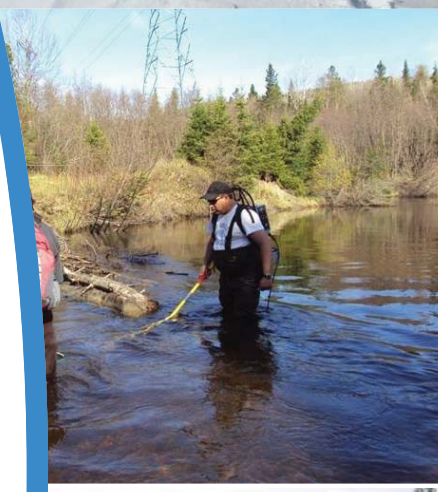
ENVIRONMENTAL ASSESSMENT FOR THE MARATHON PGM-Cu PROJECT AT MARATHON, ONTARIO



STILLWATER CANADA INC. MARATHON PGM-Cu PROJECT

SUPPORTING INFORMATION DOCUMENT No. 3 - BASELINE WATER QUALITY FOR THE MARATHON PGM-Cu PROJECT

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BASELINE WATER QUALITY CONDITIONS AT THE MARATHON PGM-Cu PROJECT SITE

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BASELINE WATER QUALITY CONDITIONS AT THE MARATHON PGM-Cu PROJECT SITE

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EXECUTIVE SUMMARY

A network of 58 water quality stations was established, including headwater and downstream areas of all of the subwatersheds that traverse the Project site, to document baseline surface water quality. Sampling of this network began in the spring of 2008, but data for the site are available dating to the early 2000s. The suite of chemical parameters that were measured included:

Parameter Category	Analytes
Physical Tests	Colour, Conductivity, Hardness (as $CaCO_3$), pH, TSS, TDS, Turbidity, DO, Temperature
Anions and Nutrients	Alkalinity, Total (as $CaCO_3$), Ammonia-N, Total Bicarbonate, Carbonate, Chloride, Fluoride, Hydroxide, Nitrate-N, Nitrite-N, TKN, Phosphorus (total), Sulphate
Carbon	DOC
Metals	Total Metals (full ICP-MS scan), Dissolved Metals (full ICP-MS scan), Mercury, Hexavalent Chromium
Aggregate Organics	BOD, Tannin and Lignins
Radionuclides	Radium-226

Chemical analysis of surface water showed that Project area waters are generally of high quality, with most parameters meeting Provincial Water Quality Objectives (PWQO) for the protection of aquatic life. Where exceedances of PWQO standards occur, the exceedances are generally small and typical of regional background conditions or reflected areas on the Project site where there is relatively high levels of mineralization associated with the Marathon PGM-Cu Project ore body.

Summary statistics were calculated for several parameters of interest in the study area. Based on the analyses and the discussion above, these statistics are considered representative of baseline concentrations for the following parameters:

- Alkalinity;
- pH;
- DOC;
- Turbidity;
- Total Suspended Solids;
- Hardness;
- Ammonia;
- Nitrate;

- Phosphate;
- Sulphate;
- Dissolved Aluminum;
- Copper;
- Iron;
- Manganese; and,
- Zinc.

For certain parameters, however, the data sets consisted largely of samples in which those parameters were not detected; their summary statistics were recommended to serve only as upper bound estimates of baseline conditions. This situation applies to the following parameters:

- Arsenic;
- Cadmium;
- Cobalt;
- Chromium (III+VI);
- Chromium (VI);
- Lead;
- Molybdenum;
- Nickel;
- Selenium;
- Thallium;
- Uranium; and
- Vanadium.

Potential groundwater-surface water interactions were assessed by correlating concentrations of conservative chemical constituents in surface water with groundwater data from bedrock wells and overburden wells. No correlation between the surface water and bedrock groundwater and surface water and overburden groundwater was noted, suggesting little interaction between the surface and subsurface environments. A positive correlation was found in each of the subwatersheds between concentrations of conservative chemical constituents in surface water in the headwater areas of the subwatersheds and the downstream areas of the subwatersheds. This result is further evidence that there is little, or limited interaction between surface water and groundwater.

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ACRONYMS AND ABBREVATIONS

BOD	Biochemical Oxygen Demand
BHP	BHP Engineering Pty Ltd.
CALA	Canadian Association for Laboratory Accreditation
CARs	Canadian Aviation Regulations
CCME	Canadian Council of Ministers of the Environment
CEA Agency	Canadian Environmental Assessment Agency
CEQG	Canadian Environmental Quality Guidelines
$CaCO_3$	Calcium Carbonate
Cu	Copper
CYSP	Marathon Municipal Airport
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EA	Environmental Assessment
EIS	Environmental Impact Statement
Fe	Iron
Hwy	Highway
HO	Harmonization Order
ICP-MS	Inductively Couple Plasma Mass Spectrometry
JRP	Joint Review Panel
M2W Line	Terrace Bay-Manitouwadge transmission line
MC	MC MINNING LTD
MPGM	Marathon PGM Corp.
MPI	Marathon Pulp Inc.
m	Metre
MDL	Method Detection Limit
MRSA	Mine Rock Storage Area
N	Nitrogen
NAG	Non-acid generating
NH_3-N	Ammonia as nitrogen
NoC	Notice of Commencement
NTU	Nephelometric Turbidity Units
O. Reg.	Ontario Regulation
OB	Overburden
OEA Act	Ontario Environmental Assessment Act

OMOE	Ontario Ministry of the Environment
OMOEE	Ontario Ministry of the Environment and Energy
PAG	Potentially acid generating
PCB	Polychlorinated biphenyl
PGE	Platinum Group Element
PGM	Platinum Group Metal
PSMF	Process Solids Management Facility
PWQO	Provincial Water Quality Objective
QA/QC	Quality Assurance Quality Control
SCI	Stillwater Canada Inc.
SFL	Sustainable Forest License
SWC	Stillwater Mining Company
TDS	Total Dissolved Solids
TGCL	True Grit Consulting Limited
TKN	Total Kjeldahl Nitrogen
ToR	Terms of Reference
TSS	Total Suspended Solids
VA	Voluntary Agreement

1.0 INTRODUCTION

Stillwater Canada Inc. (SCI) proposes to develop a platinum group metals (PGMs), copper (Cu) and possibly iron (Fe) open-pit mine and milling operation near Marathon, Ontario. A Notice of Commencement (NoC) of an environmental assessment (EA) in relation to the proposed Marathon PGM-Cu Project (the "Project") was filed by the Canadian Environmental Assessment Agency (CEA Agency) under Section 5 of the Canadian Environmental Assessment Act on April 29, 2010 (updated July 19, 2010).

The EA was referred to an independent Review Panel by the Federal Minister of the Environment on October 7, 2010. On March 23, 2011 SCI entered into a Voluntary Agreement (VA) with the Province of Ontario to have the Project subject to the Ontario Environmental Assessment Act (OEA Act). This agreement was the instrument that permitted the provincial government to issue a Harmonization Order (HO) under Section 18(2) of the Canada-Ontario Agreement on Environmental Assessment Cooperation to establish a Joint Review Panel for the Project between the Minister of the Environment, Canada and the Minister of the Environment, Ontario.

The HO was issued on March 25, 2011. The Terms of Reference (ToR) for the Project Environmental Impact Statement (EIS) and the agreement establishing the Joint Review Panel (JRP) were issued on August 8, 2011.

The following provides an overview of the proposed development including its location, surrounding land uses, the exploration history of the site and the primary conceptual features of the mining and milling facilities. The information provided below, in the Environmental Impact Statement Report and supporting technical studies is based on the conceptual mine design for the Project. The conceptual design provides planning level information for the environmental assessment process. Final detailed design will commence following EA approval in concordance with the concepts presented herein.

1.1 Project Location

The Project is located approximately 10 km north of the Town of Marathon, Ontario (Figure 1.1-1). The town, with a population of 3,353 (2011 Census), is situated adjacent to the Trans-Canada Highway 17 (Hwy 17) on the northeast shore of Lake Superior, about 300 km east and 400 km northwest (by highway) of Thunder Bay and Sault Ste. Marie, respectively.

The centre of the Project footprint sits at approximately 48° 47' N latitude and 86° 19' W longitude. The Project site is in an area characterized by relatively dense vegetation, comprised largely of a birch and, to a lesser extent, spruce-dominated mixed wood forest. The terrain is moderate to steep, with frequent bedrock outcrops and prominent east to

Figure 1.1-1: Location of the Proposed Marathon PGM-Cu Project Site near Marathon, Ontario

west oriented valleys. The climate of this area is typical of northern areas within the Canadian Shield, with long winters and short, warm summers.

1.2 Surrounding Land Uses

The Project site lies partially within the municipal boundaries of the Town of Marathon, as well as partially within the unorganized townships of Pic, O'Neil and McCoy. The primary zoning designation within the Project Site is 'rural'.

In the immediate vicinity of the Project there are several authorized aggregate sites, including SCI's licensed aggregate site located to the northeast of Hwy 17 along the existing site access road (Camp 19 Road).

The Marathon Municipal Airport (CYSP), which operates as a Registered Airport (Aerodrome class) under the Canadian Aviation Regulations (CARs; Subsection 302), is adjacent to, and south of the Project site. The airport occupies a land area of approximately 219 hectares and is accessed from Hwy 17.

Several First Nations and Métis peoples claim the Project site as falling within their traditional land use boundaries. Based on Aboriginal accounts, prior to the construction of the forestry road, the land and water uses associated with (or close to) the site would have typically been limited to the Pic River corridor, the Bamoos Lake-Hare Lake-Lake Superior corridor and the Lake Superior shoreline and near-shore area, rather than the interior of the Project site. Traditional land and water uses (or rights conferred by Treaty) that can be ascribed to the site could include:

- Hunting;
- Trapping;
- Fishing; and
- Plant harvesting for food, cultural and medicinal uses.

Primary industries supporting the Town of Marathon, as well as the region, have historically been forestry, pulp and paper, mining and tourism. The Project site is located within the Big Pic Forest Management Area. The Big Pic Forest includes Crown land east and north of Lake Superior and is generally north, south and west of the community of Manitouwadge and includes the communities of Marathon, Caramat and Hillsport.

Until July 2010 the forest was managed under the authority of a Sustainable Forest License (SFL), which was held by Marathon Pulp Inc. This SFL was revoked, with the forest reverting to the Crown as a Crown Forest. Until recently, Marathon Pulp Inc. (MPI) operated a kraft pulp mill in Marathon on the shore of Peninsula Harbour. The mill announced its indefinite shut down (effective at the end of February 2009) on February 11, 2009, and as a result there has been a significant downturn in the local economy. A second mill operated in Terrace Bay was temporarily closed in December 2011.

The Hemlo Mining Camp is located 30 km to the southeast. There are currently two mines in production at the Camp (David Bell Mine, Williams Mine), which are estimated to be in operations until 2025.

1.3 Exploration History of the Site

Exploration for copper and nickel deposits on the Project site started in the 1920s and continued until the 1940s with the discovery of titaniferous magnetite and disseminated chalcopyrite occurrences. During the past four decades, the site has undergone several phases of exploration and economic evaluation, including geophysical surveys, prospecting, trenching, diamond drill programs, geological studies, resource estimates, metallurgical studies, mining studies, and economic analyses. These studies have successively enhanced the knowledge base of the deposit.

In 1963, Anaconda acquired the Marathon property and carried out systematic exploration work including diamond drilling of 36,531 m in 173 drill holes. This culminated in the discovery of a large copper-PGM deposit. Anaconda discontinued further work on the project in the early 1980s due to low metal prices at the time.

In 1985, Fleck purchased a 100% interest in the Marathon PGM-Cu Project with the objective of improving the project economics by focusing on the platinum group element (PGE) values of the deposit. The Fleck drilling totaled 3,615 m in 37 diamond drill holes. In 1986, H.A. Symons carried out a feasibility study for Fleck based on a 9,000 tonnes per day conventional flotation plant with marketing of copper concentrate and Kilborn Limited carried out a prefeasibility review for Fleck that included preliminary results from the Lakefield pilot plant tests (Kilborn Limited, 1987). The feasibility study indicated a low internal rate of return which was confirmed by Teck Corporation who concluded the project was uneconomic due to low metal prices at the time. On June 10, 1998, Fleck changed its name to PolyMet Mining Corp.

In 2000, Geomaque acquired certain rights to the Marathon PGM-Cu Project through an option agreement with Polymet. Geomaque and its consultants carried out a study of the economic potential of the Marathon PGM-Cu Project. The study included a review of the geology and drill hole database, interpretation of the mineralized zones, statistics and geostatistics, computerized block model, resource estimation, open pit design and optimization, metallurgy, process design, environmental aspects, capital and operating cost.

Marathon PGM Corp. acquired the Marathon PGM-Cu deposit from Polymet in December 2003. Marathon PGM Corp. funded programs of advanced exploration and diamond drilling on a continuous basis between June 2004 and 2009. Approximately 320 holes and 65,000 m were drilled from 2007 to 2009 to define and expand the resource and for condemnation holes outside of the pit area. A feasibility study was published in 2008 and updated in January 2010.

Stillwater Mining Company (SWC) and Marathon PGM entered into an agreement on September 7, 2010 pursuant to which SWC would acquire all of the outstanding shares of

Marathon PGM. The acquisition agreement received ministerial approval under the Investment Canada Act on November 24, 2010 and the agreement closed on November 30, 2010. On December 31, 2010 Stillwater Mining Company formed a Canadian corporation, Stillwater Canada Inc. In March 2012, MC MINING LTD (MC) purchased 25% interest in Stillwater Canada Inc. who is the proponent of the Marathon PGM-Cu Project.

1.4 Project Overview

The Project is based on the development of an open pit mining and milling operation. Existing conditions on and around the site and the conceptual general layout of the components of the mine site, the transmission line corridor and access road are provided in Figures 1.4-1 and 1.4-2, respectively. One primary pit and a satellite pit complex to the south (currently envisaged to be comprised of four satellite pits) are proposed to be mined. Ore will be processed (crushed, ground, concentrated) at an on-site processing facility. Final concentrates containing copper and platinum group metals will be transported off-site via road and/or rail to a smelter and refinery for subsequent metal extraction and separation. The total mineral reserve (proven and probable) is estimated to be approximately 91.5 million tonnes. It is possible that an iron concentrate may also be produced, depending upon the results of further metallurgical testing and market conditions at that time.

During the operations phase of the Project, ore will be fed to the mill at an average rate of approximately 22,000 tonnes per day. The operating life of the mine is estimated to be approximately 11.5 years. The construction workforce will average approximately 400 people and will be required for between 18 and 24 months. During operations the work force will comprise an estimated 365 workers. The mine workforce will reside in local and surrounding communities, as well as in an Accommodations Complex that will be constructed in the Town of Marathon.

Approximately 288 million tonnes of mine rock[1] will be excavated. It is estimated that between eighty five to ninety percent of this material is non-acid generating (NAG) and will be permanently stored in a purposefully built Mine Rock Storage Area (MRSA) located east of the primary pit. The NAG or so-called Type 1 mine rock will also be used in the construction of access roads, dams and other site infrastructure as needed. Drainage from the MRSA will be collected, stored, treated and discharged as necessary to the Pic River. During mine operations, about 20 million tonnes of mine rock could have the potential to generate acid if left exposed for extended periods of time. This mine rock is referred to as Type 2 mine rock or potentially acid generating (PAG). The Type 2 mine rock will be managed on surface during mine operations in temporary stock piles with drainage directed into the open pits. This material will be relocated to

[1] Mine rock is rock that has been excavated from active mining areas but does not have sufficient ore grades to process for mineral extraction.

the bottom of the primary and satellite pits and covered with water to prevent potential acid generation and covered with Type 1 materials.

Process solids[2] will be managed in the Process Solids Management Facility (PSMF), as well as in the satellite pit complex. The PSMF will be designed to hold approximately 61 million m^3 of material, and its creation will require the construction of dams. Two streams of process solids will be generated. An estimated 85 to 90% of the total amount of process solids produced will be non-acid generating, or so-called Type 1 process solids. The remaining ten to fifteen percent of the process solids could be potentially acid generating and referred to as Type 2 process solids. The Type 2 process solids will be stored below the water table in the PSMF or below water in the pits to mitigate potential acid generation and covered with Type 1materials. Water collected within the PSMF, as well as water collected around the mine site other than from the MRSA will be managed in the PSMF for eventual reclamation in the milling process. Excess water not needed in the mill will be discharged, following treatment as is necessary, to Hare Lake.

Access to the Project site is currently provided by the Camp 19 Road, opposite Peninsula Road at Hwy 17. The existing road runs east towards the Pic River before turning north along the river to the Project site (approximately 8 km). The existing road will be upgraded and utilized from its junction with Hwy 17 for approximately 2.0 km. At this point a new road running north will be constructed to the future plant site. The primary rationale for developing the new road is to move traffic away from the Pic River. The new section of road will link two sections of forest access roads located on the site.

Power to the Project site will be provided via a new 115 kV transmission line that will be constructed from a junction point on the Terrace Bay-Manitouwadge transmission line (M2W Line) located to the northwest of the primary pit. The new transmission line will run approximately 4.1 km to a substation at the mill site. The width of the transmission corridor will be approximately 30 m.

Disturbed areas of the Project footprint will be reclaimed in a progressive manner during all Project phases. Natural drainage patterns will be restored as much as possible. The ultimate goal of mine decommissioning will be to reclaim land within the Project footprint to permit future use by resident biota and as determined through consultation with the public, Aboriginal peoples and government. A certified Closure Plan for the Project will be prepared as required by Ontario Regulation (O.Reg.) 240/00 as amended by O.Reg.194/06 “Mine Development and Closure under Part VII of the Mining Act” and “Mine Rehabilitation Code of Ontario”.

Maps showing the existing features and topography of the site, as well as the proposed conceptual development of the site are provided in Figure 1.4-1 and 1.4-2 below.

[2] Process solids are solids generated during the ore milling process following extraction of the ore (minerals) from the host material.

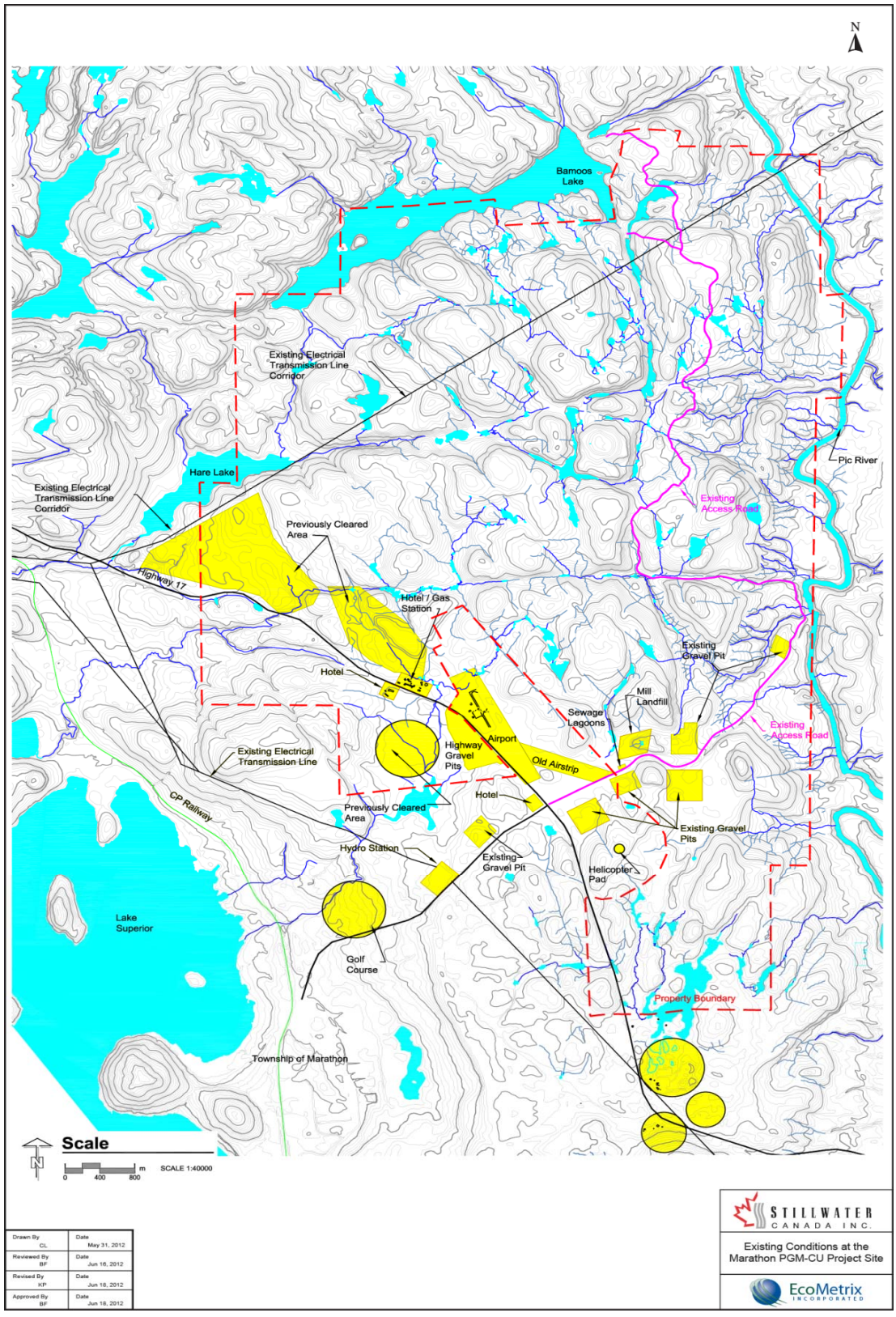

Figure 1.4-1: Existing Conditions at the Marathon PGM-Cu Project Site

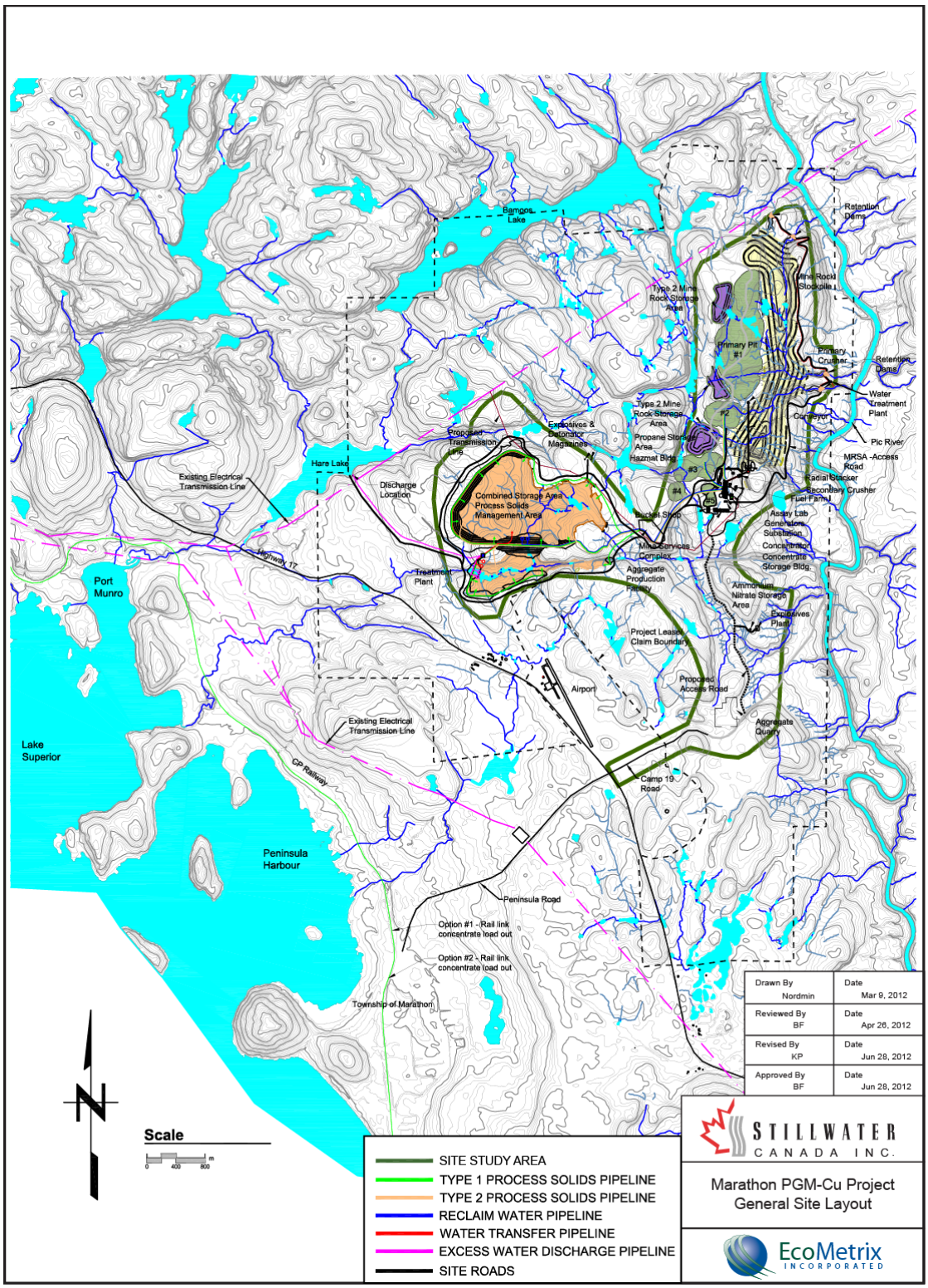

Figure 1.4-2: Marathon PGM-Cu Project General Site Layout

1.5 Scope of Work

This report summarizes the results of water quality sampling completed on and around the Marathon PGM-Cu Project site near Marathon, Ontario. An extensive network of water quality monitoring stations has been established including headwater and downstream areas of all of the watersheds (and subwatersheds) that traverse the Project area. In total, the network comprises 58 stations including; 13 lake stations, four Pic River stations and 41 stream stations (Figure 1.5-1). Sampling of this network began in the spring of 2008 and is ongoing[3]. The network encompasses a number of different subwatersheds draining to the Pic River and Lake Superior (Figures 1.5-2 to 1.5-10).

