total	mg/L	0.0010	0.0028	0.0021	0.0019	0.000472582	**21%**	-
Lead (Pb)-Total	mg/L	0.000010	0.00001	0.00001	0.00001	0	0%	-
Lithium (Li)-Total	mg/L	0.00050	0.00090	0.00097	0.00094	3.51188E-05	4%	-
Magnesium (Mg)-Total	mg/L	0.0040	0.695	0.718	0.683	0.017785762	3%	-
Manganese (Mn)-Total	mg/L	0.000050	0.000473	0.000470	0.000446	1.47986E-05	3%	-
Molybdenum (Mo)-Total	mg/L	0.000050	0.00005	0.00005	0.00005	0	0%	-
Nickel (Ni)-Total	mg/L	0.000060	0.000510	0.000604	0.000533	0.000049	9%	-
Potassium (K)-Total	mg/L	0.020	0.401	0.410	0.397	0.006658328	2%	-
Selenium (Se)-Total	mg/L	0.000040	0.00004	0.00004	0.00004	0	0%	-
Silver (Ag)-Total	mg/L	0.0000050	0.000005	0.000005	0.000005	0	0%	-
Sodium (Na)-Total	mg/L	0.0050	0.533	0.554	0.525	0.014977761	3%	-
Strontium (Sr)-Total	mg/L	0.000050	0.00600	0.00621	0.00605	0.000109697	2%	-
Thallium (Tl)-Total	mg/L	0.000010	0.00001	0.00001	0.00001	0	0%	-
Tin (Sn)-Total	mg/L	0.000050	0.00005	0.00005	0.00005	0	0%	-
Titanium (Ti)-Total	mg/L	0.00010	0.00011	0.00014	0.0001	2.08167E-05	18%	-

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data				May	May
Sample ID			R3-T	R3-T-Dup1	R3-T-Dup2	SD	RSD (R3-Top)	QC Statement
ALS Sample ID			L1145577-5	L1145577-7	L1145577-8			
Uranium (U)-Total	mg/L	0.000010	0.000075	0.000077	0.000075	1.1547E-06	2%	-
Vanadium (V)-Total	mg/L	0.000050	0.00005	0.00005	0.00005	0	0%	-
Zinc (Zn)-Total	mg/L	0.00080	0.0008	0.0008	0.00112	0.000184752	20%	-
Dissolved Metals								
Aluminum (Al)-Dissolved	mg/L	0.00030	0.00748	0.00861	0.00811	0.000566245	7%	-
Antimony (Sb)-Dissolved	mg/L	0.000020	0.00002	0.00002	0.00002	0	0%	-
Arsenic (As)-Dissolved	mg/L	0.000020	0.000174	0.000195	0.000211	1.85562E-05	10%	-
Barium (Ba)-Dissolved	mg/L	0.000050	0.00215	0.00300	0.00229	0.000455741	18%	-
Beryllium (Be)-Dissolved	mg/L	0.000010	0.00001	0.00001	0.00001	0	0%	-
Bismuth (Bi)-Dissolved	mg/L	0.000010	0.00001	0.00001	0.00001	0	0%	-
Boron (B)-Dissolved	mg/L	0.0010	0.0028	0.0028	0.0029	5.7735E-05	2%	-
Cadmium (Cd)-Dissolved	mg/L	0.0000050	0.000005	0.000005	0.000005	0	0%	-
Calcium (Ca)-Dissolved	mg/L	0.020	1.25	1.37	1.38	0.072341781	5%	-
Chromium (Cr)-Dissolved	mg/L	0.000060	0.00006	0.00006	0.00006	0	0%	-
Cobalt (Co)-Dissolved	mg/L	0.000010	0.000011	0.00001	0.000034	1.35769E-05	74%	-
Copper (Cu)-Dissolved	mg/L	0.00010	0.00065	0.00067	0.00062	2.51661E-05	4%	-
Iron (Fe)-Dissolved	mg/L	0.0010	0.0011	0.0010	0.001	5.7735E-05	6%	-
Lead (Pb)-Dissolved	mg/L	0.000010	0.00001	0.00001	0.00001	0	0%	-
Lithium (Li)-Dissolved	mg/L	0.00050	0.00088	0.00094	0.00090	3.05505E-05	3%	-
Magnesium (Mg)-Dissolved	mg/L	0.0040	0.64	0.68	0.69	0.026457513	4%	-
Manganese (Mn)-Dissolved	mg/L	0.000050	0.000394	0.000639	0.00255	0.001180415	99%	fail
Mercury (Hg)-Dissolved	mg/L	0.000020	0.00002	0.00002	0.00002	0	0%	-
Molybdenum (Mo)-Dissolved	mg/L	0.000050	0.00005	0.00005	0.00005	0	0%	-
Nickel (Ni)-Dissolved	mg/L	0.000060	0.000499	0.000573	0.000586	4.6929E-05	8%	-
Potassium (K)-Dissolved	mg/L	0.020	0.49	0.52	0.50	0.015275252	3%	-
Selenium (Se)-Dissolved	mg/L	0.000040	0.00004	0.00004	0.00004	0	0%	-
Silver (Ag)-Dissolved	mg/L	0.0000050	0.000005	0.000005	0.000005	0	0%	-
Sodium (Na)-Dissolved	mg/L	0.0050	1	1	1	0	0%	-
Strontium (Sr)-Dissolved	mg/L	0.000050	0.00579	0.00609	0.00595	0.000150111	3%	-
Thallium (Tl)-Dissolved	mg/L	0.000010	0.00001	0.00001	0.00001	0	0%	-
Tin (Sn)-Dissolved	mg/L	0.000050	0.00005	0.00005	0.00005	0	0%	-

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data				May	May
Sample ID			R3-T	R3-T-Dup1	R3-T-Dup2	SD	RSD (R3-Top)	QC Statement
ALS Sample ID			L1145577-5	L1145577-7	L1145577-8			
Titanium (Ti)-Dissolved	mg/L	0.00010	0.0001	0.0001	0.0001	0	0%	-
Uranium (U)-Dissolved	mg/L	0.000010	0.000061	0.000063	0.000061	1.1547E-06	2%	-
Vanadium (V)-Dissolved	mg/L	0.000050	0.00005	0.00005	0.00005	0	0%	-
Zinc (Zn)-Dissolved	mg/L	0.00080	0.0008	0.00119	0.00083	0.000217025	**23%**	-

Note:
QC Statement - "-" if pass; "fail" if >20% and >5xDL

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data		July	July	Data		July	July
Sample ID			L300-02 TOP	L300-02-TOP-Dup	RPD (L300-02-T)	QC Statement	D301	D301-Dup	RPD (D301)	QC Statement
ALS Sample ID			L1177320-8	L1177320-10			L1177320-19	L1177320-20		
Physical Tests										
Total Suspended Solids	mg/L	3.0	3	3	0%	-	3	3	0%	-
Total Dissolved Solids	mg/L	10	16	14	13%	-	10	13	**26%**	-
Turbidity	NTU	0.10	0.30	0.30	0%	-	0.30	0.29	3%	-
Anions and Nutrients										
Gran Alkalinity (as H+)	meq/L	0.10	0.1	0.1	0%	-	0.1	0.1	0%	-
Alkalinity, Total (as CaCO3)	mg/L	5.0	5	5	0%	-	5	5	0%	-
Ammonia, Total (as N)	mg/L	0.0050	0.005	0.005	0%	-	0.005	0.005	0%	-
Bicarbonate (HCO3)	mg/L	5.0	5	5	0%	-	5	5	0%	-
Carbonate (CO3)	mg/L	5.0	5	5	0%	-	5	5	0%	-
Chloride (Cl)	mg/L	0.50	0.5	0.5	0%	-	0.5	0.5	0%	-
Conductivity (EC)	µS/cm	0.20	14.1	14.1	0%	-	10.2	10.1	1%	-
Fluoride (F)	mg/L	0.050	0.05	0.05	0%	-	0.05	0.05	0%	-
Hardness (as CaCO3)	mg/L	-	6.2	5.8	7%	-	4.1	3.8	8%	-
Hydroxide (OH)	mg/L	5.0	5	5	0%	-	5	5	0%	-
Nitrate and Nitrite (as N)	mg-N/L	0.0060	0.006	0.006	0%	-	0.006	0.0067	11%	-
Nitrate (as N)	mg-N/L	0.0060	0.006	0.006	0%	-	0.006	0.0067	11%	-
Nitrite (as N)	mg-N/L	0.0020	0.002	0.002	0%	-	0.002	0.002	0%	-
Total Kjeldahl Nitrogen	mg-N/L	0.050	0.138	0.131	5%	-	0.075	0.054	**33%**	-
pH	-	0.10	6.72	6.74	0%	-	6.74	6.74	0%	-
Orthophosphate-Dissolved (as P)	mg-P/L	0.0010	0.001	0.001	0%	-	0.001	0.001	0%	-
Phosphorus (P)-Total Dissolved	mg-P/L	0.0010	0.001	0.001	0%	-	0.0035	0.0011	**104%**	-
Phosphorus (P)-Total	mg-P/L	0.0010	0.0011	0.0010	10%	-	0.0027	0.0023	16%	-
TDS (Calculated)	mg/L	-	5.3	5.3	0%	-	3.1	3.0	3%	-
Sulfate (SO4)	mg/L	0.050	2.77	2.81	1%	-	1.39	1.32	5%	-
Cyanides										
Cyanide, Total	mg/L	0.0020	0.002	0.002	0%	-	0.002	0.002	0%	-
Organic / Inorganic Carbon										
Dissolved Organic Carbon	mg/L	1.0	3.4	3.5	3%	-	3.2	3.3	3%	-
Total Organic Carbon	mg/L	1.0	3.4	3.6	6%	-	3.4	3.3	3%	-
Inorganic Parameters										