Sampling was conducted on a monthly basis through the ice-free season (roughly May through November). Samples have also been collected in the winter under ice from the lakes within the Project area by Golder in 2007 and True Grit Consulting Ltd. in 2009. All water quality monitoring data are housed in database format (MS ACCESS™). The database, containing more than 63,000 records, includes spot measurements of water quality collected coincident with other sampling events dating back to 2001. The sampling program includes QA/QC components that assess the integrity of field collection activities (trip blanks, field blanks, field duplicates), laboratory analyses (laboratory blanks, laboratory duplicates, concentration standards) and data management (manual checks of database values with laboratory reports). All samples were submitted to and analyzed by Canadian Association for Laboratory Accreditation Inc. (CALA) accredited laboratories. The range of parameters for which analyses (or measurements) were completed is provided in Table 1.5-1. The development of the parameter list considered those substances listed in the Lake Superior Zero Discharge Demonstration Program including mercury, PCBs, dioxin, hexachlorobenzene, octachlorostyrene, dieldrin, chlordane, DDT and toxaphene. Of these nine substances only mercury is relevant to the proposed mine development and was therefore included in the baseline program.

[3] Water quality sampling on the Project site began as far back as 2001 but the sampling program as it is currently constituted was developed in 2008.

Table 1.5-1: Parameters Analyzed as part of Routine Surface Water Quality Sampling on the Project Site[4].

Parameter Category	Analytes
Physical Tests	Colour, Conductivity, Hardness (as $CaCO_3$), pH, TSS, TDS, Turbidity, DO, Temperature
Anions and Nutrients	Alkalinity, Total (as $CaCO_3$), Ammonia-N, Total Bicarbonate, Carbonate, Chloride, Fluoride, Hydroxide, Nitrate-N, Nitrite-N, TKN, Phosphorus (total), Sulphate
Carbon	DOC
Metals	Total Metals (full ICP-MS scan), Dissolved Metals (full ICP-MS scan), Mercury, Hexavalent Chromium
Aggregate Organics	BOD, Tannin and Lignins
Radionuclides	Radium-226

[4] Samples for the characterization of chlorophyll a were also collected in larger water bodies in the study area. These data are reported in EcoMetrix (2012)

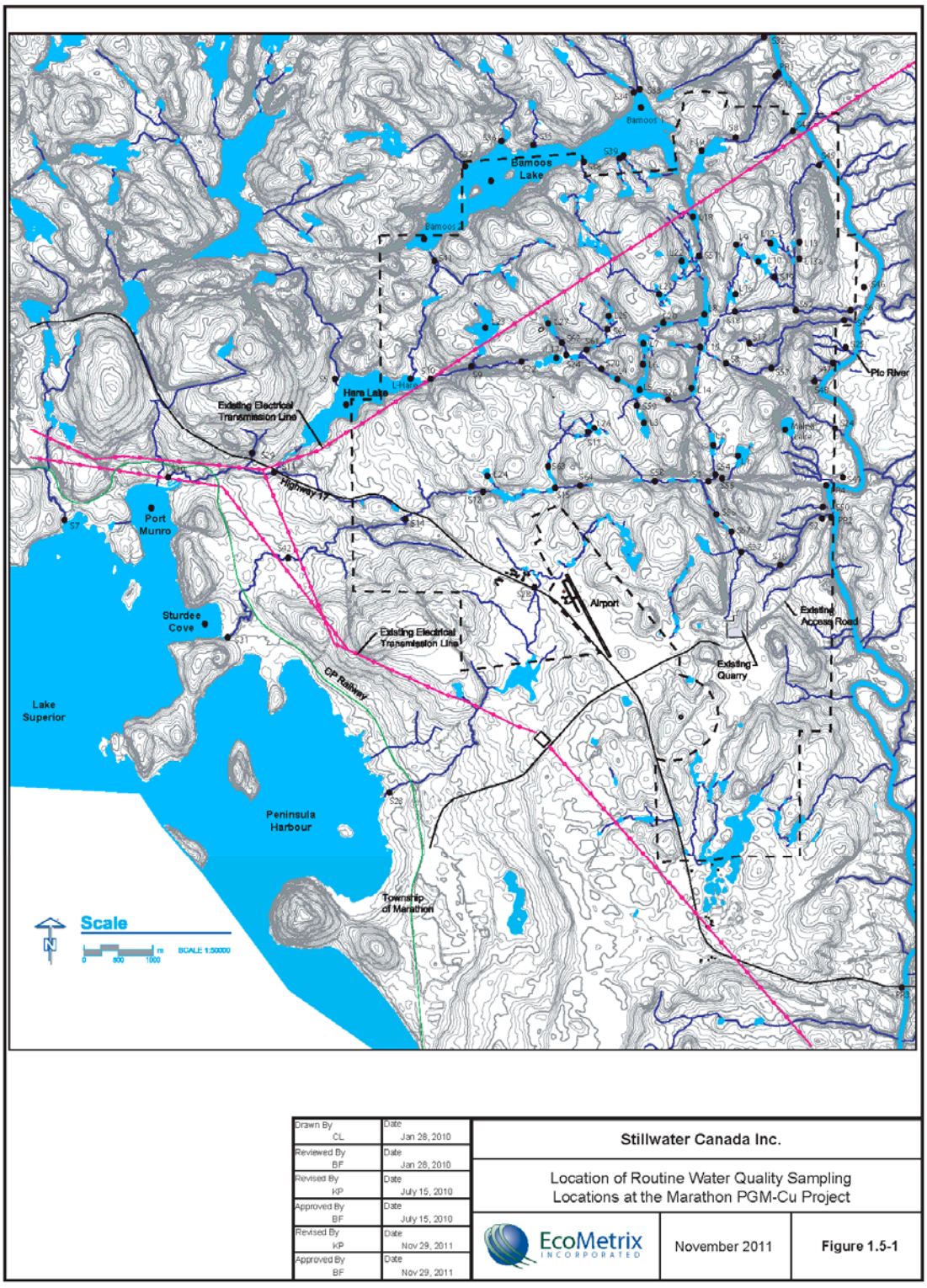

Figure 1.5-1: Location of Routine Water Quality Sampling Locations at the Marathon PGM-Cu Project