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data		July	July	Data		July	July
Sample ID			L300-02 TOP	L300-02-TOP-Dup	RPD (L300-02-T)	QC Statement	D301	D301-Dup	RPD (D301)	QC Statement
ALS Sample ID			L1177320-8	L1177320-10			L1177320-19	L1177320-20		
Silicon (as SiO2)-Dissolved	mg/L	0.21	0.51	0.48	6%	-	0.51	0.51	0%	-
Total Metals										
Mercury (Hg)-Total	mg/L	0.000020	0.00002	0.00002	0%	-	0.00002	0.00002	0%	-
Total Metals (Undigested)										
Aluminum (Al)-Total	mg/L	0.00030	0.0244	0.0202	19%	-	0.0176	0.0164	7%	-
Antimony (Sb)-Total	mg/L	0.000020	0.00002	0.00002	0%	-	0.00002	0.00002	0%	-
Arsenic (As)-Total	mg/L	0.000020	0.000226	0.000202	11%	-	0.000197	0.000189	4%	-
Barium (Ba)-Total	mg/L	0.000050	0.00223	0.00233	4%	-	0.00172	0.00172	0%	-
Beryllium (Be)-Total	mg/L	0.000010	0.00001	0.00001	0%	-	0.00001	0.00001	0%	-
Bismuth (Bi)-Total	mg/L	0.000010	0.00001	0.00001	0%	-	0.00001	0.00001	0%	-
Boron (B)-Total	mg/L	0.0010	0.0036	0.0047	**27%**	-	0.0044	0.0037	17%	-
Cadmium (Cd)-Total	mg/L	0.0000050	0.000005	0.000005	0%	-	0.0000056	0.0000072	**25%**	-
Calcium (Ca)-Total	mg/L	0.020	1.06	1.04	2%	-	0.794	0.869	9%	-
Chromium (Cr)-Total	mg/L	0.000060	0.000063	0.00006	5%	-	0.00006	0.000069	14%	-
Cobalt (Co)-Total	mg/L	0.000010	0.000080	0.000079	1%	-	0.000026	0.000033	**24%**	-
Copper (Cu)-Total	mg/L	0.00010	0.00092	0.00705	**154%**	**fail**	0.00090	0.00090	0%	-
Iron (Fe)-Total	mg/L	0.0010	0.0199	0.0124	**46%**	**fail**	0.0160	0.0164	2%	-
Lead (Pb)-Total	mg/L	0.000010	0.00001	0.00001	0%	-	0.000057	0.000061	7%	-
Lithium (Li)-Total	mg/L	0.00050	0.00078	0.00092	16%	-	0.00054	0.00060	11%	-
Magnesium (Mg)-Total	mg/L	0.0040	0.683	0.694	2%	-	0.475	0.487	2%	-
Manganese (Mn)-Total	mg/L	0.000050	0.00285	0.00290	2%	-	0.00246	0.00259	5%	-
Molybdenum (Mo)-Total	mg/L	0.000050	0.00005	0.00005	0%	-	0.00005	0.00005	0%	-
Nickel (Ni)-Total	mg/L	0.000060	0.00132	0.00139	5%	-	0.000286	0.000266	7%	-
Potassium (K)-Total	mg/L	0.020	0.386	0.394	2%	-	0.280	0.291	4%	-
Selenium (Se)-Total	mg/L	0.000040	0.00004	0.00004	0%	-	0.00004	0.00004	0%	-
Silver (Ag)-Total	mg/L	0.0000050	0.000005	0.000005	0%	-	0.000005	0.000005	0%	-
Sodium (Na)-Total	mg/L	0.0050	0.516	0.522	1%	-	0.446	0.459	3%	-
Strontium (Sr)-Total	mg/L	0.000050	0.00545	0.00551	1%	-	0.00399	0.00407	2%	-
Thallium (Tl)-Total	mg/L	0.000010	0.00001	0.00001	0%	-	0.00001	0.00001	0%	-
Tin (Sn)-Total	mg/L	0.000050	0.00005	0.00005	0%	-	0.00005	0.00005	0%	-
Titanium (Ti)-Total	mg/L	0.00010	0.00126	0.0001	**171%**	**fail**	0.00013	0.0001	**26%**	-

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data		July	July	Data		July	July
Sample ID			L300-02 TOP	L300-02-TOP-Dup	RPD (L300-02-T)	QC Statement	D301	D301-Dup	RPD (D301)	QC Statement
ALS Sample ID			L1177320-8	L1177320-10			L1177320-19	L1177320-20		
Uranium (U)-Total	mg/L	0.000010	0.000028	0.000027	4%	-	0.000060	0.000064	6%	-
Vanadium (V)-Total	mg/L	0.000050	0.00005	0.00005	0%	-	0.00005	0.00005	0%	-
Zinc (Zn)-Total	mg/L	0.00080	0.00192	0.00328	52%	-	0.00255	0.00182	33%	-
Dissolved Metals										
Aluminum (Al)-Dissolved	mg/L	0.00030	0.0153	0.0148	3%	-	0.0136	0.0125	8%	-
Antimony (Sb)-Dissolved	mg/L	0.000020	0.00002	0.00002	0%	-	0.00002	0.00002	0%	-
Arsenic (As)-Dissolved	mg/L	0.000020	0.000256	0.000210	20%	-	0.000209	0.000171	20%	-
Barium (Ba)-Dissolved	mg/L	0.000050	0.00217	0.00212	2%	-	0.00161	0.00164	2%	-
Beryllium (Be)-Dissolved	mg/L	0.000010	0.00001	0.00001	0%	-	0.00001	0.00001	0%	-
Bismuth (Bi)-Dissolved	mg/L	0.000010	0.00001	0.00001	0%	-	0.00001	0.00001	0%	-
Boron (B)-Dissolved	mg/L	0.0010	0.0038	0.0057	40%	fail	0.0058	0.0041	34%	fail
Cadmium (Cd)-Dissolved	mg/L	0.0000050	0.000005	0.000005	0%	-	0.000005	0.000005	0%	-
Calcium (Ca)-Dissolved	mg/L	0.020	1.27	1.21	5%	-	0.87	0.83	5%	-
Chromium (Cr)-Dissolved	mg/L	0.000060	0.00006	0.00006	0%	-	0.00006	0.00006	0%	-
Cobalt (Co)-Dissolved	mg/L	0.000010	0.000052	0.000050	4%	-	0.000017	0.000014	19%	-
Copper (Cu)-Dissolved	mg/L	0.00010	0.00087	0.00084	4%	-	0.00081	0.00080	1%	-
Iron (Fe)-Dissolved	mg/L	0.0010	0.0071	0.0071	0%	-	0.0079	0.0063	23%	fail
Lead (Pb)-Dissolved	mg/L	0.000010	0.00001	0.00001	0%	-	0.000028	0.000023	20%	-
Lithium (Li)-Dissolved	mg/L	0.00050	0.00085	0.00084	1%	-	0.00055	0.00064	15%	-
Magnesium (Mg)-Dissolved	mg/L	0.0040	0.74	0.68	8%	-	0.47	0.43	9%	-
Manganese (Mn)-Dissolved	mg/L	0.000050	0.00195	0.00198	2%	-	0.00132	0.00112	16%	-
Mercury (Hg)-Dissolved	mg/L	0.000020	0.00002	0.00002	0%	-	0.00002	0.00002	0%	-
Molybdenum (Mo)-Dissolved	mg/L	0.000050	0.00005	0.00005	0%	-	0.00005	0.00005	0%	-
Nickel (Ni)-Dissolved	mg/L	0.000060	0.00111	0.00110	1%	-	0.000274	0.000278	1%	-
Potassium (K)-Dissolved	mg/L	0.020	0.47	0.55	16%	-	0.36	0.37	3%	-
Selenium (Se)-Dissolved	mg/L	0.000040	0.00004	0.00004	0%	-	0.00004	0.00004	0%	-
Silver (Ag)-Dissolved	mg/L	0.0000050	0.000005	0.000005	0%	-	0.000005	0.000005	0%	-
Sodium (Na)-Dissolved	mg/L	0.0050	1	1	0%	-	1	1	0%	-
Strontium (Sr)-Dissolved	mg/L	0.000050	0.00555	0.00543	2%	-	0.00397	0.00406	2%	-
Thallium (Tl)-Dissolved	mg/L	0.000010	0.00001	0.00001	0%	-	0.00001	0.00001	0%	-
Tin (Sn)-Dissolved	mg/L	0.000050	0.00005	0.00005	0%	-	0.00005	0.00005	0%	-