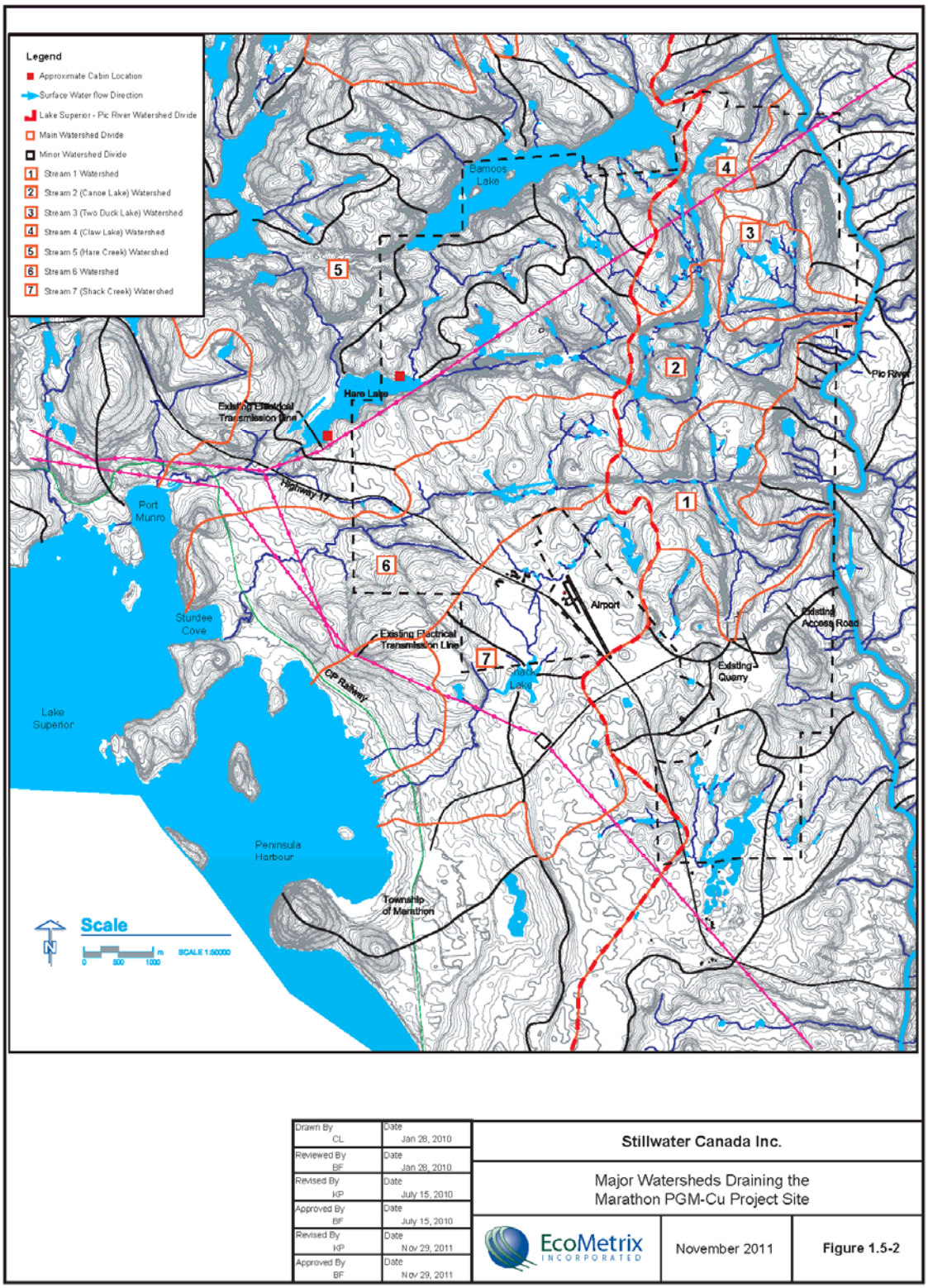

Figure 1.5-2: Major Watersheds Draining the Marathon PGM-Cu Project Site

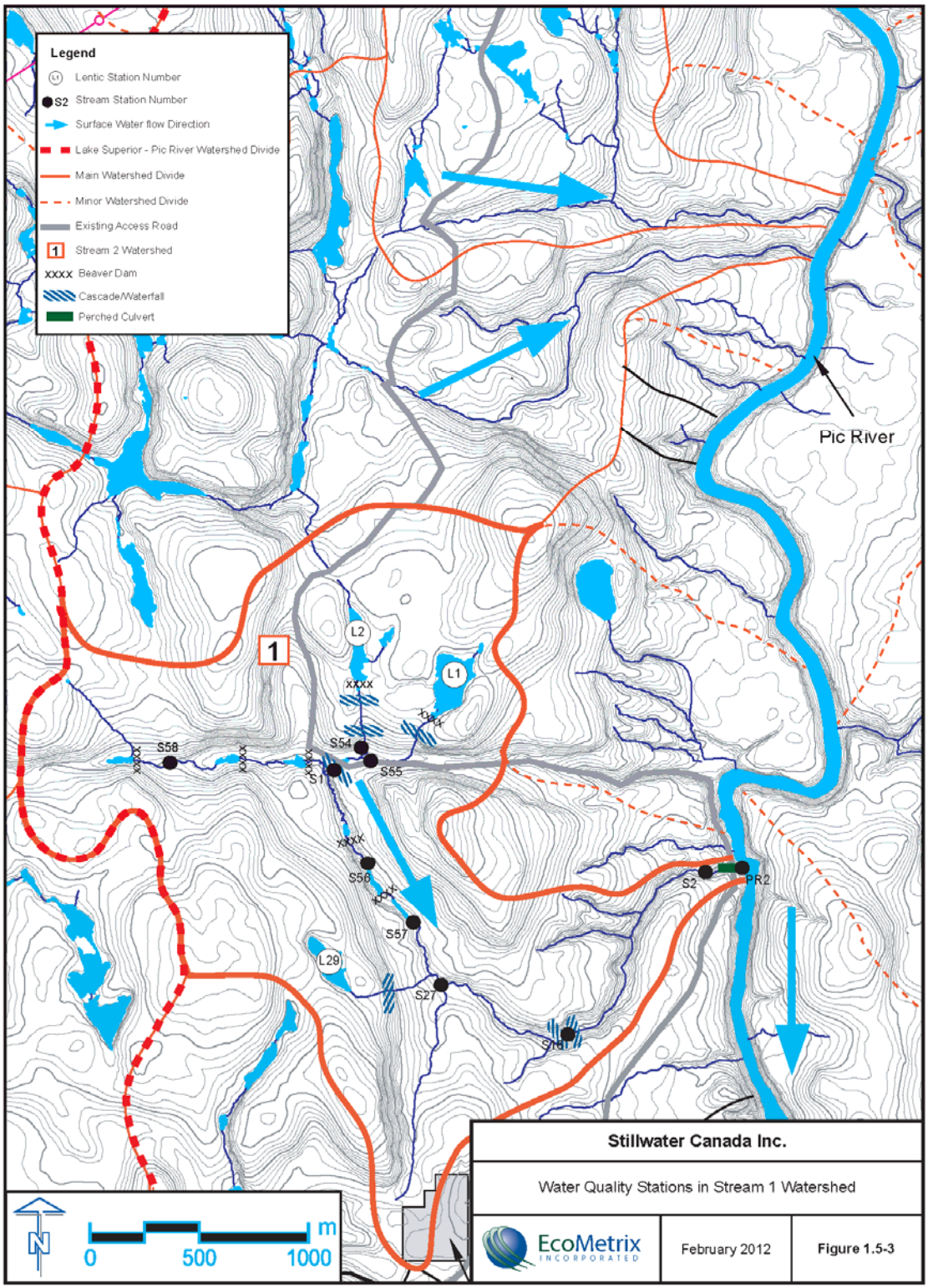

Figure 1.5-3: Water Quality Stations in the Stream 1 Watershed

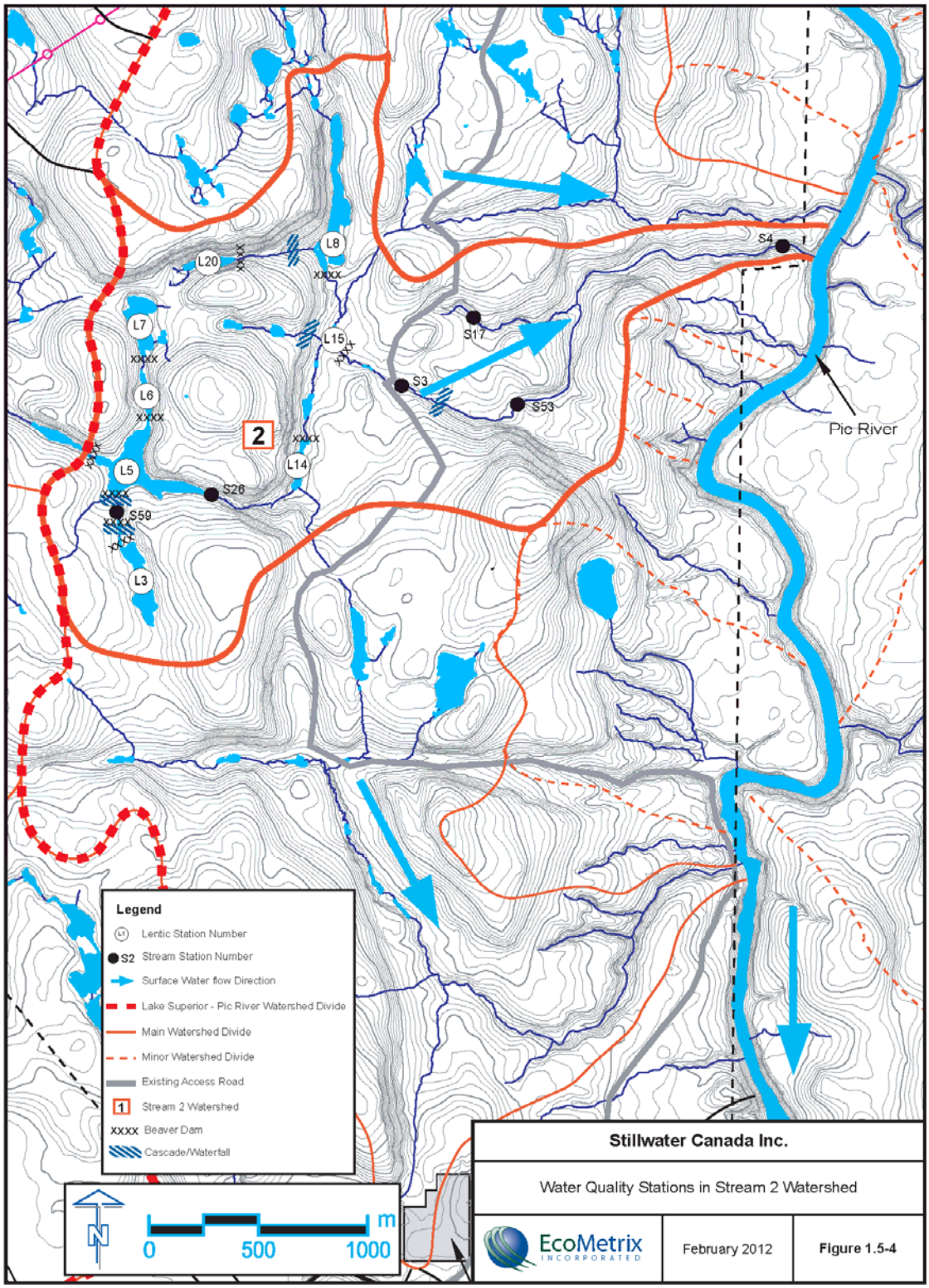

Figure 1.5-4: Water Quality Stations in the Stream 2 Watershed

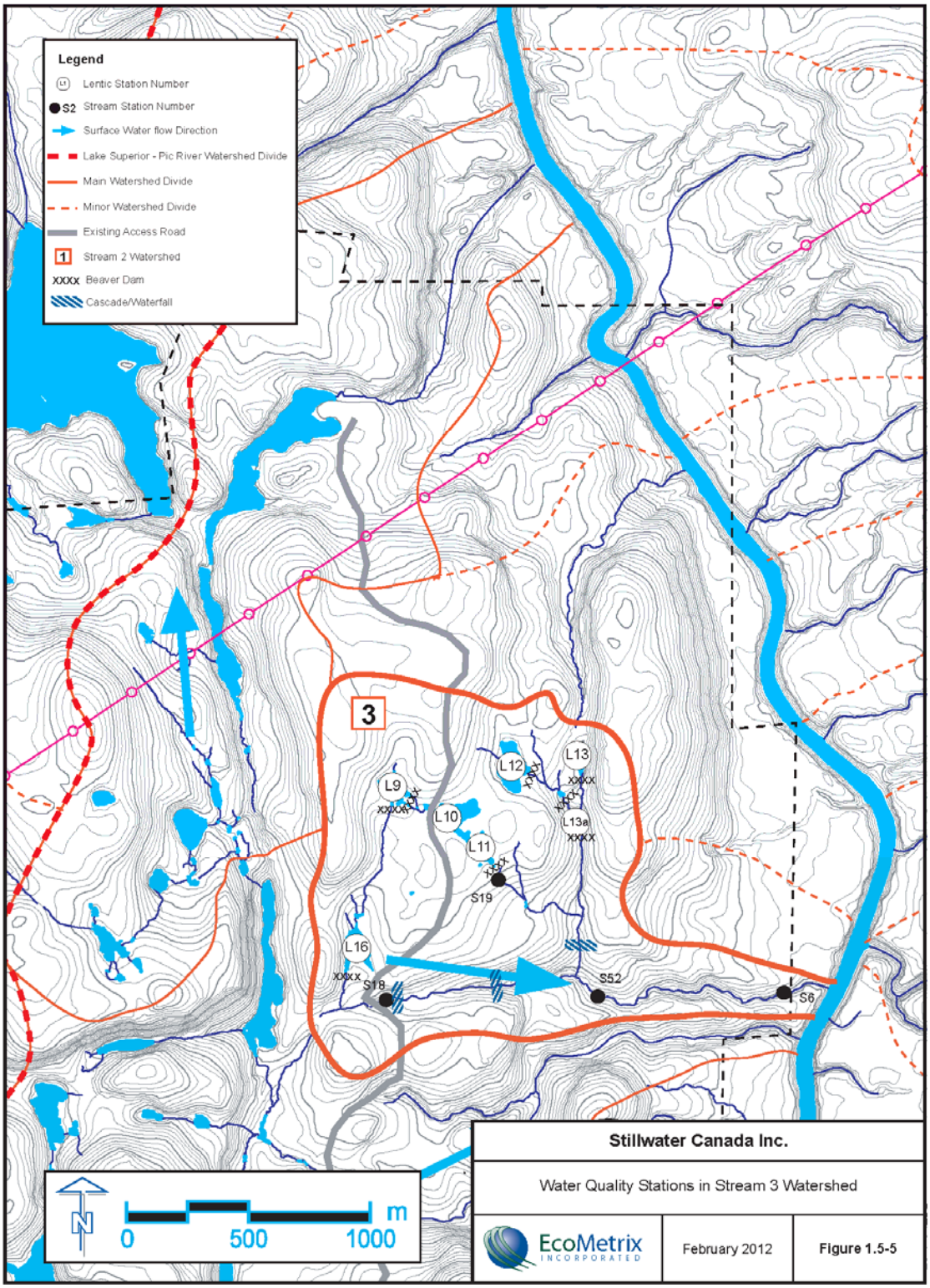

Figure 1.5-5: Water Quality Stations in the Stream 3 Watershed

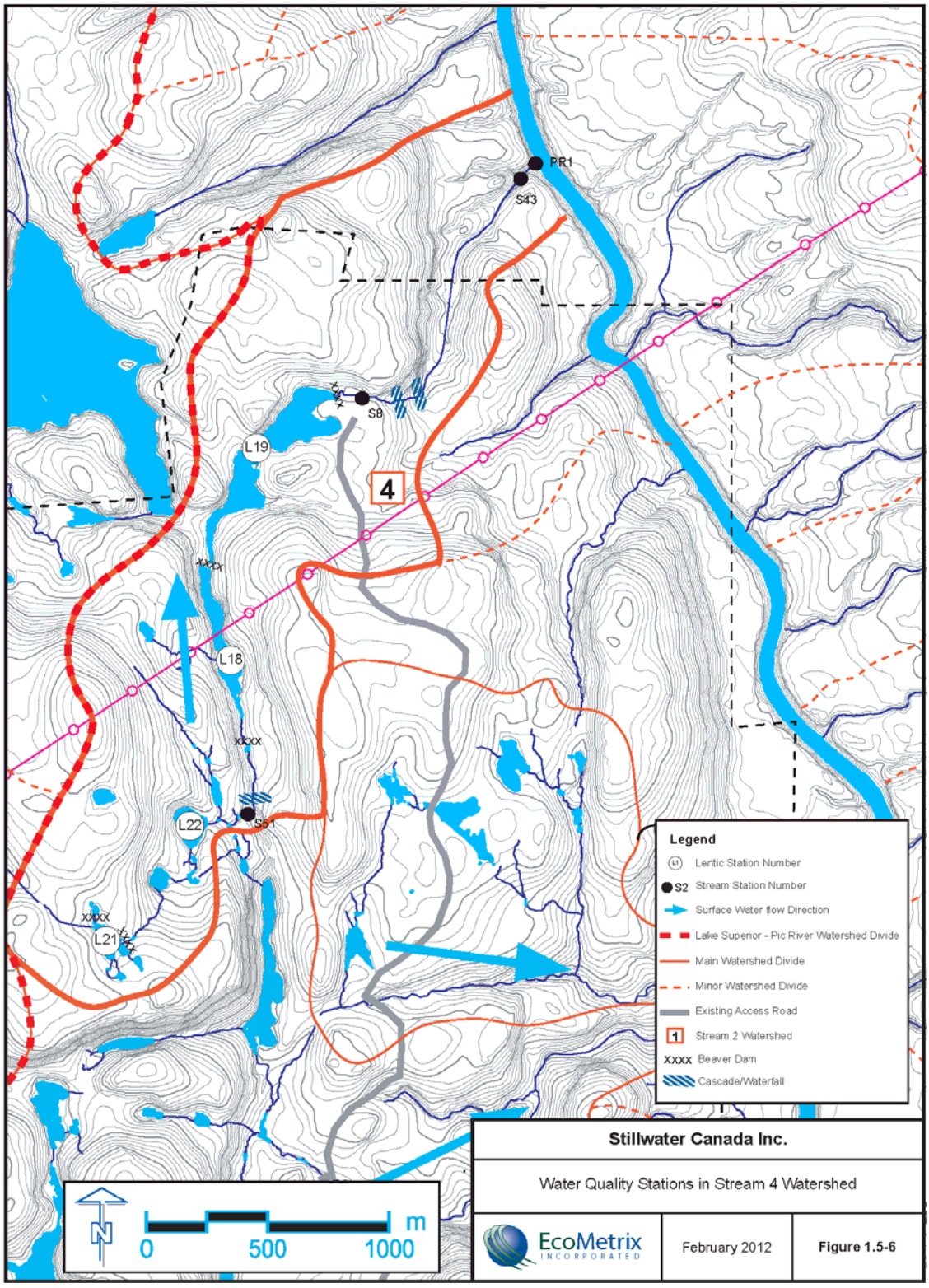

Figure 1.5-6: Water Quality Stations in the Stream 4 Watershed

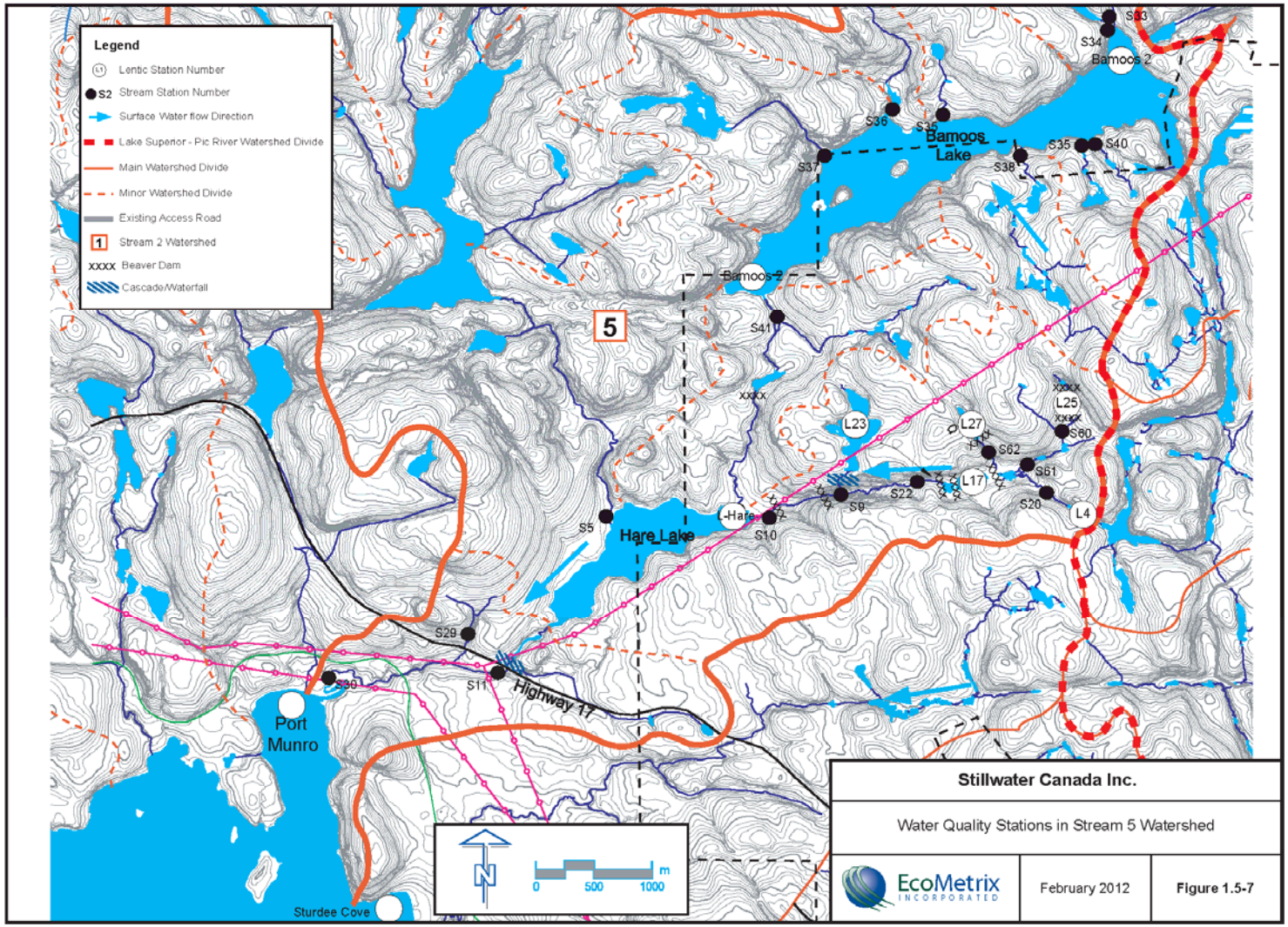

Figure 1.5-7: Water Quality Stations in the Stream 5 Watershed

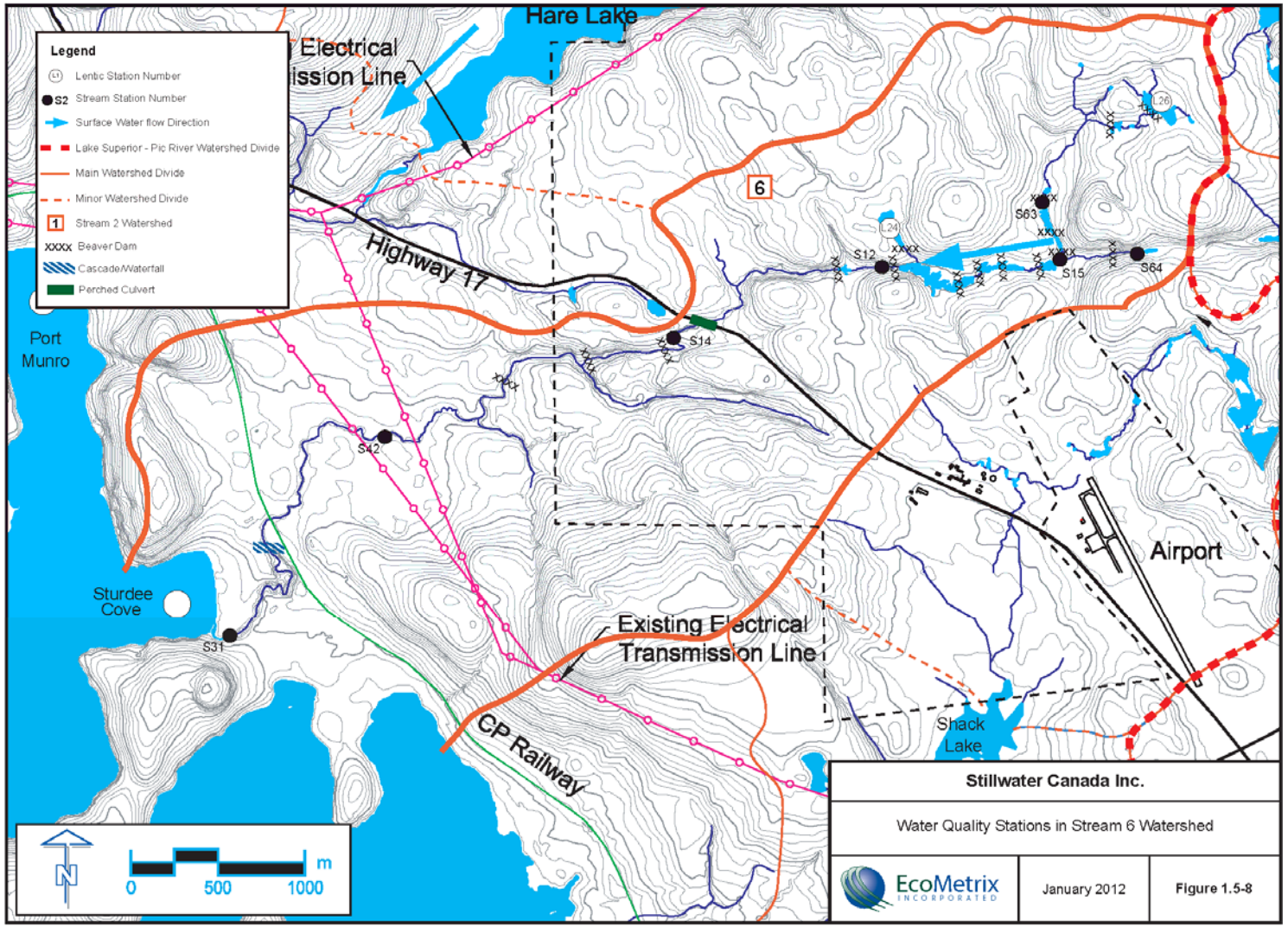

Figure 1.5-8: Water Quality Stations in the Stream 6 Watershed

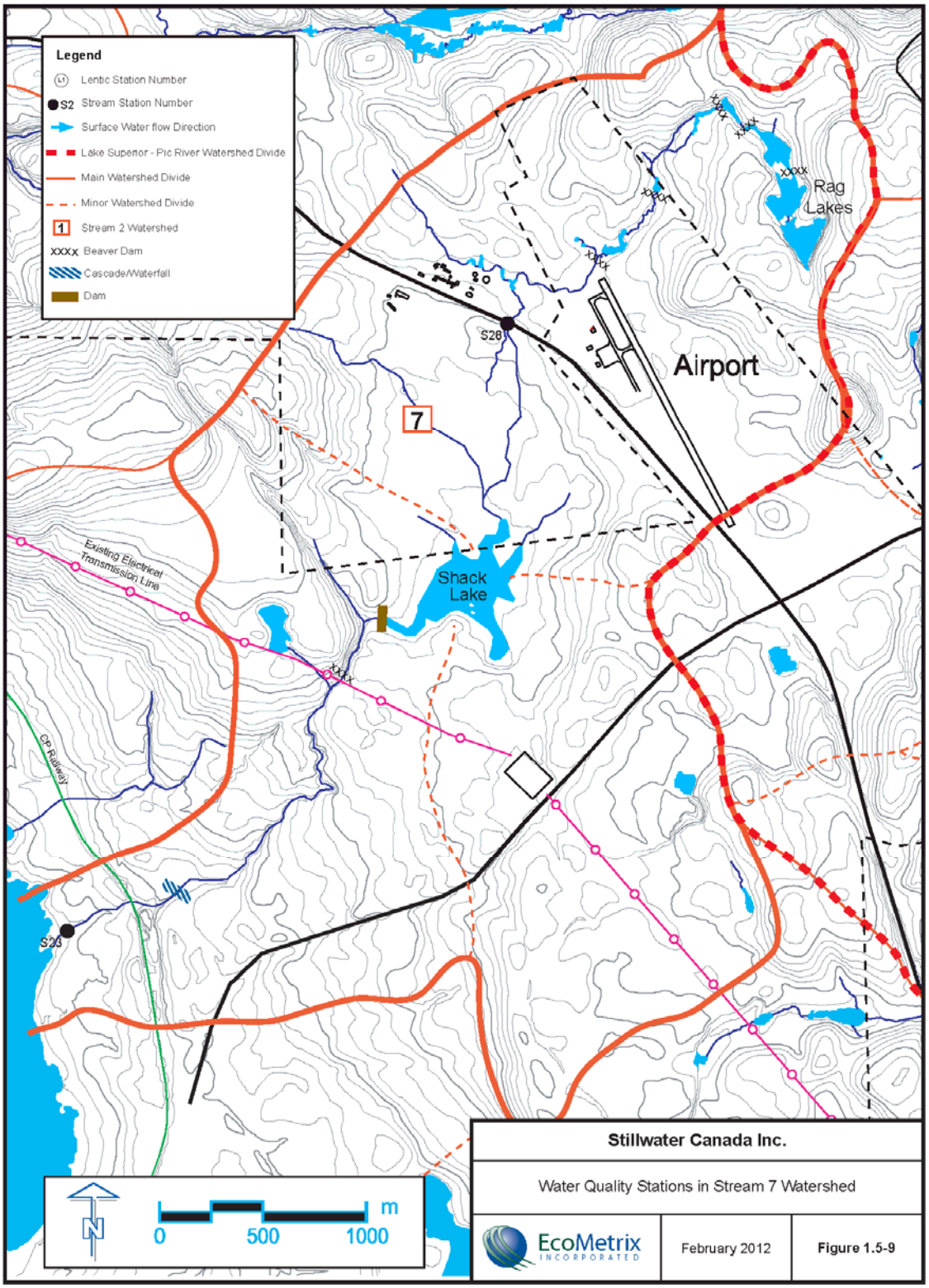

Figure 1.5-9: Water Quality Stations in the Stream 7 Watershed

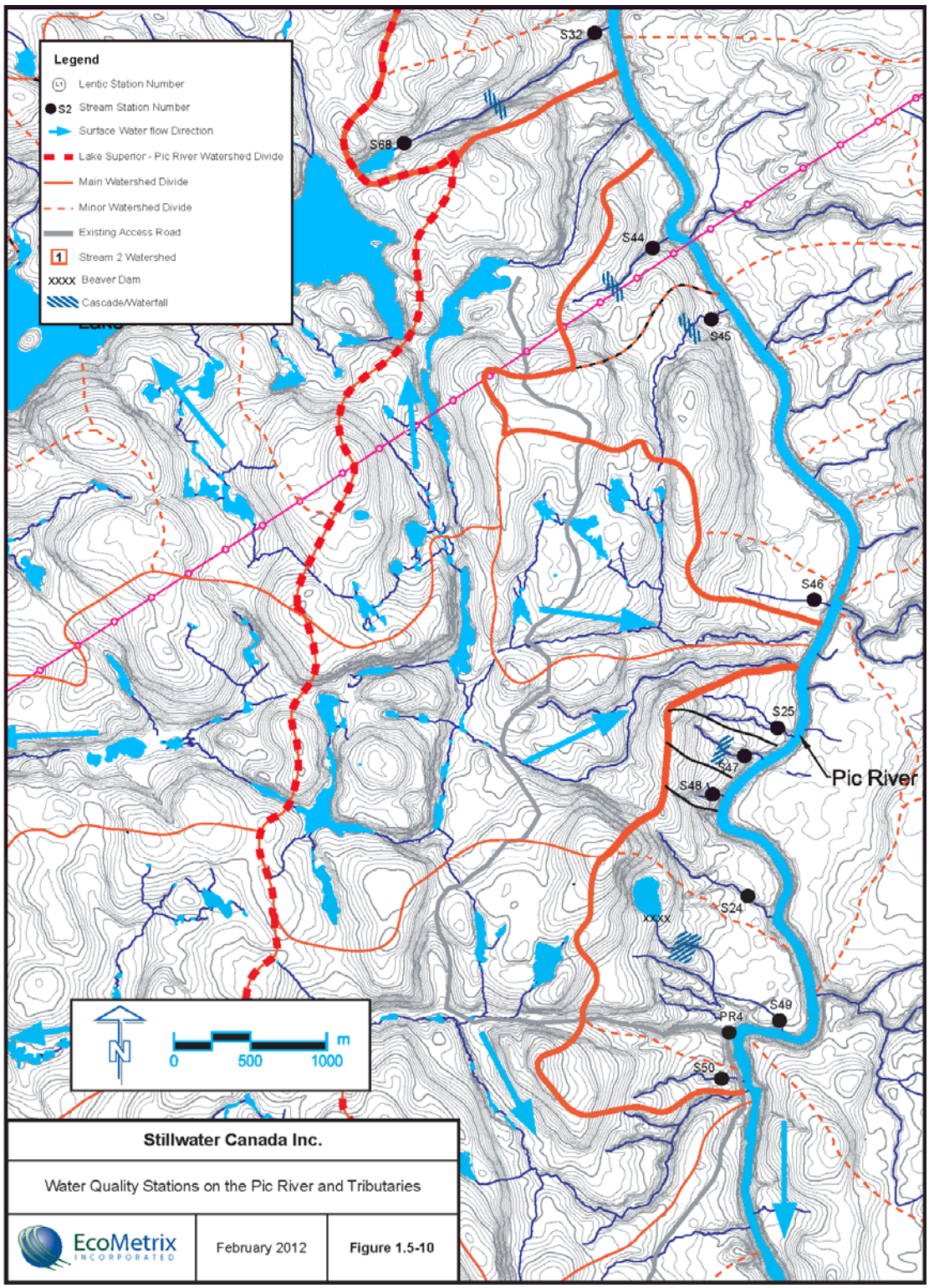

Figure 1.5-10: Water Quality Stations on the Pic River and Tributaries

Routine water quality sampling has been completed, since 2008, by True Grit Consulting Limited (TGCL). Sampling has been conducted according to standardized protocols based on the Metal Mining Environmental Effect Monitoring Technical Guidance Document (2008, 2011) Chapter 5, Section 7: Water Quality Monitoring, as summarized briefly below.

Water quality data were generated by both in-field measurements and laboratory analyses.

- In-field measurements (pH, conductivity, dissolved oxygen (DO), temperature) were made with appropriate water quality meters. Meters were calibrated according to manufacturer's instructions prior to each sampling effort and calibration checks were performed prior to each days sampling. In instances where the calibration check indicated a potential measurement error, the meter was re-calibrated prior to use in the field. Meter measurements were taken in-situ and meters were held in-situ until readings had stabilized before a water quality measurement was recorded. All in-field measurements were recorded manually on data sheets and inputted into spreadsheets for subsequent database storage. All data transferred into the master database was double checked for quality control by TGCL immediately after field activities were completed.

- Samples that were collected for subsequent laboratory analysis were collected as discrete grab samples in sterile, appropriately sized containers provided by the analytical laboratory. Samples which required preservatives (e.g., nitric acid for metal samples) were preserved in the field by TGCL immediately after collection. Sample containers were pre-labeled by the laboratory, including a station name and project-specific reference number. The date and time of each sample collected was labeled on the containers by the field sampling crew at the time of collection. Dedicated nitrile gloves were worn during all sampling activities. Following collection, the samples were stored at 4^{o}C until they were received by the laboratory. Samples were transported in sealed coolers in accordance with prescribed hold times and were at all times accompanied by appropriately completed chain-of-custody forms. Following reception at the lab, the sample confirmation forms that were provided by the lab were cross referenced with the chain-of-custody forms to ensure all samples had been received and the correct sample analyses were ordered. This same process was completed when sample analyses results were obtained from the lab to ensure that all sample results were provided as ordered. Data from the lab reports was transferred from laboratory spreadsheets into the master database and double checked for accuracy by TGCL shortly after receiving the data from the laboratory

1.6 Report Format

Following this introductory section, the remainder of the current report is organized as follows:

- Section 2.0 provides the results of the water quality monitoring program, with data discussed on a parameter-by-parameter basis, as well as on a subwatershed-by-subwatershed basis;
- Section 3.0 discusses potential groundwater-surface water interactions;
- Section 4.0 outlines the report conclusions; and,
- Section 5.0 provides a list of the references used in the preparation of this report.

Statistical summaries of the water quality data for each subwatershed in the study area are provided in Appendix 1.

2.0 RESULTS AND DISCUSSION

Water quality data from sampling campaigns conducted from 2006 to 2011 in the study area were analyzed statistically by watershed in order to generate baseline concentrations of the parameters of interest. Statistical summaries for each watershed in the study area are presented in Appendix 1, Tables A1 through A9. It is important to note that in order to conduct the statistical analyses, an analyte below the laboratory detection limit in a sample was assumed to be present at a concentration equal to its detection limit to be conservative; the role of such samples is discussed in detail in the following sections. This assumption is necessary to conduct statistical analyses but as a result establishing specific baseline concentrations can be a highly uncertain process. Summary statistics in the report, outlined in various sections, reflect this uncertainty. In some cases, the statistics are therefore considered to represent the upper bound of the baseline conditions.

Parameters analyzed as “Anions and Nutrients” were excluded from the statistical analyses below for sample L8132798, taken from station S23 on September 1, 2009, due to concerns about data integrity. These four parameters (total alkalinity, chloride, total Kjeldahl nitrogen [TKN], and total phosphorus) are believed to be mislabeled for this sample.

Summary statistics were also compared to Provincial surface water benchmarks (OMOEE, 1994), including Provincial Water Quality Objectives (PWQOs) where available. For analytes that have no Ontario Ministry of the Environment (OMOE) PWQOs, benchmarks from the Canadian Council of Ministers of the Environment (CCME, 1999) were considered.

2.1 General Chemistry

2.1.1 Alkalinity and Hardness

Natural water is considered to be of low alkalinity if its measured alkalinity is less than 20 mg $CaCO_3$/L (Bain and Stevenson, 1999). The Stream 4 and 5 watersheds may fit this definition with mean measured alkalinities of 18 and 9.1 mg/L, respectively. Measurements taken from the Stream 3 watershed generated a mean measured alkalinity of 23 mg/L, which is slightly above the low alkalinity level (20 mg/L). Minimum measured alkalinities in the Malpa Lake area samples and Pic River samples were 222 and 110 mg/L, respectively, indicating general high alkalinity in these areas.

The same trends were evident in total hardness results from the various watersheds; measured hardness minimum and averages in samples from the Malpa Lake watershed and the Pic River were higher than those for the other watersheds. In addition, the average percent difference between alkalinity and hardness in samples taken from the Malpa Lake and Pic River watersheds was 2% and 3%, respectively, with hardness generally greater than alkalinity in the former watershed and alkalinity greater than hardness in the latter. In the remaining

watersheds, the difference between measured alkalinity and hardness ranged, on average, between 15% and 40% difference, with hardness generally greater than alkalinity.

2.1.2 pH

Results from the analyses of three samples were excluded from the pH data set before summary statistics were compiled due to what are considered to be unreasonable results: sample L75978114, at station PR2, where the reported pH was 83.17; sample L81458410, at station S40, where the reported pH was 17.00; and sample L8007017, at station S41, were the reported pH was 15.0. Given that 825 pH analyses in total were used to compute the summary statistics for that parameter, the removal of these three samples is not considered to create any additional uncertainty in the analysis.

Once the summary statistics were compiled, they were compared to the Provincial surface water benchmark for pH. Specifically, the PWQO for pH consists of both lower and upper limits; measured pH should not be below 6.5 or above 8.5. Measured pH in 26 and 121 samples exceeded the upper benchmark of 8.5 and was less than the lower benchmark of 6.5, respectively. By watershed, the number of samples falling outside the PWQO range was as follows:

Table 2.1-1: pH at the Marathon PGM-Cu Project Site Outside the PWQO Range of 6.5 to 8.5

Watershed	Total Samples	Samples Outside the PWQO Range	
		pH Less Than 6.5	pH Greater than 8.5
Malpa Lake	28	1	0
Pic River	65	0	2
Shack Creek	30	0	1
Stream 1	91	3	2
Stream 2	141	21	6
Stream 3	107	8	2
Stream 4	50	5	2
Stream 5 (Hare Creek)	232	67	9
Stream 6 (Angler Creek)	81	16	2

Samples from the Malpa Lake and Shack Creek watersheds largely fell within the pH PWQO benchmarks, as did samples taken from the Pic River. For the remaining watersheds, measured pH values falling outside the PWQO range tended to be less than the lower benchmark, rather than above the upper benchmark. Nevertheless, both arithmetic and geometric mean measured pH values in each watershed fell within the PWQO range of 6.5 to 8.5.