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data		July	July	Data		July	July
Sample ID			L300-02 TOP	L300-02-TOP-Dup	RPD (L300-02-T)	QC Statement	D301	D301-Dup	RPD (D301)	QC Statement
ALS Sample ID			L1177320-8	L1177320-10			L1177320-19	L1177320-20		
Titanium (Ti)-Dissolved	mg/L	0.00010	0.0001	0.0001	0%	-	0.0001	0.0001	0%	-
Uranium (U)-Dissolved	mg/L	0.000010	0.000025	0.000024	4%	-	0.000055	0.000055	0%	-
Vanadium (V)-Dissolved	mg/L	0.000050	0.00005	0.00005	0%	-	0.00005	0.00005	0%	-
Zinc (Zn)-Dissolved	mg/L	0.00080	0.00170	0.00212	**22%**	-	0.00158	0.00332	**71%**	-

Note:
QC Statement - "-" if pass; "fail" if >20% and >5xDL

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data			July	July
Sample ID			L420	L420-Dup1	L420-Dup2	RSD (L420)	QC Statement
ALS Sample ID			L1181227-23	L1181227-24	L1181227-25		
Physical Tests							
Total Suspended Solids	mg/L	3.0	3	3	3	0%	-
Total Dissolved Solids	mg/L	10	13	15	10	20%	-
Turbidity	NTU	0.10	0.51	0.62	0.58	10%	-
Anions and Nutrients							
Gran Alkalinity (as H+)	meq/L	0.10	0.1	0.1	0.1	0%	-
Alkalinity, Total (as CaCO3)	mg/L	5.0	5	5	5	0%	-
Ammonia, Total (as N)	mg/L	0.0050	0.005	0.005	0.005	0%	-
Bicarbonate (HCO3)	mg/L	5.0	5	5.8	5.0	9%	-
Carbonate (CO3)	mg/L	5.0	5	5	5	0%	-
Chloride (Cl)	mg/L	0.50	0.5	0.5	0.5	0%	-
Conductivity (EC)	µS/cm	0.20	13.3	13.4	13.3	0%	-
Fluoride (F)	mg/L	0.050	0.05	0.05	0.05	0%	-
Hardness (as CaCO3)	mg/L	-	5.8	5.6	5.6	2%	-
Hydroxide (OH)	mg/L	5.0	5	5	5	0%	-
Nitrate and Nitrite (as N)	mg-N/L	0.0060	0.006	0.006	0.006	0%	-
Nitrate (as N)	mg-N/L	0.0060	0.006	0.006	0.006	0%	-
Nitrite (as N)	mg-N/L	0.0020	0.002	0.002	0.002	0%	-
Total Kjeldahl Nitrogen	mg-N/L	0.050	0.164	0.182	0.129	17%	-
pH	-	0.10	6.64	6.73	6.88	2%	-
Orthophosphate-Dissolved (as P)	mg-P/L	0.0010	0.001	0.001	0.001	0%	-
Phosphorus (P)-Total Dissolved	mg-P/L	0.0010	0.0018	0.0018	0.0017	3%	-
Phosphorus (P)-Total	mg-P/L	0.0010	0.0045	0.0042	0.0077	**35%**	-
TDS (Calculated)	mg/L	-	4.5	4.3	4.4	2%	-
Sulfate (SO4)	mg/L	0.050	1.55	1.44	1.56	4%	-
Cyanides							
Cyanide, Total	mg/L	0.0020	0.002	0.002	0.002	0%	-
Organic / Inorganic Carbon							
Dissolved Organic Carbon	mg/L	1.0	4.8	4.7	4.8	1%	-
Total Organic Carbon	mg/L	1.0	4.8	4.8	4.8	0%	-
Inorganic Parameters							

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data			July	July
Sample ID			L420	L420-Dup1	L420-Dup2	RSD (L420)	QC Statement
ALS Sample ID			L1181227-23	L1181227-24	L1181227-25		
Silicon (as SiO2)-Dissolved	mg/L	0.21	1.26	1.28	1.24	2%	-
Total Metals							
Mercury (Hg)-Total	mg/L	0.000020	0.00002	0.00002	0.00002	0%	-
Total Metals (Undigested)							
Aluminum (Al)-Total	mg/L	0.00030	0.0514	0.0529	0.0521	1%	-
Antimony (Sb)-Total	mg/L	0.000020	0.00002	0.00002	0.00002	0%	-
Arsenic (As)-Total	mg/L	0.000020	0.000298	0.000303	0.000277	5%	-
Barium (Ba)-Total	mg/L	0.000050	0.00245	0.00241	0.00241	1%	-
Beryllium (Be)-Total	mg/L	0.000010	0.00001	0.00001	0.00001	0%	-
Bismuth (Bi)-Total	mg/L	0.000010	0.00001	0.00001	0.00001	0%	-
Boron (B)-Total	mg/L	0.0010	0.0027	0.0027	0.0030	6%	-
Cadmium (Cd)-Total	mg/L	0.0000050	0.0000360	0.0000360	0.0000364	1%	-
Calcium (Ca)-Total	mg/L	0.020	0.880	0.982	0.912	6%	-
Chromium (Cr)-Total	mg/L	0.000060	0.000130	0.000143	0.000142	5%	-
Cobalt (Co)-Total	mg/L	0.000010	0.000067	0.000063	0.000064	3%	-
Copper (Cu)-Total	mg/L	0.00010	0.00260	0.00270	0.00266	2%	-
Iron (Fe)-Total	mg/L	0.0010	0.114	0.116	0.114	1%	-
Lead (Pb)-Total	mg/L	0.000010	0.000071	0.000071	0.000070	1%	-
Lithium (Li)-Total	mg/L	0.00050	0.00100	0.00093	0.00097	4%	-
Magnesium (Mg)-Total	mg/L	0.0040	0.794	0.810	0.801	1%	-
Manganese (Mn)-Total	mg/L	0.000050	0.00505	0.00519	0.00503	2%	-
Molybdenum (Mo)-Total	mg/L	0.000050	0.00005	0.00005	0.00005	0%	-
Nickel (Ni)-Total	mg/L	0.000060	0.000670	0.000695	0.000708	3%	-
Potassium (K)-Total	mg/L	0.020	0.525	0.545	0.539	2%	-
Selenium (Se)-Total	mg/L	0.000040	0.00004	0.00004	0.00004	0%	-
Silver (Ag)-Total	mg/L	0.0000050	0.000005	0.000005	0.000005	0%	-
Sodium (Na)-Total	mg/L	0.0050	0.571	0.582	0.576	1%	-
Strontium (Sr)-Total	mg/L	0.000050	0.00530	0.00526	0.00534	1%	-
Thallium (Tl)-Total	mg/L	0.000010	0.00001	0.00001	0.00001	0%	-
Tin (Sn)-Total	mg/L	0.000050	0.00005	0.00005	0.00005	0%	-
Titanium (Ti)-Total	mg/L	0.00010	0.00055	0.00052	0.00046	9%	-