Note that some pH analyses were measured in the field and others in the laboratory. Mean measured pH concentrations were calculated for both data sets, however, the field and laboratory means for each watershed differed by, at most, 0.5 pH units. The field measurements yielded a wider range of results than the laboratory measurements.

2.1.3 Dissolved Organic Carbon

Dissolved Organic Carbon (DOC) was measured for 940 samples from the study area. Mean measured values of DOC ranged between 6.6 mg/L (Malpa Lake watershed) and 11.2 mg/L (Stream 6 watershed). The minimum measured individual DOC value was 2 mg/L (Stream 5 watershed) and the maximum measured individual DOC value was 23.7 mg/L (Pic River). No PWQO or other suitable benchmarks were available for comparison.

2.1.4 Radium-226

Radium-226 was measured at six sample sites in the study area, corresponding to the downstream sampling locations in each of the principal subwatersheds draining the Project site. The PWQO for radium-226 is 1.0 Bq/L. No exceedances of this PWQO were recorded in the surface water samples in the study area as all samples were below the detection limit of 0.01 Bq/L.

2.1.5 Turbidity

Turbidity was measured in 936 surface water samples from the study area. The level of turbidity in these samples varied considerably within each watershed. The mean measured turbidity by watershed ranged from 3.5 NTU in the Stream 5 (S11) watershed to 88.6 NTU in the Malpa Lake watershed, with five of the means less than 5 NTU. The mean measured turbidity in the Pic River was estimated to be 71.0 NTU. It should be noted that the samples from the Malpa Lake, Stream 1, and Stream 2 watersheds generated the highest standard deviations in the data set: 141.0, 109.4, and 116.0 NTU, respectively. These elevated standard deviations are consistent with the maximum measured turbidity in each of these watersheds being 666, 1080, and 1420 NTU, respectively. Turbidity was generally highest across all watersheds during spring freshet. Note that PWQO guidelines relate to an increase in turbidity that would cause a change in the Secchi depth reading by more than ten percent. This guideline is not applicable to the establishment of turbidity baseline values but rather is the used to determine if changes have occurred after there has been a change to the environment.

2.1.6 Total Suspended Solids

There is no existing PWQO or other benchmark for total suspended solids in surface waters. Of the 945 surface water samples taken, 542 were above the detection limit and 403 were below detection. TSS varied considerably within each watershed, ranging from 0.015 mg/L in Stream 1 to 2220 mg/L measured from a stream discharging into the Pic River, north of the Stream 4 subwatershed. The average measured TSS in the study area was 28.26 mg/L.

2.2 Anions and Nutrients

2.2.1 Ammonia

The PWQO for ammonia is based on unionized ammonia measured as ammonia – 0.020 mg/L – and measurements of that chemical in the study area were of total ammonia measured as nitrogen. In order to compare the two, unionized PWQO values were calculated for each watershed on a nitrogen basis by following the PWQO guidance: the original unionized ammonia (measured as ammonia) benchmark concentration was first converted to total ammonia by dividing by the watershed-specific quantity f, where

$$f = (10^{pKa-pH} + 1)^{-1}$$

The arithmetic mean pH of each watershed was used as the pH parameter, and the pKa of ammonia was estimated using the following relation, where T is the arithmetic mean temperature in each watershed expressed in Kelvin:

$$pKa = 0.09018 + 2729.92/T$$

Once the PWQO had been converted to total ammonia in this fashion, it was multiplied by 0.8224 to convert it from an ammonia basis to a nitrogen basis. The calculated ammonia PWQO values for each watershed were as follows:

Table 2.2-1: Ammonia PWQOs in the Various Subwatersheds at the Marathon PGM-Cu Project Site

Watershed	PWQO, Total Ammonia as N (mg/L)
Malpa Lake	1.1
Pic River	0.9
Shack Creek	1.4
Stream 1	2.1
Stream 2	3.0
Stream 3	4.7
Stream 4	7.1
Stream 5 (Hare Creek)	10.9
Stream 6 (Angler Creek)	7.5

No exceedances of these PWQOs were observed in surface water samples taken from the study area. The ammonia data contained no exceedances of the PWQOs in 802 samples. Therefore, baseline concentrations of ammonia on the whole are considered to meet the PWQO.

2.2.2 Nitrate

No Provincial water quality benchmarks were available for nitrate, so concentrations of this chemical in surface water were compared to the Canadian Environmental Quality Guideline (CEQG) for protection of aquatic life in freshwater, established by the CCME. This CEQG is 13 mg/L, measured as nitrate. Since nitrate was reported as nitrogen in the chemical analyses for the study area, and not as nitrate, the CEQG was converted to an equivalent value as nitrogen to enable easier comparison of the measured concentrations to the benchmark, which was 2.9 mg/L. None of the measured nitrate concentrations in samples from any of the watersheds in the study area exceeded this benchmark. Mean measured nitrate concentrations by watershed ranged from 0.05 mg/L (Stream 6 watershed) to 0.48 mg/L (Malpa Lake watershed).

2.2.3 Phosphorus

The OMOE has not established a firm PWQO for phosphorus in surface waters. The OMOE did, however, indicate that several guidelines should be followed when evaluating phosphorus concentrations in surface waters, with the aid of further studies (1994):

- *To avoid nuisance concentrations of algae in lakes, average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L;*
- *A high level of protection against aesthetic deterioration will be provided by a total phosphorus concentration for the ice-free period of 10 µg/L or less. This should apply to all lakes naturally below this value; and,*
- *Excessive plant growth in rivers and streams should be eliminated at a total phosphorus concentration below 30 µg/L.*

In light of these guidelines, a PWQO of 10 µg/L (0.01 mg/L) has been chosen as a suitable benchmark for this baseline comparison.

Total phosphorus was analyzed in 852 samples from the study area. Mean measured phosphorus concentrations by watershed varied from 0.014 mg/L in the Stream 4 watershed to 0.148 mg/L in the Malpa Lake watershed. Thus, the arithmetic mean concentration for each watershed exceeded the PWQO, indicating that the baseline total phosphorus concentration throughout the project site exceeds this benchmark. The maximum measured total phosphorus concentration ranged from 0.132 mg/L in the Stream 4 watershed to 0.00136 mg/L in the Malpa Lake watershed.

2.2.4 Sulphate

Sulphate was analyzed in 935 samples from the study area, and was detected and quantified in all of those samples except 27 one or more from each watershed. Mean sulphate concentration ranged from 2.3 mg/L in the Pic River to 4.5 mg/L in the Shack Creek watershed. The

maximum measured sulphate concentration ranged from 3.5 mg/L in the Pic River to 9.1 mg/L in the Stream 4 watershed. No PWQO, or any other benchmark, was available for comparison to these concentrations.

2.3 Metals

2.3.1 Aluminum

The PWQO for aluminum is pH-dependent; the mean measured pH of waters sampled in each watershed was observed to be above 6.5, so the applicable PWQO was determined to be 0.075 mg/L. This guideline is based on a clay-free sample which is comparable to a filtered water sample (i.e., dissolved metal concentration). Both dissolved and total aluminum were measured in the water samples, with dissolved aluminum measured in 459 samples and total aluminum measured in 959. Measured concentrations of dissolved aluminum exceeded the PWQO in several samples from each watershed with the exception of the Malpa Lake watershed. The distribution of exceedances, by watersheds, was as follows:

Table 2.3-1: Number of Dissolved Aluminum Samples that Exceeded the PWQO

Watershed	Number of Samples Concentration > PWQO (0.075 mg/L)
Malpa Lake	0 of 14
Pic River	3 of 40
Shack Creek	4 of 14
Stream 1	20 of 46
Stream 2	30 of 76
Stream 3	28 of 62
Stream 4	9 of 32
Stream 5	97 of 128
Stream 6	39 of 47

Mean measured total aluminum concentrations ranged from 0.145 mg/L in the Stream 3 watershed to 1.408 mg/L in the Malpa Lake watershed. Mean measured dissolved aluminum concentrations ranged from 0.021 mg/L in the Malpa Lake watershed to 0.217 mg/L in the Stream 6 watershed. Dissolved aluminum was detected and quantified in the majority of water samples and detection limits did not greatly affect the summary statistics generated for this parameter. The summary statistics are therefore considered representative of baseline concentrations in the study area. Given the high level of certainty in the data set, baseline concentrations of dissolved aluminum in the study area are considered to be below the PWQO in the Pic River, the Stream 3 and the Malpa Lake watersheds but above the PWQO in all other watersheds throughout the project.

2.3.2 Arsenic

The current PWQO for arsenic is 0.100 mg/L, with a Revised Interim PWQO of 0.005 mg/L also in place. Both benchmark values were used for comparison to samples from the study area.

None of the 959 measured total arsenic concentrations in samples from the study area exceeded the PWQO of 0.100 mg/L. It should be noted that arsenic was not detected in 934 out of the 959 samples. Seventeen of these samples, however, had elevated detection limits such that they exceeded the 0.005 mg/L Revised Interim PWQO. These samples were distributed as follows:

Table 2.3-2: Number of Total Arsenic Sample Detection Limits that Exceeded the Revised Interim PWQO

Watershed	Number of Samples, Detection Limit > Revised Interim PWQO (0.005 mg/L)
Malpa Lake	3
Pic River	4
Shack Creek	0
Stream 1	2
Stream 2	4
Stream 3	0
Stream 4	0
Stream 5 (Hare Creek)	4
Stream 6 (Angler Creek)	0

As no arsenic was detected in these samples, the true arsenic concentrations present are not known. Total arsenic was detected at above the 0.005 mg/L Revised Interim PWQO in two samples (sample L8132795 and its replicate from station S30); both measured as 0.012 mg/L. In the remaining samples from the study area, total arsenic was either not detected or present at concentrations less than the Revised Interim PWQO. Dissolved arsenic was below the detection limit in 44 of the 46 samples analyzed for this parameter.

Given the above analyses and the large proportion of samples in which arsenic was not detected, it should be noted that establishing specific baseline concentrations would be a highly uncertain process. The summary statistics reflect this uncertainty because of the large number of detection limits used in their calculation instead of measured concentrations. The statistics are therefore considered representative of upper bounds of the baseline conditions. It is expected, that arsenic would be present in surface waters of the study area at concentrations less than the Revised Interim PWQO.

2.3.3 Cadmium

The current PWQO for cadmium is 0.0002 mg/L. A Revised Interim PWQO has also been established by the OMOE; this benchmark is 0.0001 mg/L if total hardness is less than 100 mg $CaCO_3$/L, or 0.0005 mg/L if total hardness is greater than 100 mg $CaCO_3$/L. The mean measured total hardness in each watershed was used to select a watershed-specific value for this benchmark, and as a result, the 0.0005 mg/L value was selected for Malpa Lake and Pic River samples, while the 0.0001 mg/L value was selected for the remaining watersheds.

Both total and dissolved cadmium were analyzed in samples from the study area. For total cadmium, 959 analyses of surface water were performed. In 920 of these samples, total cadmium was either not detected, or it was present in concentrations less than both PWQOs. Fifteen of these samples, however, were analyzed using elevated detection limits such that they exceeded both PWQOs. These samples were distributed as follows:

Table 2.3-3: Number of Total Cadmium Sample Detection Limits that Exceeded the PWQO

Watershed	Number of Samples, Detection Limit > PWQO (0.0001 mg/L)
Malpa Lake	3
Pic River	4
Shack Creek	0
Stream 1	2
Stream 2	4
Stream 3	0
Stream 4	0
Stream 5 (Hare Creek)	2
Stream 6 (Angler Creek)	0

Total cadmium was detected at concentrations greater than the PWQO in 24 samples, and at concentrations greater than the Revised Interim PWQO in 40 samples, distributed as follows:

Table 2.3-4: Number of Total Cadmium Samples that Exceeded the PWQOs

Watershed	Number of Samples, Concentrations > PWQO (0.0002 mg/L)	Number of Samples, Concentrations > Revised Interim PWQO (0.0001 mg/L)
Malpa Lake	0 of 29	0 of 29
Pic River	1 of 75	1 of 75
Shack Creek	1 of 32	1 of 32
Stream 1	2 of 100	4 of 100
Stream 2	11 of 161	13 of 161
Stream 3	3 of 130	7 of 130
Stream 4	0 of 54	1 of 54
Stream 5 (Hare Creek)	5 of 285	10 of 285
Stream 6 (Angler Creek)	1 of 93	3 of 93

Note that the PWQO is independent of hardness, but the Revised Interim PWQO is not. For a certain range of hardness values, the Revised Interim PWQO is greater than the PWQO, and for others, the Revised Interim PWQO is less, leading to two slightly different exceedance distribution patterns among study area watersheds.

Dissolved cadmium was measured in 89 samples in total. Overall concentrations ranged from 0.0001 to 0.0013 mg/L. It should be noted that cadmium was not detected in the majority of the samples taken in the study area (910 out of 959 for total cadmium, and 31 out of 45 for dissolved cadmium). The cadmium data set contained a large number of instances of analyses below the method detection limit which creates large uncertainty in establishing baseline concentrations. The summary statistics are therefore considered to be representative of upper bounds of baseline concentrations only. Taken together, the analysis of total cadmium indicates that baseline concentrations are likely less than both PWQOs in the study area.

2.3.4 Cobalt

Both total cobalt and dissolved cobalt were measured in samples from the study area, and analysis results were compared to the PWQO of 0.0009 mg/L. A total of 1052 samples were analyzed for total cobalt, of which 85 generated cobalt concentrations greater than the PWQO:

Table 2.3-5: Number of Total Cobalt Samples that Exceeded the PWQO

Watershed	Number of Samples, Concentration > PWQO (0.0009 mg/L)
Malpa Lake	7 of 29
Pic River	21 of 75
Shack Creek	5 of 32
Stream 1	5 of 100
Stream 2	17 of 161
Stream 3	11 of 130
Stream 4	5 of 54
Stream 5 (Hare Creek)	9 of 285
Stream 6 (Angler Creek)	4 of 93

Of the 1052 samples, cobalt was not detected in 837, including 17, in which elevated detection limits (i.e., exceeding the PWQO) were used in the analysis:

Table 2.3-6: Number of Total Cobalt Sample Detection Limits that Exceeded the PWQO

Watershed	Number of Samples, Detection Limit > PWQO (0.0009 mg/L)
Malpa Lake	2 of 29
Pic River	4 of 75
Shack Creek	4 of 32
Stream 1	1 of 100
Stream 2	3 of 161
Stream 3	0 of 130
Stream 4	0 of 54
Stream 5 (Hare Creek)	2 of 285
Stream 6 (Angler Creek)	1 of 93

Mean measured total cobalt concentrations in each watershed ranged from 0.00066 mg/L in the Stream 6 watershed to 0.0015 mg/L in the Malpa Lake watershed. These mean total cobalt concentrations were less than the PWQO in the Stream 2 through 6 watersheds and Shack Creek. The mean total cobalt concentrations were greater than the PWQO for the Malpa Lake, Pic River, and Stream 1 watersheds.

45 samples were analyzed for dissolved cobalt; and it was not detected in 34 of the samples. Mean measured dissolved cobalt concentrations in each watershed ranged from 0.00024 mg/L in the Stream 4 watershed to 0.0005 mg/L in both the Malpa Lake and Stream 6 watersheds.

These analyses indicate that baseline concentrations of cobalt in the study area may vary widely, and may be greater than the PWQO for certain specific watersheds. It should be noted that the cobalt data set is highly influenced by the detection limits used in the analyses and

therefore the uncertainties in baseline concentrations are substantial. For these reasons, it is recommended that the summary statistics generated for cobalt serve as representative of upper bounds of baseline concentrations only.

2.3.5 Copper

Like arsenic and cadmium, copper has been assigned not only a PWQO (0.005 mg/L) but also a Revised Interim PWQO. This latter benchmark has been designated as 0.001 mg/L if the hardness of the water is less than 20 mg $CaCO_3$/L, and 0.005 mg/L if the hardness of the water is more than 20 mg $CaCO_3$/L. Given this situation, a watershed-specific PWQO was selected using the arithmetic mean measured hardness concentrations in each watershed. As a result, the Stream 4 and 5 watersheds were assigned the value of 0.001 mg/L, and the remaining watersheds were compared to the 0.005 mg/L value.

Both total copper and dissolved copper were measured in samples from the study area. 959 samples were analyzed for total copper, of which 357 exceeded their respective Revised Interim PWQOs.

Table 2.3-7: Number of Total Copper Samples that Exceeded the Revised Interim PWQO

Watershed	Number of Samples, Concentration > PWQO (0.005 mg/L)
Malpa Lake	4 of 29
Pic River	8 of 75
Shack Creek	8 of 32
Stream 1	3 of 100
Stream 2	62 of 161
Stream 3	124 of 130
Stream 4	50 of 54
Stream 5 (Hare Creek)	95 of 285
Stream 6 (Angler Creek)	3 of 93

The Stream 4 and 5 watersheds are the only watersheds for which the PWQO is not equal to the Revised Interim PWQO. For the Stream 4 watershed, measured total copper concentrations exceeded the Revised Interim PWQO (0.001 mg/L) in 50 samples, of which 27 also exceeded the 0.005 mg/L PWQO. Similarly, for the Stream 5 watershed, measured total copper concentrations exceeded the Revised Interim PWQO in 95 samples, of which 13 also exceeded the PWQO.

Copper was not detected in 331 of the 959 samples analyzed for total copper. Mean measured total copper concentrations in each watershed ranged from a minimum of 0.001 mg/L in the Stream 1, 2, 4, 5, 6, Malpa Lake, Pic River, and Shack Creek watersheds to a maximum of 2.55 mg/L in the Shack Creek watershed. The eight samples from Shack Creek that exceeded the PWQO were all taken from the same station (S28); the total copper concentrations in those

samples ranged from 0.66 mg/L to 2.55 mg/L. The rest of the values from Shack Creek stations were considerably lower resulting in a mean of 0.292 mg/L. The watersheds with the highest proportions of concentrations above the PWQO were Stream 3 (124/130), and Stream 4 (50/54).

Analyses for dissolved copper were performed on 45 samples from the study area. Mean measured dissolved copper concentrations ranged from 0.0019 mg/L in the Stream 5 watershed to 0.008 mg/L in the Stream 3 watershed.

Overall, measured total copper concentrations in about 38% of the analyzed samples exceeded the Revised Interim PWQO. Particularly high values were observed in samples taken from station S28, although exceedances of the PWQO were found in every watershed. The two watersheds with the most exceedances proportional to the number of samples taken were Stream 3 and Stream 4, indicating that baseline copper concentrations in these watersheds is likely higher than the PWQO. In addition, sufficient quantified copper concentrations were available in the data set to recommend the use of the summary statistics as representative of baseline values.

2.3.6 Chromium

Two different PWQOs for chromium have been instituted by the OMOE, one each for chromium (III) and chromium (VI). In the analysis for the study area, total chromium and chromium (VI) were both analyzed; total chromium, hereafter referred to as chromium (III+VI), was compared to the chromium (III) PWQO, since that species is the most common in natural waters, and measured chromium (VI) concentrations were compared to the chromium (VI) PWQO.

For chromium (III+VI), both total and dissolved amounts were measured in samples from the study area, whereas only total chromium (VI) was measured in those same samples. 930 water samples were analyzed for total chromium (III+VI), of which 19 were found to contain chromium concentrations greater than the PWQO, 0.0089 mg/L. Chromium was not detected in a further 10 samples, in which the detection limits were greater than the PWQO.

Table 2.3-8: Number of Chromium (III+VI) Sample Concentrations and Detection Limits that Exceeded the PWQO

Watershed	Number of Samples, Concentration > PWQO (0.0089 mg/L)	Number of Samples, Detection Limit > PWQO (0.0089 mg/L)
Malpa Lake	5 of 29	1 of 29
Pic River	6 of 75	3 of 75
Shack Creek	0 of 32	0 of 32
Stream 1	2 of 100	0 of 100
Stream 2	5 of 161	3 of 161
Stream 3	0 of 130	0 of 130
Stream 4	0 of 54	0 of 54
Stream 5	1 of 285	3 of 285
Stream 6	0 of 93	0 of 93

Of the 959 samples analyzed for total chromium (III+VI), chromium was not detected in 803. The fraction of samples, however, in which chromium was not detected, varied considerably by watershed:

Table 2.3-9: Number of Chromium (III+VI) Samples below the Detection Limit

Watershed	Total Samples Analyzed	Number of Samples, Concentration < Detection Limit
Malpa Lake	29	9
Pic River	75	20
Shack Creek	32	28
Stream 1	100	83
Stream 2	161	131
Stream 3	130	116
Stream 4	54	51
Stream 5	285	278
Stream 6	93	87

The samples taken from the Shack Creek, Stream 4, Stream 5, and Stream 6 watersheds had low chromium concentrations with chromium (III+VI) not detected in all but seven samples. Chromium was not detected in most of the samples from Malpa Lake or the Stream 1, 2, and 3 watersheds. In the Pic River, however, chromium was detected in most of the water samples. As might be expected from this pattern of non-detects, the mean measured total chromium (III+VI) concentration in each watershed is close to the detection limit in the Shack Creek and the Stream 4, 5, and 6 watersheds, higher in Malpa Lake, Stream 1, 2, and 3 watersheds, and higher still in the Pic River. As such, it is recommended that the summary statistics for chromium (III+VI) be used as upper bounds on baseline concentrations, rather than as baseline concentrations themselves.

Dissolved chromium (III+VI) was analyzed in 45 water samples and was below the laboratory detection limit in 44 of them. As expected mean measured concentrations of dissolved chromium (III+VI) were roughly equal to the detection limits used in the various studies contributing to the data sets. The Pic River was the only location that returned an actual value, which was 0.001 mg/L.

The data set for total chromium (VI) also indicated low concentrations throughout the study area with 901 of the 909 collected samples resulting in concentrations below detection limits. Nevertheless, measured exceedances of the chromium (VI) PWQO were noted in seven of the eight remaining samples. In addition, the detection limits used in the historic baseline studies were greater than the PWQO:

Table 2.3-10: Number of Chromium (VI) Sample Concentrations or Detection Limits that Exceeded the PWQO

Watershed	Number of Samples, Concentrations > PWQO (0.001 mg/L)	Number of Samples, Detection Limit > PWQO (0.001 mg/L)
Malpa Lake	0 of 28	28 of 28
Pic River	1 of 71	70 of 71
Shack Creek	5 of 32	20 of 32
Stream 1	0 of 95	95 of 95
Stream 2	1 of 151	150 of 151
Stream 3	0 of 121	121 of 121
Stream 4	0 of 43	43 of 43
Stream 5	0 of 277	277 of 277
Stream 6	0 of 91	90 of 91

Given the large uncertainties present in the chromium (VI) data set due to the large numbers of non-detects, it is recommended that the chromium (VI) summary statistics be used as upper bound baseline concentrations for the study area. However, the upper bound is more conservative if chromium (III+VI) concentrations are used for upper bounds rather than the measured chromium (VI) concentrations themselves.

2.3.7 Iron

Total iron was measured in 959 samples, and measured concentrations exceeded the PWQO of 0.3 mg/L in 705 of those samples. These exceedances were distributed as follows:

Table 2.3-11: Number of Total Iron Samples that Exceeded the PWQO

Watershed	Number of Samples, Concentration > PWQO (0.300 mg/L)
Malpa Lake	25 of 29
Pic River	73 of 75
Shack Creek	9 of 32
Stream 1	56 of 100
Stream 2	147 of 161
Stream 3	89 of 130
Stream 4	43 of 54
Stream 5	171 of 285
Stream 6	92 of 93

Iron was not detected in 20 samples out of the 959, and no detection limits greater than the PWQO were used in the analyses. Mean measured concentrations of total iron ranged between 0.495 mg/L in the Shack Creek watershed and 2.56 mg/L in the Malpa Lake watershed.

Dissolved iron was analyzed in 45 samples, and was not detected in eight. Mean measured dissolved iron concentrations ranged from 0.050 mg/L in the Malpa Lake watershed to 0.550 mg/L in the Stream 6 watershed.

Overall, only the samples from the Shack Creek watershed met the PWQO with samples from the remaining watersheds commonly containing iron near 1 mg/L. Even higher iron concentrations were found in the Stream 1, 2, 5, and 6 watersheds.

The iron data set, unlike those of many of the other analytes measured during these sampling campaigns, contained very few values below detection (about 2.1% of samples), and overall confidence in this data set is thus higher than for other analytes. The summary statistics generated for iron are thus considered representative of baseline concentrations in the study area.

2.3.8 Lead

As in the case of arsenic, cadmium, and copper, two sets of PWQO benchmarks have been instituted by the OMOE for lead. The first PWQO is based on measured alkalinity as follows:

Table 2.3-12: PWQOs for Lead at Different Alkalinity Levels

Alkalinity as $CaCO_3$ (mg/L)	Lead PWQO (mg/L)
<20	0.005
20 to 40	0.010
40 to 80	0.020
> 80	0.025

Secondly, the OMOE has instituted a Revised Interim PWQO based on measured hardness instead of alkalinity as follows:

Table 2.3-13: PWQOs for Lead at Different Hardness Levels

Hardness as $CaCO_3$ (mg/L)	Lead Revised Interim PWQO (mg/L)
<30	0.001
30 to 80	0.003
>80	0.005

The mean measured alkalinity and hardness were used to select appropriate PWQO and Revised Interim PWQO values for each watershed, as follows:

Table 2.3-14: PWQOs for Lead in the Different Watersheds at the Marathon PGM-Cu Project Site

Watershed	PWQO (mg/L)	Revised Interim PWQO (mg/L)
Malpa Lake	0.025	0.005
Pic River	0.025	0.005
Shack Creek	0.02	0.003
Stream 1	0.02	0.003
Stream 2	0.01	0.003
Stream 3	0.01	0.001
Stream 4	0.005	0.001
Stream 5	0.005	0.001
Stream 6	0.005	0.001

Both the PWQO and the Revised Interim PWQO were used as benchmarks for comparison to measured lead concentrations in surface water samples from the study area.

Total lead was measured in 959 samples from the study area. Observed exceedances of the PWQO and Revised Interim PWQO in both measured concentrations and detection limits are summarized as follows:

Table 2.3-15: Number of Total Lead Sample Concentrations and Detection Limits that Exceeded the PWQO

Watershed	PWQO (mg/L)	Number of Samples, Concentration > PWQO	Number of Samples, Detection Limit > PWQO
Malpa Lake	0.025	0 of 29	0 of 29
Pic River	0.025	0 of 75	0 of 75
Shack Creek	0.02	0 of 32	8 of 32
Stream 1	0.02	1 of 100	0 of 100
Stream 2	0.01	1 of 161	0 of 161
Stream 3	0.01	1 of 130	0 of 130
Stream 4	0.005	0 of 54	0 of 54
Stream 5	0.005	3 of 285	2 of 285
Stream 6	0.005	0 of 93	0 of 93

Table 2.3-16: Number of Total Lead Sample Concentrations and Detection Limits that Exceeded the Revised Interim PWQO

Watershed	Revised Interim PWQO (mg/L)	Number of Samples, Concentration > Revised Interim PWQO	Number of Samples, Detection Limit > Revised Interim PWQO
Malpa Lake	0.005	1 of 29	2 of 29
Pic River	0.005	0 of 75	4 of 75
Shack Creek	0.003	1 of 32	8 of 32
Stream 1	0.003	1 of 100	1 of 100
Stream 2	0.003	6 of 161	3 of 161
Stream 3	0.001	11 of 130	0 of 130
Stream 4	0.001	0 of 54	0 of 54
Stream 5	0.001	9 of 285	2 of 285
Stream 6	0.001	6 of 93	0 of 93

Mean measured total lead concentrations ranged from 0.001 mg/L in the Stream 4 watershed, where lead was not detected in 53 of the 54 samples, to 0.026 mg/L in the Shack Creek watershed, where lead was not detected in 31 of the 32 samples taken. Elevated detection limits contributed to the magnitude of the Shack Creek mean lead concentration. The watershed with the most detected exceedances of the Revised Interim PWQO was Stream 3; the minimum detected exceedance in that watershed was 0.001 mg/L and maximum detected exceedance was 0.0106 mg/L. These exceedances were observed in samples from the number of stations, including L9, L10, L11, L12, S18, and S19.

Total lead was not detected in 864 of the 959 samples, which were distributed as follows:

Table 2.3-17: Number of Total Lead Samples below the Detection Limit

Watershed	Total Samples Analyzed	Number of Samples, Concentration < Detection Limit
Malpa Lake	29	21
Pic River	75	47
Shack Creek	32	31
Stream 1	100	97
Stream 2	161	138
Stream 3	130	117
Stream 4	54	53
Stream 5	285	274
Stream 6	93	86

The watersheds with the highest proportion of detected concentrations were the Pic River and Stream 2, which had mean measured concentrations of 0.0017 and 0.0015 mg/L, respectively.

Overall, measured baseline concentrations of lead in the study area were largely dependent on the detection limits. The summary statistics generated for lead are therefore considered representative of upper bounds on baseline concentrations in the study area. Based on the analysis results, lead is not likely to be present at concentrations exceeding the PWQO. However, concentrations greater than the Revised Interim PWQO cannot be ruled out, especially in the Stream 3 watershed, where total lead was detected in several locations.

2.3.9 Manganese

No surface water benchmarks were available for comparison to measured manganese concentrations in the study area. As in the case of iron, total manganese was detected in 941 out of 952 samples. Mean measured concentrations of total manganese ranged from 0.040 mg/L in the Stream 3 watershed to 0.125 mg/L in the Stream 1 watershed.

Dissolved manganese was analyzed in 45 samples, and not detected in two of those samples. Mean dissolved manganese concentrations ranged from 0.0054 mg/L in the Pic River to 0.223 mg/L in the Stream 6 watershed, where that measurement was from the only sample taken from that watershed.

Given the large number of detected and quantified manganese samples in the data set, the summary statistics for manganese are considered representative of baseline concentrations in the study area.

2.3.10 Mercury

The PWQO for mercury is 0.0002 mg/L which was exceeded once in May 2010, where total mercury was detected with a concentration of 0.0402 mg/L (Stream 1). Two samples, in

Streams 5 and 6 were analyzed using elevated detection limits (0.001 mg/L) such that they exceeded the PWQO.

2.3.11 Molybdenum

The PWQO for molybdenum is 0.040 mg/L, and no exceedances of this PWQO were noted in water samples taken from the study area. Of 959 samples analyzed for total molybdenum, the metal was only detected in five; the number of samples by watershed below detection was distributed as follows:

Table 2.3-18: Number of Total Molybdenum Samples below the Detection Limit

Watershed	Number of Samples, Concentration < Detection Limit
Malpa Lake	29 of 29
Pic River	74 of 75
Shack Creek	32 of 32
Stream 1	100 of 100
Stream 2	158 of 161
Stream 3	130 of 130
Stream 4	54 of 54
Stream 5	284 of 285
Stream 6	93 of 93

Dissolved molybdenum was only detected in one sample out of 41. The remaining non-detects were distributed as follows:

Table 2.3-19: Number of Dissolved Molybdenum Samples below the Detection Limit

Watershed	Number of Samples, Concentration < Detection Limit
Malpa Lake	1 of 1
Pic River	6 of 7
Stream 1	3 of 3
Stream 2	5 of 5
Stream 3	4 of 4
Stream 4	11 of 11
Stream 5	9 of 9
Stream 6	1 of 1

Only six of close to 1000 samples had detected molybdenum (total and dissolved), therefore there are inherent uncertainties in the data set and the summary statistics for molybdenum are recommended as the upper bounds of baseline concentrations in the study area. However,

because all the detection limits used in the analyses were less than the PWQO, baseline concentrations of molybdenum can safely be said to be less than the PWQO.

2.3.12 Nickel

A total of 959 samples were analyzed for total nickel. This parameter was not detected in 747 samples. Total nickel concentrations in four of the remaining samples exceeded the PWQO of 0.025 mg/L: one from the Stream 1 watershed; two from the Stream 2 watershed; and one from the Stream 6 watershed. These four concentrations ranged from between 0.048 mg/L and 0.080 mg/L. All of the mean total nickel concentrations were less than the PWQO, ranging from 0.002 mg/L in the Stream 4 watershed to 0.006 mg/L in the Malpa Lake watershed. Certain watersheds were observed to contain relatively few samples in which total nickel was detected. The Shack Creek, Stream 5, and Stream 6 watersheds fall into this category. The pattern of occurrences of values below detection is outlined below:

Table 2.3-20: Number of Total Nickel Samples below the Detection Limit

Watershed	Number of Samples, Concentration < Detection Limit
Malpa Lake	8 of 29
Pic River	30 of 75
Shack Creek	28 of 32
Stream 1	86 of 100
Stream 2	130 of 161
Stream 3	51 of 130
Stream 4	45 of 54
Stream 5	281 of 285
Stream 6	88 of 93

Dissolved nickel was analyzed in 42 samples, and was not detected in 29 of those samples. Mean measured dissolved nickel concentrations ranged from 0.0016 mg/L in the Stream 2 watershed to 0.003 mg/L in the Malpa Lake watershed.

Given the high number of non-detects in the nickel data set, the summary statistics for nickel are recommended as upper bounds of baseline conditions in the study area. It is considered likely, however, that baseline concentrations of total nickel are less than the PWQO.

2.3.13 Selenium

The OMOE has established a PWQO of 0.100 mg/L for selenium in surface waters in Ontario, and measured selenium concentrations in all 958 samples taken in the study area were less than this benchmark. Total selenium was only detected in seven samples overall: one from the Pic River; two from Stream 2; one from Stream 3; two from Stream 4; and one from Stream 5. A total of 39 samples were analyzed for dissolved selenium, and that parameter was only

detected in one of those samples, which was taken from the Pic River. The detection limits used in the analyses had a noticeable impact on the summary statistics for each watershed.

The data set contains a large proportion of non-detect results with only eight of 997 samples detecting selenium. Therefore, the summary statistics for selenium should be used as the upper bounds of baseline concentrations in study area waters, but baseline concentrations of selenium are expected to be less than the PWQO.

2.3.14 Thallium

The Interim PWQO for thallium is 0.0003 mg/L, and of the 959 samples analyzed from the study area, the total thallium concentration exceeded that PWQO in one sample (Hare Creek at Highway, 2007). Thallium was not detected in 956 of the 959 samples, distributed over the study area watersheds as follows:

Table 2.3-21: Number of Total Thallium Samples below the Detection Limit

Watershed	Number of Samples, Concentration < Detection Limit
Malpa Lake	29 of 29
Pic River	74 of 75
Shack Creek	32 of 32
Stream 1	100 of 100
Stream 2	160 of 161
Stream 3	130 of 130
Stream 4	54 of 54
Stream 5	284 of 285
Stream 6	93 of 93

Detection limits above the PWQO were used in the analyses of seventeen samples, distributed as follows:

Table 2.3-22: Number of Total Thallium Sample Detection Limits that Exceeded the PWQO

Watershed	Number of Samples, Detection Limit > PWQO (0.0003 mg/L)
Malpa Lake	3 of 29
Pic River	4 of 75
Stream 1	2 of 100
Stream 2	4 of 161
Stream 5	4 of 285

The high rate of non-detects in the thallium data set influenced the total thallium summary statistics; mean measured total thallium concentrations are therefore based almost entirely on the detection limits used in the various analysis campaigns.

Dissolved thallium was analyzed in 45 samples and was not detected in 44 of those samples. As in the case of total thallium, the dissolved thallium summary statistics were heavily influenced by the detection limits used in the analyses.

Based on the large number of samples in which thallium was not detected, the summary statistics for this parameter are recommended as the upper bounds of baseline concentrations of thallium in the study area.

2.3.15 Uranium

The OMOE has established an Interim PWQO for uranium of 0.005 mg/L. 959 samples were analyzed for total uranium, and the resulting concentrations were compared to this benchmark. Uranium was not detected in 957 of the 959 samples, and measured concentrations in neither of the remaining samples exceeded the Interim PWQO. The 957 non-detects were distributed by watershed as follows:

Table 2.3-23: Number of Total Uranium Samples below the Detection Limit

Watershed	Number of Samples, Concentration < Detection Limit
Malpa Lake	29 of 29
Pic River	74 of 75
Shack Creek	32 of 32
Stream 1	100 of 100
Stream 2	160 of 161
Stream 3	130 of 130
Stream 4	54 of 54
Stream 5	285 of 285
Stream 6	93 of 93

Detection limits used to analyze seventeen of the samples, in which uranium was not detected, exceeded the Interim PWQO. These samples were distributed among watersheds in the study area as follows:

Table 2.3-24: Number of Total Uranium Sample Detection Limits that Exceeded the PWQO

Watershed	Number of Samples, Detection Limit > PWQO (0.005 mg/L)
Malpa Lake	3 of 29
Pic River	4 of 75
Stream 1	2 of 100
Stream 2	4 of 161
Stream 5	4 of 285

Similar to thallium, the summary statistics for total uranium were highly influenced by the detection limits in the data set. Dissolved uranium was analyzed in 45 samples, and was not detected in 44 of those samples. As with the total uranium summary statistics, those for dissolved uranium were also highly influenced by laboratory detection limits. Overall, it is recommended that the summary statistics for uranium be used as upper bounds on the baseline concentrations of uranium in the study area, given the large proportion of uncertainty associated with the large proportion of values below the detection limit.

2.3.16 Vanadium

The OMOE has established an Interim PWQO of 0.006 mg/L for vanadium. Measured total vanadium concentrations in 32 of the 958 samples were greater than this PWQO. Eleven non-detect results had detection limits greater than the PWQO. These exceedances were distributed in the study area watersheds as follows:

Table 2.3-25: Number of Total Vanadium Sample Concentrations and Detection Limits that Exceeded the PWQO

Watershed	Number of Samples, Concentration > PWQO (0.006 mg/L)	Number of Samples, Detection Limit > PWQO (0.006 mg/L)
Malpa Lake	7 of 29	1 of 29
Pic River	13 of 75	4 of 75
Stream 1	2 of 100	1 of 100
Stream 2	7 of 161	3 of 161
Stream 5	2 of 285	2 of 285
Stream 6	1 of 93	0 of 93

Of the 958 samples analyzed for total vanadium, vanadium was not detected in 784. These non-detects were distributed as follows:

Table 2.3-26: Number of Total Vanadium Samples below the Detection Limit

Watershed	Number of Samples, Total Vanadium Not Detected
Malpa Lake	5 of 29
Pic River	17 of 75
Shack Creek	29 of 32
Stream 1	83 of 100
Stream 2	127 of 161
Stream 3	111 of 130
Stream 4	52 of 54
Stream 5	276 of 285
Stream 6	84 of 93

All of the mean measured total vanadium concentrations were less than the PWQO, ranging from 0.0011 mg/L in the Stream 4 watershed to 0.00534 mg/L in the Malpa Lake watershed.

Dissolved vanadium was analyzed in 45 samples, and was not detected in 41 of those samples. Overall, the summary statistics for vanadium were influenced by the presence of many samples in which vanadium was not detected. The recommended use is as the upper bounds of baseline concentrations of vanadium in the study area. However, given the exceedances of the PWQO, the presence of vanadium at concentrations greater than the Interim PWQO cannot be ruled out.

2.3.17 Zinc

The OMOE has established both a PWQO and a Revised Interim PWQO for zinc, assigned the values of 0.030 mg/L and 0.020 mg/L, respectively. Both benchmarks were used for comparison to measured zinc concentrations in water samples from the study area.

959 samples were analyzed for total zinc. Zinc was not detected in 257. These non-detects were distributed as follows:

Table 2.3-27: Number of Total Zinc Samples below the Detection Limit

Watershed	Number of Samples, Concentration < Detection Limit
Malpa Lake	8 of 29
Pic River	25 of 75
Shack Creek	15 of 32
Stream 1	42 of 100
Stream 2	48 of 161
Stream 3	33 of 130
Stream 4	18 of 54
Stream 5	56 of 285
Stream 6	12 of 93

Six of these 257 non-detects were analyzed using detection limits greater than the Revised Interim PWQO, although all six met the former PWQO. Measured zinc concentrations in twenty-two samples of the 702 samples in which zinc was detected exceeded the Revised Interim PWQO. The distribution of samples with concentrations or detection limits exceeding the Revised Interim PWQO is as follows:

Table 2.3-28: Number of Total Zinc Sample Concentrations and Detection Limits that Exceeded the Revised Interim PWQO

Watershed	Number of Samples, Concentration > PWQO (0.020 mg/L)	Number of Samples, Detection Limit > PWQO (0.020 mg/L)
Malpa Lake	3 of 29	1 of 29
Pic River	2 of 75	2 of 75
Stream 1	3 of 100	0 of 100
Stream 2	4 of 161	2 of 161
Stream 3	2 of 130	0 of 130
Stream 4	2 of 54	0 of 54
Stream 5	4 of 285	1 of 285
Stream 6	2 of 93	0 of 93

All of the mean total zinc concentrations met both PWQOs, ranging from 0.0051 mg/L in the Shack Creek watershed to 0.0102 mg/L in the Malpa Lake watershed.

Dissolved zinc was analyzed in 45 samples from the study area and was not detected in 28 of those samples. Mean measured dissolved zinc concentrations ranged from 0.0017 mg/L in the Stream 1 watershed to 0.0031 mg/L in the Pic River.

Given the limited number of non-detects in the zinc data set a relatively high confidence in the data is warranted. Therefore, it is recommended that the summary statistics for zinc be used as representative baseline concentrations in the study area.

2.4 Background Water Chemistry of Stream 1, 2, 3 and 4 Subwatersheds

The Streams 1 through 4 subwatersheds discharge into the Pic River and parts of each are located within the proposed Project footprint. A number of representative sampling stations within these subwatersheds are discussed below. These particular sampling sites were chosen because they are located at the downstream ends of their respective subwatersheds.

2.4.1 Subwatershed 1

Station S2 represents the downstream end of subwatershed 1. General water quality based on data collected at monitoring station S2 is as follows:

Table 2.4-1: Water Chemistry in Subwatershed 1, Station S2

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	265	118
Dissolved Aluminum	0.075	0.190	0.062
Ammonia (as N)	1.5	0.110	0.032
Arsenic	0.1 or 0.005 (Interim)	0.0100	0.0015
Cadmium	0.0002 or 0.0005 (Interim)	0.0009	0.0001
Cobalt	0.0009	0.00500	0.00083
Copper	0.005	0.0100	0.0031
Dissolved Organic Carbon	-	11.5	6.6
Iron	0.3	4.03	0.80
Lead	0.025 or 0.005 (Interim)	0.010	0.0015
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.0100	0.0015
Nickel	0.025	0.0200	0.0034
Nitrate (as N)	-	0.400	0.142
pH	6.5-8.5	8.3	7.8
Phosphorus	0.03	0.071	0.022
Selenium	0.1	0.0050	0.0011
Sulphate	-	5.40	3.77
Total Hardness (as $CaCO_3$)	-	263	122

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Total Kjeldahl Nitrogen	-	0.397	0.275
Total Suspended Solids	-	86	18
Zinc	0.03 or 0.02 (Interim)	0.1300	0.0108

Several analytes including arsenic, mercury, molybdenum, and selenium were not detected above their respective method detection limits (MDL). Concentrations of dissolved aluminum were below the Provincial Water Quality Objective (PWQO) value of 0.075 mg/L with the exception of one exceedance occurring in May 2011 with a concentration of 0.19 mg/L. The average concentration was 0.062 mg/L. Concentrations of ammonia did not exceed the site specific objective of 1.5 mg/L NH_3-N for any of the samples, with an average concentration of 0.03 mg/L. Concentrations of cadmium were consistently below the MDL of 0.0009 mg/L with the exception of the sample collected in November 2008 that had a concentration of 0.00012 mg/L. Cobalt concentrations were consistently below the MDL, with the exception of the sample collected in July 2009 that exceeded the PWQO value with a concentration of 0.002 mg/L. This concentration was an order of magnitude higher than all other samples and most likely represents an anomalous value. Concentrations of copper were 0.003 mg/L on average. Samples collected from S2 exhibited one exceedance the PWQO value in July 2009 with a concentration of 0.007 mg/L. Concentrations of iron were 0.8 mg/L on average and exceeded the PWQO value in 16 of 19 samples collected. Concentrations of lead were consistently below the MDL with the exception of the sample collected in July 2009 with a concentration of 0.002 mg/L. Concentrations of nickel were only above the MDL in 4 of the 19 samples collected and exhibited an average concentration of 0.003 mg/L. Concentrations of total phosphorus were above the MDL on average and exceeded the PWQO value during five sampling events including May and July 2009, July and August 2010 and May 2011. Concentrations of zinc were 0.01 mg/L on average and exceeded the PWQO value for one sampling event in July 2008.

Samples collected from station S2 exhibited consistent pH values ranging from 7.1 to 8.3 with an average value of 7.8. All pH measures were within the PWQO range of 6.5 to 8.5.

Alkalinity averaged 118 mg/L with a minimum level of 24.2 mg/L occurring in May 2009 and a maximum level of 265 mg/L occurring in August 2008. Dissolved organic carbon (DOC) averaged 7mg/L with a minimum concentration of 4 mg/L in July and August 2008 and a maximum concentration of 11.5 mg/L in August 2009. Nitrate (as N) averaged 0.1 mg/L with a minimum concentration less than 0.03 mg/L on three occasions and a maximum concentration of 0.4 mg/L in November 2008 and May 2010. Sulphate averaged 3.8 mg/L with a minimum concentration of 2.1 mg/L in August 2010 and a maximum concentration of 5.4 mg/L in November 2008. Total hardness averaged 122 mg/L and ranged from 31.8 mg/L in May 2009 to 263 mg/L in August 2010. Total Kjeldahl nitrogen (TKN) showed little variation and was on

average 0.28 mg/L. When above the MDL total suspended solids (TSS) ranged from 3.5 mg/L in November 2009 to 86.2 mg/L in July 2008. TSS averaged 18 mg/L.

2.4.2 Subwatershed 2

Station S4 represents the downstream end of subwatershed 2. General water quality based on data collected at monitoring station S4 is as follows:

Table 2.4-2: Water Chemistry in Subwatershed 2, Station S4

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	150	91
Dissolved Aluminum	0.075	0.151	0.050
Ammonia (as N)	1.0	0.040	0.023
Arsenic	0.1 or 0.005 (Interim)	0.0100	0.0016
Cadmium	0.0002 or 0.0001 (Interim)	0.00090	0.00014
Cobalt	0.0009	0.00500	0.00096
Copper	0.005	0.0100	0.0049
Dissolved Organic Carbon	-	10.8	7.1
Iron	0.3	4.45	1.52
Lead	0.025 or 0.005 (Interim)	0.0100	0.0017
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.010	0.0016
Nickel	0.025	0.0200	0.0038
Nitrate (as N)	-	0.471	0.141
pH	6.5-8.5	8.3	7.9
Phosphorus	0.03	0.223	0.045
Selenium	0.1	0.0050	0.0012
Sulphate	-	6.29	5.00
Total Hardness (as $CaCO_3$)	-	229	109
Total Kjeldahl Nitrogen	-	0.550	0.312
Total Suspended Solids	-	436	66
Zinc	0.03 or 0.02 (Interim)	0.3700	0.0289

At sampling station S4, several analytes including arsenic, cadmium, mercury, molybdenum, and selenium were present in concentrations below their respective MDL.

Concentrations of dissolved aluminum were consistently above the MDL value and exhibited an average concentration of 0.05 mg/L. An exceedance of the PWQO value occurred in May 2011

with a dissolved aluminum concentration of 0.15 mg/L. Concentrations of ammonia did not exceed the site specific objective of 1 mg/L NH_3-N for any of the samples. Concentrations of cobalt were consistently below the MDL value with the exception of two exceedances occurring in May of 2009 and May of 2011 with concentrations of 0.0015 and 0.002 mg/L, respectively. Concentrations of copper exceeded the PWQO value in 6 of the 16 samples collected with an average concentration of 0.005 mg/L. Concentrations of lead were consistently below the MDL value with the exception of three sampling events in May of 2009, 2010 and 2011 with concentrations of 0.0014 mg/L, 0.0011 mg/L and 0.002 mg/L. Concentrations of lead at location S4 did not exceed the PWQO value for any of the samples collected. Concentrations of nickel were 0.004 mg/L on average and did not exceed the PWQO value. Concentrations of total phosphorus were above the MDL on average and exceeded the PWQO value during 6 of the 15 sampling events. Concentrations of zinc were 0.03 mg/L on average and did not exceed the PWQO value for any of the samples collected.

Samples collected from station S4 exhibited consistent pH values ranging from 7.3 to 8.3 with an average value of 7.9.