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data			July	July
Sample ID			L420	L420-Dup1	L420-Dup2	RSD (L420)	QC Statement
ALS Sample ID			L1181227-23	L1181227-24	L1181227-25		
Uranium (U)-Total	mg/L	0.000010	0.000080	0.000077	0.000079	2%	-
Vanadium (V)-Total	mg/L	0.000050	0.000079	0.000079	0.000088	6%	-
Zinc (Zn)-Total	mg/L	0.00080	0.0154	0.0157	0.0176	7%	-
Dissolved Metals							
Aluminum (Al)-Dissolved	mg/L	0.00030	0.0400	0.0390	0.0388	2%	-
Antimony (Sb)-Dissolved	mg/L	0.000020	0.00002	0.00002	0.00002	0%	-
Arsenic (As)-Dissolved	mg/L	0.000020	0.000263	0.000280	0.000248	6%	-
Barium (Ba)-Dissolved	mg/L	0.000050	0.00239	0.00236	0.00237	1%	-
Beryllium (Be)-Dissolved	mg/L	0.000010	0.00001	0.00001	0.00001	0%	-
Bismuth (Bi)-Dissolved	mg/L	0.000010	0.00001	0.00001	0.00001	0%	-
Boron (B)-Dissolved	mg/L	0.0010	0.0030	0.0030	0.0031	2%	-
Cadmium (Cd)-Dissolved	mg/L	0.0000050	0.0000372	0.0000401	0.0000343	8%	-
Calcium (Ca)-Dissolved	mg/L	0.020	0.88	0.90	0.87	2%	-
Chromium (Cr)-Dissolved	mg/L	0.000060	0.000087	0.000098	0.000111	12%	-
Cobalt (Co)-Dissolved	mg/L	0.000010	0.000061	0.000059	0.000057	3%	-
Copper (Cu)-Dissolved	mg/L	0.00010	0.00238	0.00242	0.00245	1%	-
Iron (Fe)-Dissolved	mg/L	0.0010	0.0729	0.0724	0.0717	1%	-
Lead (Pb)-Dissolved	mg/L	0.000010	0.000049	0.000046	0.000045	4%	-
Lithium (Li)-Dissolved	mg/L	0.00050	0.00105	0.00091	0.00093	8%	-
Magnesium (Mg)-Dissolved	mg/L	0.0040	0.75	0.76	0.74	1%	-
Manganese (Mn)-Dissolved	mg/L	0.000050	0.00474	0.00478	0.00475	0%	-
Mercury (Hg)-Dissolved	mg/L	0.000020	0.00002	0.00002	0.00002	0%	-
Molybdenum (Mo)-Dissolved	mg/L	0.000050	0.00005	0.00005	0.00005	0%	-
Nickel (Ni)-Dissolved	mg/L	0.000060	0.000688	0.000703	0.000641	5%	-
Potassium (K)-Dissolved	mg/L	0.020	0.45	0.42	0.38	8%	-
Selenium (Se)-Dissolved	mg/L	0.000040	0.00004	0.00004	0.00004	0%	-
Silver (Ag)-Dissolved	mg/L	0.0000050	0.000005	0.000005	0.000005	0%	-
Sodium (Na)-Dissolved	mg/L	0.0050	1	1	1	0%	-
Strontium (Sr)-Dissolved	mg/L	0.000050	0.00531	0.00522	0.00527	1%	-
Thallium (Tl)-Dissolved	mg/L	0.000010	0.00001	0.00001	0.00001	0%	-
Tin (Sn)-Dissolved	mg/L	0.000050	0.00005	0.00005	0.00005	0%	-