Alkalinity averaged 91mg/L with a minimum level of 49 mg/L occurring in May 2009 and a maximum level of 150 mg/L occurring in July 2011. DOC averaged 7.1 mg/L with a minimum concentration of 5 mg/L in both August and October 2008 and a maximum concentration of 10.8 mg/L in August 2009. Sulphate concentrations averaged 5 mg/L with a minimum concentration of 3.9 mg/L in July 2008 and a maximum concentration of 6.3 mg/L in July 2010. Total hardness averaged 109 mg/L and ranged from 50.3 to 229 mg/L in May and 2011, respectively. Nitrate concentrations ranged from 0.034 to 0.471 mg/L with an average of 0.14 mg/L. TKN was consistent throughout the sampling period, averaging 0.3 mg/L and ranging from 0.22 mg/L in July 2011 to 0.55 mg/L in July 2008. TSS varied widely from below the MDL of 2 mg/L in October 2009 to 436 mg/L in May 2011.

2.4.3 Subwatershed 3

Station S6 represents the downstream end of subwatershed 3. General water quality based on data collected at monitoring station S6 is as follows:

Table 2.4-3: Water Chemistry in Subwatershed 3, Station S6

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	241	88
Dissolved Aluminum	0.075	0.130	0.046
Ammonia (as N)	0.9	0.220	0.037
Arsenic	0.1 or 0.005 (Interim)	0.0010	0.0010
Cadmium	0.0002 or 0.0001 (Interim)	0.00009	0.00009
Cobalt	0.0009	0.00113	0.00056
Copper	0.005	0.0138	0.0069
Dissolved Organic Carbon	-	11.0	6.6
Iron	0.3	2.49	0.82
Lead	0.025 or 0.005 (Interim)	0.0011	0.0010
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.001	0.0010
Nickel	0.025	0.0050	0.0027
Nitrate (as N)	-	0.434	0.171
pH	6.5-8.5	8.4	8.0
Phosphorus	0.03	0.109	0.025
Selenium	0.1	0.0050	0.0010
Sulphate	-	6.29	4.76
Total Hardness (as $CaCO_3$)	-	238	99
Total Kjeldahl Nitrogen	-	0.420	0.287
Total Suspended Solids	-	162	25
Zinc	0.03 or 0.02 (Interim)	0.1510	0.0138

At sampling station S6, several analytes including arsenic, cadmium, mercury, molybdenum, and selenium were not detected at or above their respective MDL. Concentrations of dissolved aluminum were 0.046 mg/L on average. An exceedance of the PWQO value occurred in May 2011 with a dissolved aluminum concentration of 0.13 mg/L. Concentrations of ammonia did not exceed the site specific objective of 0.9 mg/L NH_3-N for any of the samples. Concentrations ranged from below detection to 0.22 mg/L with an average concentration of 0.04 mg/L. Concentrations of cobalt were consistently below the MDL with the exception of four samples. An exceedance above the PWQO value occurred in May of 2011 with a concentration of 0.001 mg/L. Concentrations of copper exceeded the PWQO value in 13 of the 15 samples collected with an average concentration of 0.007 mg/L. Concentrations of iron were 0.8 mg/L on average, reaching a maximum concentration of 2.5 mg/L. Concentrations of iron exceeded the PWQO value of 0.3 mg/L in 5 of the 15 samples collected. Concentrations of nickel were 0.003 mg/L

on average and did not exceed the PWQO value of 0.025 mg/L for any of the sampling events. Concentrations of total phosphorus were 0.03 mg/L on average and ranged from 0.006 to 0.109 mg/L. Two exceedances of the PWQO value were associated with the May 2010 and May 2011 sampling events with concentrations of 0.037 and 0.109 mg/L, respectively. Concentrations of zinc were 0.01 mg/L on average and with the exception of the August 2008 sampling event, did not exceed the PWQO value for any of the samples collected.

Samples collected from S6 exhibited consistent pH values ranging from 7.3 to 8.3 with an average value of 8.0. All measures were within the PWQO.

Alkalinity averaged 88 mg/L, with a minimum level of 40.5 mg/L in May 2009 and a maximum level of 241 mg/L in August 2008. DOC had an average concentration of 6.6 mg/L, with a minimum concentration of 4 mg/L in July, August and October 2008 and a maximum concentration of 11 mg/L in August 2009. Sulphate concentrations averaged 4.8 mg/L, with a minimum concentration of 4.0 mg/L in July 2008 and a maximum concentration of 6.3 mg/L in October 2008. Total hardness averaged 99 mg/L and ranged from 42.2 mg/L in May 2009 to 238 mg/L in August 2008. The mean nitrate concentration was 0.17 mg/L ranging from 0.06 mg/L in September 2010 to 0.43 mg/L in May 2010. TKN showed little variability, averaging 0.3 mg/L and ranging from 0.2 mg/L in October 2008 to 0.4 mg/L in August 2009. TSS ranged from < 2 mg/L in August 2008 and September 2010 to 162 mg/L in May 2011. Mean TSS was 25 mg/L.

2.4.4 Subwatershed 4

Station S8 is downstream of Claw Lake, and represents the downstream end of subwatershed 4. General water quality based on data collected at monitoring station S8 is as follows:

Table 2.4-4: Water Chemistry in Subwatershed 4, Station S8

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	38	15
Dissolved Aluminum	0.075	0.152	0.053
Ammonia (as N)	3.9	0.100	0.033
Arsenic	0.1 or 0.005 (Interim)	0.0010	0.0010
Cadmium	0.0002 or 0.0001 (Interim)	0.00019	0.00010
Cobalt	0.0009	0.01020	0.00120
Copper	0.005 or 0.001 (Interim)	0.0220	0.0064
Dissolved Organic Carbon	-	10.3	6.6
Iron	0.3	5.31	1.08
Lead	0.005 or 0.001 (Interim)	0.0010	0.0010

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.001	0.0010
Nickel	0.025	0.0036	0.0021
Nitrate (as N)	-	0.202	0.062
pH	6.5-8.5	7.8	7.3
Phosphorus	0.03	0.132	0.023
Selenium	0.1	0.0050	0.0009
Sulphate	-	9.17	4.49
Total Hardness (as $CaCO_3$)	-	47	19
Total Kjeldahl Nitrogen	-	1.890	0.462
Total Suspended Solids	-	28	4.8
Zinc	0.03 or 0.02 (Interim)	0.1040	0.0164

A summary of the general water quality based on data collected at monitoring station S8, downstream of Claw Lake (L19) at the downstream end of the subwatershed, is provided in Table 5.4-10.

At sampling station S8, several analytes including arsenic, mercury, molybdenum, and lead were not detected at their respective MDL. Concentrations of dissolved aluminum were 0.053 mg/L on average. Three exceedances of the PWQO value were associated with the sampling events in July 2008, August 2010 and May 2011 with concentrations of 0.14, 0.15 and 0.08 mg/L respectively. Concentrations of ammonia did not exceed the site specific objective of 0.4 mg/L NH_3-N for any of the samples. Concentrations of ammonia were 0.03 mg/L on average. Concentrations of cadmium were above the MDL for two sampling events, August 2010 and July 2011 with concentrations of 0.002 and 0.0001 mg/L respectively. The August 2010 samples also exceeded the PWQO value for cadmium of 0.0001 mg/L. Concentrations of cobalt were consistently below the MDL value with the exception of five samples ranging from 0.0006 to 0.01 mg/L. Concentrations that exceed the PWQO value occurred in September 2008, August 2010 and July 2011 with values of 0.0025, 0.010, and 0.0017 mg/L, respectively. Concentrations of copper exceeded the PWQO value in 12 of the 19 samples collected, ranging from 0.004 to 0.022 mg/L with an average concentration of 0.006 mg/L. Concentrations of iron were 1.1 mg/L on average, reaching a maximum concentration of 5.3 mg/L. Concentrations of iron exceeded the PWQO value of 0.3 mg/L in all of the samples collected from this station. Concentrations of nickel were consistently below the MDL value with the exception of one sample collected in August 2010 with a concentration of 0.0036 mg/L. Concentrations of total phosphorus were 0.023 mg/L on average and ranged from 0.007 to 0.03 mg/L. Three exceedances of the PWQO value were associated with the July 2009, August 2010 and July 2011 sampling events with concentrations of 0.13, 0.08 and 0.43 mg/L, respectively. A selenium concentration of 0.0006 mg/L was reported in August 2010. All other samples

exhibited concentrations of selenium that were below the MDL. Concentrations of zinc ranged from 0.003 to 0.1 mg/L and were 0.016 mg/L on average. With the exception of the September and October 2008 and the August 2010 sampling events, did not exceed the PWQO value for any of the samples collected.

Samples collected from station S8 exhibited consistent pH values ranging from 6.6 to 7.8 with an average value of 7.3. All values were within the PWQO range.

Alkalinity was low, averaging 15 mg/L with a minimum level of 8 mg/L occurring in May 2009 and a maximum level of 39 mg/L occurring in August 2010. DOC averaged 6.6 mg/L with a minimum concentration of 5 mg/L and a maximum concentration of 10.3 mg/L. Sulphate concentrations averaged 4.5 mg/L with a minimum concentration of 3.7 mg/L in October 2009 and a maximum concentration of 9.2 mg/L in August 2010. Total hardness averaged only 19 mg/L and ranged from 11 mg/L in May 2009 to 47 mg/L in August 2010. TKN was consistent at Station S8 averaging 0.29 mg/L and ranged from 0.23 mg/L in October 2008 to 0.42 mg/L in August 2009. Nitrate concentrations averaged 0.062 mg/L and range from less than 0.03 mg/L to 0.20 mg/L. TSS displayed little variability, averaging 4.8 mg/L with a minimum concentration below the MDL (2.0 mg/L) occurring on several occasions. The maximum concentration was 28.4 mg/L, sampled in July 2009.

2.4.5 Pic River

Water quality in the Pic River is represented by data from two monitoring stations, one upstream of the Project site (PR1) and one downstream of the Project site (PR2). General water quality based on data collected at monitoring station PR1 and PR2 is summarized in below. At PR1 and PR2 several analytes including cadmium, mercury, molybdenum, and selenium were not detected at their respective MDL.

Station PR1 is in the Pic River, just to the north of the Project site. General water quality based on data collected at monitoring station PR1 is as follows:

Table 2.4-5: Water Chemistry in the Pic River, Station PR1

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	139	112
Dissolved Aluminum	0.075	0.071	0.037
Ammonia (as N)	0.8	0.053	0.024
Arsenic	0.1 or 0.005 (Interim)	0.0100	0.0016
Cadmium	0.0002 or 0.0005 (Interim)	0.00090	0.00014
Cobalt	0.0009	0.00500	0.00121
Copper	0.005	0.0100	0.0033
Dissolved Organic Carbon	-	15.1	10.1
Iron	0.3	5.84	1.99
Lead	0.025 0.005 (Interim)	0.0100	0.0018
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.010	0.0016
Nickel	0.025	0.0200	0.0046
Nitrate (as N)	-	0.131	0.051
pH	6.5-8.5	8.4	8.0
Phosphorus	0.03	0.214	0.072
Selenium	0.1	0.0050	0.0012
Sulphate	-	3.09	2.16
Total Hardness (as $CaCO_3$)	-	212	120
Total Kjeldahl Nitrogen	-	0.580	0.436
Total Suspended Solids	-	389	118
Zinc	0.03 or 0.02 (Interim)	0.0300	0.0082

Average dissolved aluminum concentrations were 0.0368 mg/L and all values were below the PWQO.

Arsenic was only detected once in June of 2009 just above the MDL and was not above the PWQO. Cobalt was detected in half of the sampling events. The detected concentrations ranged from 0.0006 to 0.005 mg/L. The PWQO was exceeded on 5 occasions; May June, August and September of 2009 and May 2011. Copper concentrations ranged from 0.001 to 0.01 mg/L with an average of 0.0033 mg/L. The PWQO was exceeded twice; June 2009 and May 2011. All iron concentrations were above the PWQO with a mean of 1.99 mg/L and a range of 0.311 to 5.84 mg/L. Lead concentrations were generally close to the MDL of 0.001 mg/L and no values exceeded guidelines. All zinc concentrations were below the PWQO and range from 0.003 to 0.018 mg/L. Ammonia concentrations were always below the station

specific PWQO (0.8 mg/L). Ammonia ranged from below detection, 0.02 mg/L, to 0.05 mg/L. The mean nickel concentration was 0.0046 mg/L and all measured levels were below the PWQO. Nickel concentrations ranged from 0.002 mg/L to 0.02 mg/L. The mean phosphorus concentration was 0.0716 mg/L and exceeds the PWQO guideline. Overall the range was 0.0078 to 0.214 mg/L of total phosphorus in 15 samples. Individual exceedances occurred in the spring and summer of 2009 (May to September) and 2010 (May, July).

Samples collected from the PR1 station exhibited consistent pH values ranging from 6.7 to 8.4 with an average value of 8.0.

Alkalinity averaged 112 mg/L with a minimum concentration of 81.5 mg/L occurring in May 2009 and a maximum concentration of 139 mg/L occurring in October 2011. DOC averaged 10.1 mg/L with a minimum concentration of 7.0 mg/L occurring in August 2008 and a maximum concentration of 15.1 mg/L occurring in August 2009. Sulphate concentrations did not vary greatly, averaging 2.2 mg/L with a minimum concentration of 1.4 mg/L in September 2010 and a maximum concentration of 3.1 mg/L in June 2009. Total hardness averaged 120 mg/L and ranged from 64.7 mg/L in May 2009 to 212 mg/L in May 2011. TKN showed little variability, averaging 0.44 mg/L and ranging from less than 0.25 mg/L in October 2011 to 0.58 mg/L in July 2008. TSS average 18 mg/L and ranged widely from 12 mg/L to 389 mg/L.

Station PR2 is in the Pic River, just to the south of the outlet of Stream 1. General water quality based on data collected at monitoring station PR2 is as follows:

Table 2.4-6: Water Chemistry in the Pic River, Station PR2

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	137	107
Dissolved Aluminum	0.075	0.122	0.035
Ammonia (as N)	0.6	0.034	0.022
Arsenic	0.1 or 0.005 (Interim)	0.0100	0.0015
Cadmium	0.0002 or 0.0005 (Interim)	0.00090	0.00014
Cobalt	0.0009	0.00500	0.00105
Copper	0.005	0.0100	0.0030
Dissolved Organic Carbon	-	14.7	8.8
Iron	0.3	5.47	1.53
Lead	0.025 0.005 (Interim)	0.0100	0.0017
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.010	0.0015
Nickel	0.025	0.0200	0.0040
Nitrate (as N)	-	0.166	0.058

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
pH	6.5-8.5	9.2	8.1
Phosphorus	0.03	0.170	0.050
Radium-226	1.0 Bq/L	0.01 Bq/L	0.01Bq/L
Selenium	0.1	0.0050	0.0011
Sulphate	-	3.54	2.55
Total Hardness (as $CaCO_3$)	-	217	115
Total Kjeldahl Nitrogen	-	0.662	0.411
Total Suspended Solids	-	302	83
Zinc	0.03 or 0.02 (Interim)	0.0400	0.0078

The mean dissolved aluminum concentration was 0.035 mg/L and ranged from below the MDL to 0.122 mg/L. The maximum level measured in May 2011 was the only exceedance of the PWQO. Ammonia concentrations were generally between 0.02 and 0.03 mg/L and none exceeded the station specific PWQO of 0.65 mg/L. All arsenic concentrations were generally near the MDL (0.001 mg/L). Only two measures exceeded the MDL and neither value exceeded the PWQO. The mean cobalt concentration was 0.001 mg/L. Cobalt levels ranged from below the MDL (0.005 mg/L) to 0.0035 mg/L. Cobalt concentration in May and June 2009 and May 2011 exceeded the PWQO with concentration of 0.0017, 0.0025 and 0.0021 mg/L, respectively. Copper concentrations averaged 0.003 mg/L with a minimum of 0.001 mg/L and a maximum of 0.006 mg/L. In June 2009 and May 2011 the copper concentrations were both 0.006 mg/L exceeding the PWQO. All other copper concentrations were less than PWQO. All iron concentration exceeded the PWQO. The average iron level was 1.53 mg/L with a range of 0.31 to 5.47 mg/L. Nickel concentrations averaged 0.004 mg/L and all values were below the PWQO. Lead was only above the MDL on three occasions, June 2009 and May 2010 and 2011. None of the measured lead concentrations exceeded the PWQO. Zinc levels averaged 0.0078 mg/L ranging from less than 0.003 to 0.04 mg/L. The maximum value measured in July 2008 exceeded the PWQO whereas all other samples were below the 0.02 mg/L guideline. Phosphorus concentration ranged from 0.0059 to 0.17 mg/L with a mean of 0.05 mg/L. Eight of the 17 samples exceeded the PWQO.

The average pH was 8.1. The May 2010 pH value was 9.2 exceeding the upper bound of the guideline range. All other measures were within the 6.5 to 8.5 PWQO range.

Alkalinity averaged 107 mg/L with a maximum level of 137 mg/L occurring in October 2011 and a minimum level of 57 mg/L occurring in September 2009. DOC had an average concentration of 8.8 mg/L with a minimum concentration of 6 mg/L occurring in September 2008 and a maximum concentration of 14.7 mg/L occurring in August 2009. Sulphate concentrations did not vary greatly, averaging 2.6 mg/L with a maximum concentration of 3.5 mg/L in September 2009 and a minimum concentration of 1.8 mg/L in August 2010. Total hardness averaged 115

mg/L and ranged from 61.9 mg/L in September 2009 to 217 mg/L in May 2011. TKN averaged 0.4 mg/L and ranged from less than 0.3 mg/L in October 2011 to 0.66 mg/L in July 2009. Nitrate (as N) concentrations ranged from less than 0.03 mg/L to 0.17 mg/L with an average of 0.058 mg/L. TSS ranged widely from 2.1 mg/L in October 2011 to 302 mg/L inn June 2009 and averaged 83 mg/L.

2.5 Background Water Chemistry of Stream 5 and 6 Subwatersheds

The Stream 5 and 6 subwatersheds drain naturally to Lake Superior. During mine operations water that is not needed to support the milling process will be discharged (following treatment as appropriate) to Hare Lake, which is in the Stream 5 subwatershed. The PSMF will occupy the upper portion of the Stream 6 subwatershed and water that naturally drains this area will be managed therein. The natural drainage pattern of the Stream 6 subwatershed will be restored following mine closure.

The discussion of water quality at sampling sites within these subwatersheds is not limited to the downstream areas, as was the case for the Stream 1 to 4 subwatersheds rather the discussion considers stations throughout each sub-basin.

2.5.1 Stream 5 Subwatershed

Data from four sampling locations are provided to represent the water quality in the Stream 5 subwatershed. Station S41 is located in the Bamoos Lake outlet creek in the upper part of the subwatershed. S10 is located on an inlet to Hare Lake that drains the northwest portion of the Project site (i.e., Stream 5). S11 is located on the Hare Lake outlet and S30 is located near where Hare Creek flows into Lake Superior (Port Munro).

General water quality based on data collected at monitoring station S41 is as follows:

Table 2.5-1: Water Chemistry in Subwatershed 5, Station S41

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	7.8	6.5
Dissolved Aluminum	0.075	0.037	0.036
Ammonia (as N)	0,4	0.021	0.020
Arsenic	0.1 or 0.005 (Interim)	0.0010	0.0010
Cadmium	0.0002 or 0.0001 (Interim)	0.00009	0.00009
Cobalt	0.0009	0.00050	0.00050
Copper	0.005 or 0.001 (Interim)	0.0050	0.0022

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Dissolved Organic Carbon	-	5.3	4.6
Iron	0.3	0.10	0.07
Lead	0.005 or 0.001 (Interim)	0.0010	0.0010
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.001	0.0010
Nickel	0.025	0.0020	0.0020
Nitrate (as N)	-	0.219	0.138
pH	6.5-8.5	7.0	6.8
Phosphorus	0.03	0.014	0.007
Selenium	0.1	0.0004	0.0004
Sulphate	-	4.21	3.92
Total Hardness (as $CaCO_3$)	-	10	9.7
Total Kjeldahl Nitrogen	-	0.230	0.205
Total Suspended Solids	-	4	2.3
Zinc	0.03 or 0.02 (Interim)	0.0042	0.0032

At S41, several analytes including arsenic, cadmium, cobalt, mercury, molybdenum, lead, nickel, and selenium, were not detected at their respective MDL. Dissolved aluminum concentrations in July and August 20010 were both around 0.036 mg/L and did not exceed the PWQO. The S41 station specific PWQO for ammonia was determined to be 0.4 mg/L. No samples exceeded this value and only a single sample from November 2009 (0.021 mg/L) was above the MDL. Copper concentrations averaged 0.002 mg/L and ranged from 0.0015 to 0.005 mg/L, all equal to or below the PWQO. Only three of the seven samples resulted in total phosphorus concentrations above the MDL, none of which exceeded the PWQO of 0.02 mg/L.

Samples collected from station S41 exhibited consistent pH values ranging from 6.5 to 7.0 with an average value of 6.8. All values were within the PWQO range.

Alkalinity averaged 6.5 mg/L, with a minimum level of 5.2 mg/L occurring in May 2010 and a maximum level of 7.8 mg/L occurring in August 2009. DOC averaged 4.6 mg/L, with a minimum concentration of 3.8 mg/L in November 2009 and a maximum concentration of 5.3 mg/L in May 2010. Nitrate (as N) averaged 0.1 mg/L, with a minimum concentration of 0.07 mg/L and maximum concentration of 0.2 mg/L. Sulphate and hardness concentrations did not vary greatly, averaging 3.9 mg/L and 9.7 mg/L, respectively. TKN exhibited almost no variability and with concentrations around 0.2 mg/L throughout the sampling period. TSS values were consistently low with a mean of 2.3 mg/L.

General water quality based on data collected at monitoring station S10 is as follows:

Table 2.5-2: Water Chemistry in Subwatershed 5, Station S10

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	21	7.5
Dissolved Aluminum	0.075	0.394	0.174
Ammonia (as N)	13.2	0.320	0.052
Arsenic	0.1 or 0.005 (Interim)	0.0010	0.0010
Cadmium	0.0002 or 0.0001 (Interim)	0.00011	0.00009
Cobalt	0.0009	0.00330	0.00070
Copper	0.005 or 0.001 (Interim)	0.0018	0.0011
Dissolved Organic Carbon	-	10.7	8.4
Iron	0.3	6.37	1.48
Lead	0.005 or 0.001 (Interim)	0.0030	0.0011
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.001	0.0010
Nickel	0.025	0.0020	0.0020
Nitrate (as N)	-	0.111	0.056
pH	6.5-8.5	7.9	6.8
Phosphorus	0.03	0.042	0.017
Selenium	0.1	0.0050	0.0009
Sulphate	-	3.72	2.83
Total Hardness (as $CaCO_3$)	-	21	9.1
Total Kjeldahl Nitrogen	-	1.140	0.440
Total Suspended Solids	-	14	4.4
Zinc	0.03 or 0.02 (Interim)	0.0123	0.0063

At sampling station S10, several analytes including arsenic, mercury, molybdenum, nickel, and selenium were not detected at their respective MDL. Dissolved aluminum had an average concentration 0.174 mg/L. The concentrations ranged from a minimum of 0.08 mg/L to a maximum of 0.394 mg/L. All samples exceeded the PWQO of 0.075 mg/L. The station specific PWQO for ammonia was 13.2 mg/L. Eleven of 19 measures were above the MDL and ranged in concentration from 0.027 to 0.32 with an average of 0.05 mg/L. All samples were at least an order of magnitude below the PWQO. Only one sample exceeded the MDL for cadmium and had a concentration of 0.00011 mg/L (July 2011) which slightly exceeds the PWQO of 0.0001 mg/L. About half of the cobalt samples were below the MDL. The samples above the MDL ranged from 0.0006 mg/L to 0.0033 mg/L. One sample, the maximum from August 2008, exceeded the PWQO. Three samples exceeded the PWQO for copper. These exceedances

occurred in May 2010, September 2010, and July 2011 with concentrations of 0.0018, 0.0011, 0.0011 mg/L, respectively. Iron averaged 1.48 mg/L and ranged from 0.316 to 6.37 mg/L and all samples exceeded the PWQO of 0.3 mg/L. Lead was only over the MDL once with a concentration of 0.003 mg/L which exceeds the interim PWQO of 0.001 mg/L. Zinc concentrations averaged 0.006 mg/L with a range of 0.0034 to 0.012 mg/L. None of the measured concentrations exceeded the PWQO of 0.02 mg/L. Phosphorus concentrations averaged 0.0171 mg/L with a concentration range of 0.007 to 0.042 mg/L. The August 2008, October 2009 and September 2010 samples were above PWQO with levels of 0.032, 0.039, and 0.035 mg/L, respectively.

Three of the eight pH measurements were below the lower bound of the PWQO range. The overall mean pH was 6.8.

Alkalinity was low, averaging 7.5 mg/L with a minimum level below the MDL (5.0 mg/L) occurring on several occasions and a maximum level of 21 mg/L occurring in August 2008. DOC averaged 8.4 mg/L, had a minimum concentration of 6 mg/L in November 2008 and a maximum concentration of 10.7 mg/L in May 2009. Nitrate (as N) averaged 0.06 mg/L ranging from below the MDL (0.03 mg/L) on several occasions, to a maximum concentration of 0.11 mg/L in May 2010. Sulphate averaged 2.8 mg/L with a minimum concentration of 1.3 mg/L in August 2008 and a maximum concentration of 3.7 mg/L in May 2010. Total hardness did not vary greatly, averaging 9.1 mg/L. TKN averaged 0.4 mg/L and ranged from less than the MDL, 0.25 mg/L, in October 2011 to 1.1 mg/L in August 2008. TSS averaged 4.4 mg/L, had a minimum concentration below the MDL of 2.0 mg/L occurring on several occasions and a maximum concentration of 14.3 mg/L in July 2011.

General water quality based on data collected at monitoring station S11 is as follows:

Table 2.5-3: Water Chemistry in Subwatershed 5, Station S11

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	10.5	8.1
Dissolved Aluminum	0.075	0.230	0.088
Ammonia (as N)	1.4	0.030	0.022
Arsenic	0.1 or 0.005 (Interim)	0.0010	0.0010
Cadmium	0.0002 or 0.0001 (Interim)	0.00009	0.00009
Cobalt	0.0009	0.00050	0.00050
Copper	0.005 or 0.001 (Interim)	0.0014	0.0010
Dissolved Organic Carbon	-	11.9	6.4
Iron	0.3	0.43	0.21

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Lead	0.005 or 0.001 (Interim)	0.0010	0.0010
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.001	0.0010
Nickel	0.025	0.0020	0.0020
Nitrate (as N)	-	0.311	0.120
pH	6.5-8.5	10.2	7.8
Phosphorus	0.03	0.049	0.008
Selenium	0.1	0.0050	0.0008
Sulphate	-	4.71	3.37
Total Hardness (as $CaCO_3$)	-	13	11
Total Kjeldahl Nitrogen	-	0.310	0.249
Total Suspended Solids	-	3	2.2
Zinc	0.03 or 0.02 (Interim)	0.0067	0.0041

At sampling station S11, several analytes including arsenic, cadmium, cobalt, mercury, molybdenum, nickel, and selenium were not detected below their respective MDL. Dissolved aluminum concentration ranged from 0.039 to 0.23 mg/L with a mean of 0.088 mg/L. Seven of the 11 samples measurement for dissolved aluminum exceeded the PWQO or 0.075 mg/L. Ammonia concentrations ranged from below the MDL (i.e., 0.02 mg/L) to 0.03 mg/L. Concentrations were below the station specific PWQO of 1.4 mg/L. All copper concentrations were around 0.001 mg/L which is equal to the MDL. The July, October and November, 2009 samples all slightly exceeded the PWQO (0.001 mg/L). Iron concentrations averaged 0.21 mg/L and ranged from 0.097 to 0.43 mg/L. The November 2008 and 2009 concentrations were 0.38 mg/L and 0.43 mg/L both exceeding the PWQO. Generally, lead concentrations at S11 were below detection, however a single sample (July, 2010) resulted in a concentrations equal to the 0.001 MDL. This value is equal to the PWQO given the hardness in the sample. Approximately two-thirds of the 20 samples had phosphorus concentrations below the MDL (0.005 mg/L). For the remaining third the range was between 0.005 and 0.0491 mg/L. Overall, the mean was 0.008 mg/L. The maximum value from November 2009 exceeded the PWQO of 0.03 mg/L.

The range in pH was 5.7 to 10.6 with these two values being lower than and greater than the PWQO range, respectively. Overall the mean pH was 7.7.

Alkalinity varied little, averaging 8.1 mg/L and ranging from a concentration below the MDL (5 mg/L) in June and October 2009 to a concentration of 10.5 mg/L in July 2009. DOC averaged 6.4 mg/L, had a minimum concentration of 5 mg/L occurring numerous times, and a maximum concentration of11.9 mg/L occurring in May 2011. Nitrate (as N) averaged 0.1 mg/L, had a minimum concentration of 0.03 mg/L in September 2010 and a maximum concentration of 0.3 mg/L in June 2009. Sulphate concentrations averaged 3.4 mg/L, had a minimum concentration

of 2.7 mg/L in September 2010 and a maximum concentration of 4.7 mg/L in June 2009. Total hardness averaged 11.2 mg/L and ranged from 9 mg/L in August 2009 to 13.2 mg/L in August 2008. TKN and TSS were consistent, averaging at 0.2 and 2.2 mg/L, respectively.

General water quality based on data collected at monitoring station S30 is as follows:

Table 2.5-4: Water Chemistry in Subwatershed 5, Station S30

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	36	16
Dissolved Aluminum	0.075	0.120	0.067
Ammonia (as N)	2.9	0.040	0.022
Arsenic	0.1 or 0.005 (Interim)	0.0120	0.0020
Cadmium	0.0002 or 0.0001 (Interim)	0.00031	0.00010
Cobalt	0.0009	0.00050	0.00050
Copper	0.005 or 0.001 (Interim)	0.0020	0.0011
Dissolved Organic Carbon	-	8.8	6.2
Iron	0.3	0.59	0.27
Lead	0.005 or 0.001 (Interim)	0.0010	0.0010
Mercury	0.0002	0.001	0.00028
Molybdenum	0.04	0.001	0.0009
Nickel	0.025	0.0020	0.0020
Nitrate (as N)	-	0.130	0.102
pH	6.5-8.5	7.9	7.4
Phosphorus	0.03	0.239	0.028
Selenium	0.1	0.0050	0.0011
Sulphate	-	4.00	3.51
Total Hardness (as $CaCO_3$)	-	43	20
Total Kjeldahl Nitrogen	-	0.360	0.217
Total Suspended Solids	-	13	2.8
Zinc	0.03 or 0.02 (Interim)	0.0060	0.0038

At sampling station S30, several analytes including cobalt, mercury, molybdenum, lead, nickel, and selenium and were not detected at their respective MDL. The mean dissolved aluminum concentration was 0.0671 mg/L with a range of 0.018 to 0.12 mg/L. All values were below PWQO. No sample concentrations exceeded the ammonia as N PWQO developed for S30. Fifteen of 21 samples were below the MDL (0.02 mg/L) and the highest concentration reported was 0.04 mg/L. Only the 30 July 2008 had a cadmium concentration above the MDL of 0.00009

mg/L with a level of 0.00031 mg/L. This single value exceeds the interim PWQO of 0.0001 mg/L. Half of the samples collected had copper concentrations below the 0.001 mg/L MDL. The remaining samples ranged from 0.0001 mg/L to 0.002 mg/L. After accounting for hardness eight of the 11 samples with copper concentrations at or above the MDL were also equal to or exceeded the PWQO. Iron concentrations averaged 0.26 mg/L and ranging from 0.10 mg/L and 0.59 mg/L. Iron exceeded the PWQO seven times. A single pH measurement in June 2009, 6.4, was below the 6.5 bound outlined in the PWQO. Phosphorus concentrations ranged from below MDL (0.005 mg/L) to 0.24 mg/L. The maximum value was the only instance of a concentration exceeding the PWQO.

The maximum pH was 7.9 and the mean was 7.4. All values were within the PWQO.

Alkalinity averaged 16 mg/L with a minimum level of 9.5 mg/L occurring in May 2011 and a maximum concentration of 36 mg/L occurring in August 2008. DOC averaged 6.2 mg/L with a minimum concentration of 5 mg/L on all sample dates from August to November 2008 and a maximum concentration of 8.8 mg/L in August 2009. Nitrate (as N) averaged 0.1 mg/L, had a minimum concentration of 0.04 mg/L in September 2010 and a maximum concentration of 0.13 mg/L in October 2008. Sulphate concentrations did not vary greatly, averaging 3.5 mg/L with a minimum concentration of 2.7 mg/L in September 2010 and a maximum concentration of 4 mg/L in July 2008. Total hardness averaged 20 mg/L and ranged from a minimum concentration of 13 mg/L in November 2008 to a maximum concentration of 43 mg/L in August 2008. TKN showed little variability, averaging 0.2 mg/L with a minimum concentration below the MDL (0.005 mg/L) in September 2009 and May 2010 and maximum concentration of 0.36 mg/L in July 2008. TSS averaged 2.8 mg/L with a minimum concentration below the MDL (2 mg/L) occurring on several occasions and a maximum concentration of 13 mg/L in July 2009.

2.5.2 Stream 6 Subwatershed

Data from two sampling locations are provided to represent the water quality in the Stream 6 subwatershed. Station S14 is at the Stream 6 crossing with Highway 17. S31 is near the mouth of Stream 6 at Lake Superior (Sturdee Cove).

General water quality based on data collected at monitoring station S14 is as follows:

Table 2.5-5: Water Chemistry in Subwatershed 6, Station S14

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	43	18
Dissolved Aluminum	0.075	0.490	0.181
Ammonia (as N)	2.9	0.060	0.031
Arsenic	0.1 or 0.005 (Interim)	0.0010	0.0010
Cadmium	0.0002 or 0.0001 (Interim)	0.00131	0.00015

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Cobalt	0.0009	0.00108	0.00054
Copper	0.005	0.0026	0.0011
Dissolved Organic Carbon	-	16.9	11.2
Iron	0.3	2.72	1.13
Lead	0.005 or 0.001 (Interim)	0.0018	0.0010
Mercury	0.0002	0.0001	0.0001
Molybdenum	0.04	0.001	0.0010
Nickel	0.025	0.0020	0.0020
Nitrate (as N)	-	0.130	0.054
pH	6.5-8.5	8.2	7.4
Phosphorus	0.03	0.023	0.010
Selenium	0.1	0.0050	0.0009
Sulphate	-	4.30	2.69
Total Hardness (as $CaCO_3$)	-	47	23
Total Kjeldahl Nitrogen	-	0.570	0.425
Total Suspended Solids	-	21	4.4
Zinc	0.03 or 0.02 (Interim)	0.0125	0.0066

In S14, several analytes including arsenic, mercury, molybdenum, nickel, and selenium were not detected at their respective MDLs. Mean dissolved aluminum was 0.182 mg/L exceeding the PWQO. Eight of ten samples exceeded the PWQO and the ranged from 0.04 to 0.49 mg/L. The station specific PWQO for ammonia at S14 of 2.9 mg/L was at least an order of magnitude higher than any of the measured ammonia concentrations. Cadmium was generally below the MDL (0.00009 mg/L). The exception was July 2009 when the cadmium concentration was 0.0013 mg/L, exceeding the PWQO but likely an anomalous data point not representative of the station conditions. Generally, cobalt was below the MDL of 0.0005 mg/L. Twice cobalt concentrations were measured at levels above the MDL and above the PWQO, however similar to cadmium it is not likely these measures indicate the normal cadmium levels in this location. Copper concentrations were below the MDL with the exception of July 2008 and 2009 and May and October 2011. The range of values above the MDL was 0.001 to 0.0026 mg/L with the only instance of copper exceeding the PWQO occurring in May 2011. The mean iron concentration (1.27 mg/L) and all individual samples exceeded the PWQO. Lead was generally below the MDL and was only measured once, in July 2009. In Jul 2009 the measured lead concentration was 0.0018 mg/L a value less than the PWQO. Phosphorus was measured above its respective MDL in 16 of 18 samples analyzed. Levels ranged from less than 0.005 to 0.023 mg/L. The mean was 0.001 mg/L. There were no exceedances of the PWQO of phosphorus at this station.

Samples collected at S14 exhibited relatively consistent pH values with a mean of 7.4. A single measure was 6.3, less than the PWQO range.

Alkalinity averaged 18 mg/L with a minimum level of 6 mg/L occurring in May 2011 and a maximum level of 43 mg/L occurring in August 2008. DOC averaged 11.2 mg/L, had a minimum concentration of 8 mg/L in July, August and October 2008 and a maximum concentration of 16.9 mg/L in July 2010. Nitrate (as N) averaged 0.05 mg/L, had a minimum concentration that was below MDL (0.03 mg/L) occurring on several occasions, and a maximum concentration of 0.13 mg/L in November 2008. Sulphate concentrations averaged 2.7 mg/L with a minimum concentration of 1.4 mg/L in August 2008 and a maximum concentration of 4.3 mg/L in November 2008. Total hardness averaged 22.7 mg/L and ranged from 7.3 mg/L in May 2009 to 47.2 mg/L in August 2008. TKN showed little variability, averaging 0.42 mg/L and ranging from 0.31 mg/L in May 2009 to 0.57 mg/L in July 2008. TSS averaged 4.4 mg/L, had a minimum concentration that was below the MDL (2.0 mg/L) occurring on several occasions and a maximum concentration of 20.8 mg/L in October 2009.

General water quality based on data collected at monitoring station S31 is as follows:

Table 2.5-6: Water Chemistry in Subwatershed 6, Station S31

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Alkalinity (as $CaCO_3$)	-	99	52
Dissolved Aluminum	0.075	0.158	0.088
Ammonia (as N)	4.3	0.054	0.028
Arsenic	0.1 or 0.005 (Interim)	0.0010	0.0010
Cadmium	0.0002 or 0.0001 (Interim)	0.00009	0.00009
Cobalt	0.0009	0.01000	0.00110
Copper	0.005	0.0080	0.0015
Dissolved Organic Carbon	-	23.0	10.0
Iron	0.3	1.68	0.67
Lead	0.02 or 0.003 (Interim)	0.0049	0.0012
Mercury	0.0002	0.001	0.00025
Molybdenum	0.04	0.001	0.0009
Nickel	0.025	0.0020	0.0020
Nitrate (as N)	-	0.182	0.079
pH	6.5-8.5	7.7	7.3
Phosphorus	0.03	0.402	0.052
Selenium	0.1	0.0050	0.0013
Sulphate	-	5.11	4.07
Total Hardness (as $CaCO_3$)	-	106	57

Analyte	PWQO (mg/L)	Maximum (mg/L)	Average (mg/L)
Total Kjeldahl Nitrogen	-	0.590	0.296
Total Suspended Solids	-	38	6.7
Zinc	0.03 or 0.02 (Interim)	0.0090	0.0038

In S31, several analytes including arsenic, cadmium, mercury, molybdenum, nickel and selenium were not detected at their respective MDL. Dissolved aluminum concentrations averaged 0.088 mg/L and range from 0.028 to 0.158 mg/L. In 6 of the 10 samples dissolved aluminum was higher than the PWQO value of 0.075 mg/L. All concentrations for ammonia as N were lower than the station specific developed PWQO (2.9 mg/L) by an order of magnitude. Cobalt was below the MDL in all but on instance. In October 2008 the concentration was 0.0006 mg/L which is below the PWQO. Lead was only above the MDL in on instance (August 2009) with a concentration of 0.0049 mg/L which is above the PWQO. Copper concentrations varied from below the MDL to 0.008 mg/L (August 2008) which was the only exceedance of the PWQO. All iron concentrations exceeded the PQWO. The concentrations ranged from 0.305 to 1.68 mg/L with a mean of 0.67 mg/L. Phosphorus was generally above the MDL and detected values ranged from 0.0064 to 0.402 mg/L. Only the maximum value from May 2010 exceeded the PWQO. Zinc was detected in 8 of the 16 sampling events. The concentrations ranged from 0.003 to 0.009 mg/L. All concentrations were an order of magnitude lower than the PWQO.

Samples collected from the Stream 6 watershed exhibited consistent pH values ranging from 6.6 to 7.7 with an average value of 7.3.

Alkalinity averaged 52 mg/L with a minimum level of 24 mg/L occurring in May 2010 and a maximum level of 99 mg/L occurring in August 2008. DOC averaged 10 mg/L with a minimum concentration of 5 mg/L in August 2008 and a maximum concentration of 23 mg/L in September 2009. Nitrate (as N) averaged 0.08 mg/L, had a minimum concentration below the MDL (0.03 mg/L) in September 2010 and a maximum concentration of 0.18 mg/L in May 2010. Sulphate concentrations averaged 4 mg/L with a minimum concentration of 3 mg/L in August 2009 and a maximum concentration of 5 mg/L in September 2008. Total hardness averaged 57 mg/L and ranged from 29 mg/L in September 2009 to 106 mg/L in August 2008. TKN averaged 0.3 mg/L and ranged from 0.008 mg/L in September 2009 to 0.6 mg/L in October 2008. The majority of TSS measures were relatively low and consistent. In October 2008 and May 2011 TSS was 38.3 and 35.6 mg/L whereas the remainder of the 16 samples were less that 4 mg/L. Overall the average was 6.7 mg/L.

3.0 GROUNDWATER-SURFACE WATER INTERACTIONS

The potential relationship between groundwater and surface water was explored through a correlation analysis. Data for groundwater wells in the overburden and in the bedrock were compared with surface water data on a subwatershed-by-subwatershed basis. That is, where multiple years of groundwater data were available for a given subwatershed these data were compared to surface water quality data for that same subwatershed. Sufficient groundwater data were available for the Stream 1, 2, 5 and 6 subwatersheds as these were the only subwatersheds in which groundwater wells were established in 2007, 2008 or 2009[5]. The correlation analysis was restricted to two conservative constituents (chloride, sulphate) that are considered important natural tracers.

For each of the subwatersheds and for both chloride and sulphate there was not a significant correlation ($p > 0.1$) between neither the bedrock groundwater data and the surface water data nor the overburden groundwater data and the surface water data. In other words groundwater quality and surface water quality (in terms of the conservative tracers) appeared to be largely independent of each other, suggesting little direct interaction between the surface and subsurface environments.

The correlation analysis was taken one-step further by comparing chloride and sulphate levels in surface water in headwater areas of the subwatersheds to chloride and sulphate levels in surface water in downstream areas of the subwatersheds. This analysis was done to test the hypothesis that surface water in the downstream areas of the subwatersheds on the Project site is derived, largely, from the small water bodies in the headwater areas and not from the groundwater environment. For each of the subwatersheds, chloride and sulphate levels in surface water in headwater areas of the subwatersheds and surface water in downstream areas of the subwatersheds were strongly positively correlated. The results of this analysis are interpreted as confirming the notion that surface water in the downstream areas of the subwatersheds on the Project site was derived, largely, from the small water bodies in the headwater areas and not from the groundwater environment. These results also serve to reinforce the suggestion that the surface waters systems are dominated by surface waters as opposed to the groundwater environment. This conclusion is consistent with the information provided in the baseline hydrological assessment at the Project site (Calder, 2012) and the baseline hydrogeological assessment at the Project site (TGCL, 2011).

[5] Additional groundwater wells were established on the Project site in 2011, sufficient data have not been collected at these locations for the purposes of the groundwater-surface water interaction analysis.

4.0 CONCLUSIONS

Summary statistics were calculated for several parameters of interest in the study area. Based on the analyses and the discussion above, these statistics are considered representative of baseline concentrations for the following parameters:

- Alkalinity;
- pH;
- DOC;
- Turbidity;
- Total Suspended Solids;
- Hardness;
- Ammonia;
- Nitrate;
- Phosphate;
- Sulphate;
- Dissolved Aluminum;
- Copper;
- Iron;
- Manganese; and,
- Zinc.

For certain parameters, however, because the data sets consisted largely of samples, in which those parameters were not detected, their summary statistics were recommended to serve only as upper bound estimates of baseline conditions. This situation applies to the following parameters:

- Arsenic;
- Cadmium;
- Cobalt;
- Chromium (III+VI);
- Chromium (VI);
- Lead;
- Molybdenum;
- Nickel;
- Selenium;
- Thallium;
- Uranium; and,
- Vanadium.

Potential groundwater-surface water interactions were assessed by correlating concentrations of conservative chemical constituents in surface water with groundwater data from bedrock wells and overburden wells. No correlation between the surface water and bedrock

groundwater or surface water and overburden groundwater was noted, suggesting little interaction between the surface and subsurface environments. A positive correlation was found in each of the subwatersheds between concentrations of conservative chemical constituents in surface water in the headwater areas of the subwatersheds and the downstream areas of the subwatersheds. This result is further evidence that there is little, or limited interaction between surface water and groundwater.

5.0 REFERENCES

Bain, M.B. and Stevenson, N.J (Ed.). 1999. Aquatic Habitat Assessment: Common Methods. American Fisheries Society, Bethesda, Maryland.

Calder Engineering Ltd. (Calder). 2012. Baseline hydrological conditions at the Marathon PGM-Cu Project Site. A report prepared for Stillwater Canada Inc.

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian water quality guidelines for the protection of aquatic life. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

EcoMetrix Incorporated (EcoMetrix). 2012. Marathon PGM-Cu Project Site - Baseline Aquatic Resources Baseline Report. Prepared by EcoMetrix Incorporated.

Ontario Ministry of the Environment and Energy (OMOEE). 1994. Provincial water quality objectives for the Ontario Ministry of the Environment and Energy. Queens Printer of Ontario. Revised 1999.

True Grit Consulting Limited (TGCL). 2011. Baseline hydrogeological conditions at the Marathon PGM-Cu Project Site. A report prepared for Stillwater Canada Inc.