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data			July	July
Sample ID			L420	L420-Dup1	L420-Dup2	RSD (L420)	QC Statement
ALS Sample ID			L1181227-23	L1181227-24	L1181227-25		
Titanium (Ti)-Dissolved	mg/L	0.00010	0.00034	0.00036	0.00022	25%	-
Uranium (U)-Dissolved	mg/L	0.000010	0.000073	0.000073	0.000071	2%	-
Vanadium (V)-Dissolved	mg/L	0.000050	0.000060	0.000060	0.000065	5%	-
Zinc (Zn)-Dissolved	mg/L	0.00080	0.0148	0.0156	0.0151	3%	-

Note:
QC Statement - "-" if pass; "fail" if >20% and >5xDL

Table 4-2: Summary of Replicate Sample Comparison

RESULTS OF ANALYSIS	Units	DL	Data			August	August
Sample ID			L300-02 TOP	L300-02 TOP-Dup1	L300-02 TOP-Dup2	RSD (L300-02-T)	QC Statement
ALS Sample ID			L1192736-5	L1192736-7	L1192736-8		
Physical Tests							
Total Suspended Solids	mg/L	3.0	3	3	3	0%	-
Total Dissolved Solids	mg/L	10	10	16	24	**42%**	-
Turbidity	NTU	0.10	0.30	0.32	0.31	3%	-
Anions and Nutrients							
Gran Alkalinity (as H+)	meq/L	0.10	0.10	0.1	0.1	0%	-
Alkalinity, Total (as CaCO3)	mg/L	5.0	5	5	5	0%	-
Ammonia, Total (as N)	mg/L	0.0050	0.005	0.005	0.005	0%	-
Bicarbonate (HCO3)	mg/L	5.0	5	5	5	0%	-
Carbonate (CO3)	mg/L	5.0	5	5	5	0%	-
Chloride (Cl)	mg/L	0.50	0.5	0.5	0.5	0%	-
Conductivity (EC)	µS/cm	0.20	14.6	14.2	14.1	2%	-
Fluoride (F)	mg/L	0.050	0.05	0.05	0.05	0%	-
Hardness (as CaCO3)	mg/L	-	6.1	5.8	5.5	5%	
Hydroxide (OH)	mg/L	5.0	5	5	5	0%	-
Nitrate and Nitrite (as N)	mg-N/L	0.0060	0.006	0.006	0.006	0%	-
Nitrate (as N)	mg-N/L	0.0060	0.006	0.006	0.006	0%	-
Nitrite (as N)	mg-N/L	0.0020	0.002	0.002	0.002	0%	-
Total Kjeldahl Nitrogen	mg-N/L	0.050	0.157	0.168	0.137	10%	-
pH	-	0.10	6.76	6.78	6.76	0%	-
Orthophosphate-Dissolved (as P)	mg-P/L	0.0010	0.001	0.001	0.001	0%	-
Phosphorus (P)-Total Dissolved	mg-P/L	0.0010	0.0021	0.0020	0.0021	3%	-
Phosphorus (P)-Total	mg-P/L	0.0010	0.0033	0.0030	0.0029	7%	-
TDS (Calculated)	mg/L	-	5.3	5.1	5.3	2%	
Sulfate (SO4)	mg/L	0.050	2.83	2.82	3.16	7%	-
Cyanides							
Cyanide, Total	mg/L	0.0020	0.002	0.002	0.0024	11%	-
Organic / Inorganic Carbon							
Dissolved Organic Carbon	mg/L	1.0	4.2	4.1	4.2	1%	-
Total Organic Carbon	mg/L	1.0	3.8	4.4	4.1	7%	-
Inorganic Parameters							