APPENDIX 1

Table A1: Malpa Lake Watershed

	n	ND	Min	Max	Mean	Std Dev	GeoMean
Parameter Name	**-**	**-**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Alkalinity as CaCO3	29	1	10	371	222	56	204
Aluminum, Dissolved	14	5	0.01	0.057	0.021	0.016	0.017
Aluminum, Total	29	0	0.012	13.6	1.408	2.931	0.197
Ammonia as N	29	15	0.02	0.21	0.036	0.043	0.027
Ammonia, Unionized, as N	1	1	0.002	0.002	0.002		0.002
Antimony, Dissolved	1	1	0.005	0.005	0.005		0.005
Antimony, Total	29	29	0.0005	0.05	0.009	0.014	0.004
Arsenic, Dissolved	1	1	0.001	0.001	0.001		0.001
Arsenic, Total	29	27	0.001	0.01	0.002	0.003	0.001
Barium, Dissolved	1	0	0.02	0.02	0.020		0.020
Barium, Total	29	2	0.01	0.11	0.031	0.027	0.025
Beryllium, Dissolved	1	1	0.001	0.001	0.001		0.001
Beryllium, Total	29	29	0.0005	0.01	0.002	0.003	0.001
Bismuth, Dissolved	1	1	0.001	0.001	0.001		0.001
Bismuth, Total	29	29	0.001	0.01	0.002	0.003	0.001
Boron, Dissolved	1	1	0.05	0.05	0.050		0.050
Boron, Total	29	28	0.0037	0.5	0.095	0.140	0.058
Cadmium, Dissolved	1	1	0.0001	0.0001	0.000		0.000
Cadmium, Total	29	29	0.00009	0.0009	0.000	0.000	0.000
Calcium, Dissolved	5	0	63	79.5	71.020	6.469	70.785
Calcium, Total	22	0	1.77	269	78.230	48.632	63.294
Cerium, Total	1	1	0.001	0.001	0.001		0.001
Cesium, Total	1	1	0.001	0.001	0.001		0.001
Chemical Oxygen Demand	1	0	3	3	3.000		3.000
Chloride	28	2	0.2	2	0.495	0.451	0.400
Chromium, Dissolved	1	1	0.001	0.001	0.001		0.001
Chromium, Hexavalent	28	28	0.01	0.01	0.010	0.000	0.010
Chromium, Total	29	9	0.001	0.036	0.005	0.007	0.003
Cobalt, Dissolved	1	1	0.0005	0.0005	0.001		0.001
Cobalt, Total	29	15	0.0001	0.0077	0.002	0.002	0.001
Color, True	28	0	11.7	48.1	26.436	10.280	24.308
Copper, Dissolved	1	0	0.002	0.002	0.002		0.002
Copper, Total	29	4	0.001	0.024	0.004	0.005	0.003
Dissolved Organic Carbon	28	0	3	11.7	6.650	2.338	6.236

Table A1: Malpa Lake Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Dissolved Oxygen	7	0	3.65	8.1	4.976	1.590	4.790
Dissolved Oxygen, Field	19	0	0.27	14.36	4.658	3.943	2.984
Electrical Conductivity	8	0	20.8	415	330.725	129.686	260.295
Electrical Conductivity, Field	13	0	273	471	376.615	66.412	370.880
Electrical Conductivity, Field	6	0	244	472	373.833	97.958	362.124
Europium, Total	1	1	0.001	0.001	0.001		0.001
Fluoride	28	7	0.03	0.1	0.061	0.024	0.056
Gallium, Total	1	1	0.001	0.001	0.001		0.001
Iron, Dissolved	1	1	0.05	0.05	0.050		0.050
Iron, Total	29	0	0.07	19.7	2.560	3.915	1.166
Lanthanum, Total	1	1	0.001	0.001	0.001		0.001
Lead, Dissolved	1	1	0.001	0.001	0.001		0.001
Lead, Total	29	21	0.001	0.011	0.002	0.003	0.002
Lithium, Total	27	27	0.005	1	0.193	0.292	0.110
Magnesium, Dissolved	5	0	11.6	15.4	13.620	1.668	13.538
Magnesium, Total	22	0	0.458	78	16.721	14.503	12.974
Manganese, Dissolved	1	0	0.024	0.024	0.024		0.024
Manganese, Total	29	0	0.005	0.783	0.101	0.147	0.059
Mercury, Dissolved	14	14	0.0001	0.0001	0.000	0.000	0.000
Mercury, Total	15	15	0.0001	0.0001	0.000	0.000	0.000
Molybdenum, Dissolved	1	1	0.001	0.001	0.001		0.001
Molybdenum, Total	29	29	0.001	0.01	0.002	0.003	0.001
Nickel, Dissolved	1	0	0.003	0.003	0.003		0.003
Nickel, Total	29	8	0.001	0.023	0.006	0.006	0.004
Niobium, Total	1	1	0.001	0.001	0.001		0.001
Nitrate as N	29	4	0.03	1.06	0.483	0.383	0.275
Nitrite as N	1	1	0.05	0.05	0.050		0.050
pH	14	0	6.86	8.34	8.072	0.359	8.064
pH, Field	14	0	6.03	8.47	7.981	0.639	7.954
Phosphorus, Total	26	0	0.006	1.36	0.149	0.280	0.053
Potassium, Dissolved	5	0	0.7	0.88	0.790	0.082	0.787
Potassium, Total	21	6	0.474	10	1.312	2.030	0.910
Rubidium, Total	1	1	0.001	0.001	0.001		0.001
Scandium, Total	1	1	0.001	0.001	0.001		0.001
Selenium, Dissolved	1	1	0.005	0.005	0.005		0.005
Selenium, Total	29	29	0.0004	0.005	0.001	0.002	0.001

Table A1: Malpa Lake Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Silicon, Dissolved	1	0	3.1	3.1	3.100		3.100
Silicon, Total	24	0	4	26.7	7.014	4.822	6.218
Silver, Dissolved	1	1	0.0001	0.0001	0.000		0.000
Silver, Total	29	29	0.0001	0.001	0.000	0.000	0.000
Sodium, Dissolved	5	0	1.32	1.84	1.536	0.223	1.523
Sodium, Total	19	1	0.827	5	1.600	0.884	1.469
Strontium, Dissolved	1	0	0.072	0.072	0.072		0.072
Strontium, Total	29	0	0.013	0.173	0.070	0.024	0.066
Sulphate	28	1	1.91	4.64	3.241	0.841	3.130
Tannin & Lignin	28	15	0.32	1.08	0.840	0.235	0.797
Temperature	13	0	3.5	13.6	8.392	4.283	7.261
Temperature, Field	14	0	0.7	12	7.429	4.354	5.379
Thallium, Dissolved	1	1	0.0003	0.0003	0.000		0.000
Thallium, Total	29	29	0.0001	0.003	0.001	0.001	0.000
Thorium, Total	1	1	0.001	0.001	0.001		0.001
Tin, Dissolved	1	1	0.001	0.001	0.001		0.001
Tin, Total	29	27	0.001	0.0624	0.004	0.012	0.002
Titanium, Dissolved	1	1	0.002	0.002	0.002		0.002
Titanium, Total	29	2	0.001	0.805	0.117	0.170	0.047
Total Dissolved Solids	28	0	40	301	244.857	55.524	233.525
Total Hardness as CaCO3	29	0	5.6	992	255.090	157.441	214.118
Total Kjeldahl Nitrogen	29	2	0.23	2.15	0.475	0.391	0.402
Total Particulate	1	1	0.002	0.002	0.002		0.002
Total Suspended Solids	29	2	2	1920	185.997	374.147	51.370
Tungsten, Dissolved	1	1	0.01	0.01	0.010		0.010
Tungsten, Total	29	29	0.001	0.1	0.019	0.028	0.012
Turbidity	29	0	0.51	666	88.646	140.720	28.231
Uranium, Dissolved	1	1	0.005	0.005	0.005		0.005
Uranium, Total	29	29	0.001	0.05	0.010	0.014	0.006
Vanadium, Dissolved	1	0	0.001	0.001	0.001		0.001
Vanadium, Total	29	5	0.001	0.036	0.005	0.007	0.003
Yttrium, Total	1	1	0.001	0.001	0.001		0.001
Zinc, Dissolved	1	1	0.003	0.003	0.003		0.003
Zinc, Total	29	8	0.0014	0.056	0.010	0.013	0.006
Zirconium, Dissolved	1	1	0.004	0.004	0.004		0.004
Zirconium, Total	29	27	0.001	0.04	0.007	0.011	0.004

Table A2: Pic River

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Acidity	4	3	1	5	2	2	1
Alkalinity as CaCO3	75	1	57	151	110	20	108
Aluminum, Dissolved	40	5	0.01	0.122	0.036	0.025	0.028
Aluminum, Total	75	1	0.012	4.85	0.868	1.151	0.315
Ammonia as N	73	40	2.28E-05	0.053	0.023	0.008	0.019
Antimony, Dissolved	7	6	0.0005	0.005	0.003	0.002	0.002
Antimony, Total	75	74	0.0005	0.05	0.007	0.010	0.004
Arsenic, Dissolved	7	6	0.001	0.001	0.001	1.7963E-11	0.001
Arsenic, Total	75	66	0.001	0.01	0.0015	0.0020	0.0011
Barium, Dissolved	7	0	0.0101	0.02	0.0159	0.0052	0.0151
Barium, Total	75	5	0.01	0.1	0.0254	0.0195	0.0215
Beryllium, Dissolved	7	6	0.0005	0.001	0.0008	0.0003	0.0007
Beryllium, Total	75	74	0.0005	0.01	0.0015	0.0020	0.0011
Bismuth, Dissolved	7	6	0.001	0.001	0.001	1.7963E-11	0.001
Bismuth, Total	75	73	0.001	0.01	0.001	0.002	0.001
Boron, Dissolved	7	3	0.006	0.05	0.031	0.023	0.020
Boron, Total	75	70	0.0028	0.5	0.072	0.103	0.051
Cadmium, Dissolved	7	6	0.0001	0.0001	0.0001	2.2454E-12	0.0001
Cadmium, Total	75	72	0.00009	0.0009	0.0001	0.0002	0.0001
Calcium, Dissolved	18	0	24.4	38.2	31.9	4.7	31.6
Calcium, Total	60	0	18.5	31100	554.9	4010.2	39.5
Cerium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Cerium, Total	4	1	0.001	0.0108	0.007	0.004	0.005
Cesium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Cesium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Chemical Oxygen Demand	4	0	14	21	18	3	18
Chloride	73	5	0.0231	2	0.537	0.409	0.432
Chromium, Dissolved	7	6	0.001	0.001	0.001	1.7963E-11	0.001
Chromium, Hexavalent	71	70	0.01	10	1.276	3.347	0.024
Chromium, Total	75	20	0.001	0.0109	0.004	0.003	0.003
Cobalt, Dissolved	7	4	0.0001	0.0005	0.000	0.000	0.000
Cobalt, Total	75	38	0.00017	0.005	0.001	0.001	0.001
Color, True	75	1	19	103	53	19	49
Copper, Dissolved	7	0	0.0016	0.007	0.003	0.002	0.003
Copper, Total	75	5	0.001	0.01	0.003	0.002	0.003
Dissolved Organic Carbon	75	1	6	23.7	10.2	3.9	9.6
Dissolved Oxygen	19	0	3.1	6.77	4.768	1.331	4.597
Dissolved Oxygen, Field	44	1	0.17	144	8.10	21.27	3.46
Electrical Conductivity	19	0	144	290	195.684	37.541	192.336
Electrical Conductivity, Field	12	1	97	253	204.167	61.915	193.638
Electrical Conductivity, Field	34	0	103.1	260	184.291	44.877	178.407

Table A2: Pic River

Parameter Name	n -	ND -	Min mg/L	Max mg/L	Mean mg/L	Std Dev mg/L	GeoMean mg/L
Europium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Europium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Fluoride	75	28	0.03	0.1	0.056	0.026	0.051
Gallium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Gallium, Total	4	1	0.001	0.0017	0.001	0.000	0.001
Iron, Dissolved	7	3	0.05	0.12	0.077	0.034	0.071
Iron, Total	75	0	0.275	5.84	1.811	1.533	1.252
Lanthanum, Dissolved	3	3	0.001	0.001	0.001	0	0.001
Lanthanum, Total	4	1	0.001	0.0054	0.004	0.002	0.003
Lead, Dissolved	7	6	0.001	0.001	0.001	1.7963E-11	0.001
Lead, Total	75	47	0.001	0.01	0.002	0.002	0.001
Lithium, Dissolved	3	3	0.005	0.005	0.005	6.7212E-11	0.005
Lithium, Total	71	69	0.005	1	0.143	0.212	0.092
Magnesium, Dissolved	18	0	4.72	8.04	6.515	1.015	6.436
Magnesium, Total	60	0	3.84	6010	108.199	774.841	8.472
Manganese, Dissolved	7	0	0.0024	0.008	0.005	0.002	0.005
Manganese, Total	75	0	0.0163	0.201	0.066	0.044	0.053
Mercury, Dissolved	42	41	0.0001	0.0001	0.0001	3.9674E-12	1E-04
Mercury, Total	36	36	0.0001	0.0001	1E-04	4.3385E-12	1E-04
Molybdenum, Dissolved	7	6	0.001	0.001	0.001	1.7963E-11	0.001
Molybdenum, Total	75	74	0.001	0.01	0.001	0.002	0.001
Nickel, Dissolved	4	3	0.002	0.002	0.002	0.000	0.002
Nickel, Total	75	30	0.0019	0.02	0.004	0.004	0.003
Niobium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Niobium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Nitrate as N	75	45	0.03	0.178	0.058	0.043	0.047
Nitrite as N	4	4	0.03	0.03	0.030	0.000	0.030
pH	31	1	7.74	9.12	8.058	0.240	8.055
pH, Field	34	0	6.71	9.23	7.928	0.578	7.907
Phosphorus, Total	67	1	0.0059	0.246	0.061	0.064	0.034
Potassium, Dissolved	15	0	0.77	0.9	0.831	0.040	0.830
Potassium, Total	56	18	0.397	2.1	0.907	0.329	0.852
Rubidium, Dissolved	3	0	0.0016	0.0017	0.0017	5.7735E-05	0.0017
Rubidium, Total	1	0	0.0023	0.0023	0.002		0.002
Scandium, Dissolved	3	0	0.0029	0.0032	0.003	0.000	0.003
Scandium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Selenium, Dissolved	7	6	0.001	0.005	0.003	0.002	0.003
Selenium, Total	74	73	0.0004	0.005	0.001	0.002	0.001
Silicon, Dissolved	4	0	1.7	2.2	2.025	0.222	2.015
Silicon, Total	63	0	2.1	8.79	4.082	1.600	3.823

Table A2: Pic River

Parameter Name	n -	ND -	Min mg/L	Max mg/L	Mean mg/L	Std Dev mg/L	GeoMean mg/L
Silver, Dissolved	7	6	0.0001	0.0001	0.0001	2.2454E-12	0.0001
Silver, Total	75	74	0.0001	0.001	0.000	0.000	0.000
Sodium, Dissolved	15	0	0.756	1.86	1.066	0.277	1.038
Sodium, Total	52	0	0.367	1.83	0.998	0.369	0.921
Strontium, Dissolved	7	0	0.0266	0.045	0.037	0.009	0.036
Strontium, Total	75	0	0.029	0.067	0.044	0.007	0.043
Sulphate	75	5	1.39	3.54	2.323	0.428	2.284
Tannin & Lignin	72	11	0.59	2	1.076	0.326	1.033
Temperature	3	0	3.7	19.7	10.633	8.211	8.525
Temperature	28	0	2.7	20.6	13.889	5.910	12.280
Temperature, Field	34	0	0.1	19.4	11.953	4.881	9.122
Thallium, Dissolved	7	6	0.0001	0.0003	0.000	0.000	0.000
Thallium, Total	75	74	0.0001	0.003	0.000	0.001	0.000
Thorium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Thorium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Tin, Dissolved	7	4	0.001	0.0015	0.001	0.000	0.001
Tin, Total	75	73	0.001	0.01	0.002	0.002	0.001
Titanium, Dissolved	7	3	0.002	0.0037	0.003	0.001	0.002
Titanium, Total	75	0	0.0069	0.282	0.083	0.078	0.050
Total Dissolved Solids	75	1	72	250	151.920	24.539	149.824
Total Hardness as CaCO3	75	1	61.9	316	119.145	41.147	113.512
Total Kjeldahl Nitrogen	71	4	0.25	0.662	0.421	0.099	0.409
Total Organic Carbon	4	0	23	25.2	24.300	0.959	24.286
Total Suspended Solids	71	1	2.1	389	99.541	112.675	45.308
Tungsten, Dissolved	7	6	0.001	0.01	0.006	0.005	0.004
Tungsten, Total	75	74	0.001	0.1	0.014	0.021	0.010
Turbidity	73	1	6.26	286	70.859	72.044	39.491
Uranium, Dissolved	7	6	0.001	0.005	0.003	0.002	0.003
Uranium, Total	75	74	0.001	0.05	0.007	0.010	0.005
Vanadium, Dissolved	7	5	0.001	0.001	0.001	1.7963E-11	0.001
Vanadium, Total	75	17	0.001	0.010	0.004	0.003	0.003
Yttrium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Yttrium, Total	4	1	0.001	0.0021	0.002	0.001	0.002
Zinc, Dissolved	7	3	0.001	0.0075	0.003	0.002	0.003
Zinc, Total	75	25	0.001	0.13	0.009	0.016	0.006
Zirconium, Dissolved	7	3	0.003	0.004	0.004	0.000	0.004
Zirconium, Total	75	65	0.001	0.04	0.006	0.008	0.004

Table A3: Shack Creek Watershed

	n	ND	Min	Max	Mean	Std Dev	GeoMean
Parameter Name	**-**	**-**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Alkalinity as CaCO3	31	0	6.1	138	68.777	50.535	44.907
Aluminum, Dissolved	14	0	0.016	0.42	0.095	0.133	0.050
Aluminum, Total	32	0	0.024	1.8	0.224	0.327	0.126
Ammonia as N	32	10	0.02	0.132	0.037	0.025	0.032
Antimony, Total	32	32	0.0006	0.005	0.004	0.002	0.003
Arsenic, Total	32	31	0.001	0.0012	0.001	0.000	0.001
Barium, Total	32	4	0.01	0.027	0.015	0.005	0.014
Beryllium, Total	32	32	0.001	0.001	0.001	0.000	0.001
Bismuth, Total	32	32	0.001	0.001	0.001	0.000	0.001
Boron, Total	32	32	0.05	0.05	0.050	0.000	0.050
Cadmium, Total	32	30	0.00009	0.000272	0.000	0.000	0.000
Calcium, Dissolved	5	0	8.8	47.5	37.920	16.440	32.550
Calcium, Total	25	0	2.45	49.8	22.290	17.085	14.850
Chloride	31	3	0.1	44	15.535	16.145	3.194
Chromium, Hexavalent	32	26	0.0005	1.69	0.062	0.297	0.006
Chromium, Total	32	28	0.001	0.0026	0.001	0.000	0.001
Cobalt, Total	32	27	0.0005	0.00463	0.001	0.001	0.001
Color, True	32	0	12.8	112	54.422	35.490	41.783
Copper, Total	32	23	0.001	2.55	0.292	0.594	0.006
Dissolved Organic Carbon	31	0	3	13.2	7.713	3.303	6.976
Dissolved Oxygen	7	0	1.6	7.4	3.900	1.746	3.587
Dissolved Oxygen, Field	22	0	0.32	12.1	5.433	3.820	3.710
Electrical Conductivity	7	0	28	371	230.286	147.131	155.537
Electrical Conductivity, Field	7	0	16	344	153.143	140.293	96.638
Electrical Conductivity, Field	16	0	17	410	159.438	140.096	95.020
Fluoride	31	8	0.03	0.14	0.081	0.033	0.074
Iron, Total	32	7	0.001	8.34	0.495	1.453	0.073
Lead, Total	32	31	0.001	0.1	0.026	0.044	0.003
Lithium, Total	31	23	0.05	4.04	0.644	1.099	0.206
Magnesium, Dissolved	5	0	2.47	8.28	6.752	2.436	6.203
Magnesium, Total	25	0	0.0075	8.86	3.564	3.323	0.930
Manganese, Total	32	8	0.0072	1.69	0.074	0.295	0.022
Mercury, Dissolved	16	16	0.0001	0.0001	0.000	0.000	0.000
Mercury, Total	16	16	0.0001	0.0001	0.000	0.000	0.000
Molybdenum, Total	32	32	0.001	0.001	0.001	0.000	0.001
Nickel, Total	32	28	0.002	0.002	0.002	0.000	0.002

Table A3: Shack Creek Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Nitrate as N	18	1	0.03	0.31	0.172	0.064	0.157
Nitrite as N	5	1	0.048	0.17	0.094	0.047	0.086
pH	14	0	7.15	8.45	7.825	0.422	7.814
pH, Field	16	0	6.57	8.6	7.808	0.583	7.787
Phosphorus, Total	21	5	0.005	1.19	0.086	0.266	0.013
Potassium, Dissolved	5	0	0.16	1.33	1.008	0.483	0.811
Potassium, Total	25	9	0.08	1.3	0.820	0.396	0.644
Selenium, Total	32	32	0.0004	0.005	0.001	0.002	0.001
Silicon, Total	26	0	1.5	4	2.662	0.687	2.574
Silver, Total	32	32	0.0001	0.0001	0.000	0.000	0.000
Sodium, Dissolved	5	0	0.418	17.3	13.404	7.296	7.962
Sodium, Total	24	0	0.45	19.9	7.838	7.711	3.204
Strontium, Total	32	0	0.0064	0.057	0.027	0.017	0.022
Sulphate	31	1	1.57	7.4	4.519	1.844	4.112
Tannin & Lignin	32	7	0.37	3	1.376	0.708	1.191
Temperature	14	0	2.1	16.7	11.300	4.756	9.906
Temperature, Field	16	0	0.2	15	10.075	4.777	6.993
Thallium, Total	32	32	0.0003	0.0003	0.000	0.000	0.000
Tin, Total	32	32	0.001	0.001	0.001	0.000	0.001
Titanium, Total	32	15	0.002	0.0554	0.006	0.011	0.003
Total Dissolved Solids	32	0	26	263	136.563	75.762	113.341
Total Hardness as CaCO3	32	0	10.3	161	79.841	55.099	56.375
Total Kjeldahl Nitrogen	31	2	0.0082	5.96	0.527	1.020	0.325
Total Suspended Solids	32	10	2	164	13.309	31.752	4.606
Tungsten, Total	32	32	0.01	0.01	0.010	0.000	0.010
Turbidity	32	0	0.42	31.5	2.758	5.878	1.454
Uranium, Total	32	32	0.005	0.005	0.005	0.000	0.005
Vanadium, Total	32	29	0.001	0.0028	0.001	0.000	0.001
Zinc, Total	32	15	0.003	0.0178	0.005	0.004	0.004
Zirconium, Total	32	32	0.001	0.004	0.003	0.001	0.003

Table A4: Stream 1 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Acidity	2	1	1	1	1.000	0.000	1.000
Alkalinity as CaCO3	100	17	5	265	61.771	64.284	31.785
Aluminum, Dissolved	46	1	0.01	0.33	0.091	0.085	0.056
Aluminum, Total	100	0	0.01	25.2	0.480	2.512	0.154
Ammonia as N	99	53	0.0001	0.16	0.034	0.029	0.025
Ammonia, Unionized, as N	2	2	0.002	0.002	0.002	0.000	0.002
Antimony, Dissolved	3	3	0.0005	0.005	0.002	0.003	0.001
Antimony, Total	100	100	0.0005	0.05	0.005	0.007	0.003
Arsenic, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Arsenic, Total	100	100	0.001	0.01	0.001	0.001	0.001
Barium, Dissolved	3	0	0.0105	0.03	0.019	0.010	0.017
Barium, Total	100	7	0.0069	0.3	0.020	0.030	0.016
Beryllium, Dissolved	3	3	0.0005	0.001	0.001	0.000	0.001
Beryllium, Total	100	100	0.0005	0.01	0.001	0.001	0.001
Bismuth, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Bismuth, Total	100	100	0.001	0.01	0.001	0.001	0.001
Boron, Dissolved	3	1	0.0058	0.05	0.021	0.025	0.012
Boron, Total	100	96	0.0046	0.5	0.057	0.064	0.048
Cadmium, Dissolved	3	2	0.0001	0.0007	0.000	0.000	0.000
Cadmium, Total	100	95	0.00009	0.0009	0.000	0.000	0.000
Calcium, Dissolved	22	0	1.3	83.1	29.197	23.237	16.242
Calcium, Total	79	0	1.14	84.9	17.043	18.771	8.904
Cerium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Cerium, Total	4	3	0.001	0.0012	0.001	0.000	0.001
Cesium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Cesium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Chemical Oxygen Demand	1	1	3	3	3.000		3.000
Chloride	98	11	0.1	2	0.458	0.516	0.318
Chromium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Chromium, Hexavalent	95	95	0.01	10	1.167	3.213	0.022
Chromium, Total	100	83	0.001	0.07	0.002	0.007	0.001
Cobalt, Dissolved	3	1	0.0001	0.0005	0.000	0.000	0.000
Cobalt, Total	100	82	0.0001	0.032	0.001	0.003	0.001
Color, True	96	0	9.7	132	41.423	23.225	35.640
Copper, Dissolved	3	0	0.0019	0.003	0.003	0.001	0.003
Copper, Total	100	19	0.001	0.11	0.004	0.011	0.002
Dissolved Organic Carbon	98	0	3	14	6.896	2.113	6.589
Dissolved Oxygen	23	0	1.06	8.63	4.952	2.044	4.410
Dissolved Oxygen, Field	61	0	0.25	14.78	4.593	3.527	3.225
Electrical Conductivity	26	0	9	425	161.319	125.410	100.232
Electrical Conductivity, Field	50	0	7	339	89.000	81.956	55.350
Electrical Conductivity, Field	15	0	9	391	142.733	129.721	77.043
Europium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Europium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Fluoride	96	42	0.03	0.18	0.062	0.036	0.053

Table A4: Stream 1 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Gallium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Gallium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Iron, Dissolved	3	0	0.09	0.15	0.123	0.031	0.121
Iron, Total	100	0	0.067	41.9	0.988	4.191	0.401
Lanthanum, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Lanthanum, Total	4	4	0.001	0.001	0.001	0.000	0.001
Lead, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Lead, Total	100	97	0.001	0.03	0.001	0.003	0.001
Lithium, Dissolved	2	2	0.005	0.005	0.005	0.000	0.005
Lithium, Total	99	99	0.005	1	0.111	0.130	0.089
Magnesium, Dissolved	22	0	0.36	12.3	5.767	4.126	3.571
Magnesium, Total	79	4	0.0001	13	3.543	3.585	1.465
Manganese, Dissolved	3	0	0.0014	0.269	0.093	0.152	0.015
Manganese, Total	94	0	0.0027	2.07	0.125	0.360	0.029
Mercury, Dissolved	49	49	0.0001	0.0001	0.000	0.000	0.000
Mercury, Total	53	52	0.0001	0.0402	0.001	0.006	0.000
Molybdenum, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Molybdenum, Total	100	100	0.001	0.01	0.001	0.001	0.001
Nickel, Dissolved	3	1	0.001	0.004	0.002	0.002	0.002
Nickel, Total	100	86	0.001	0.07	0.003	0.007	0.002
Niobium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Niobium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Nitrate as N	98	29	0.03	0.958	0.171	0.178	0.108
Nitrite as N	1	0	0.0238	0.0238	0.024		0.024
pH	41	0	5.88	8.5	7.698	0.593	7.674
pH, Field	50	0	5.03	8.78	7.663	0.654	7.633
Phosphate	2	0	2.9	3.7	3.300	0.566	3.276
Phosphorus, Total	93	20	0.005	1.1	0.031	0.115	0.012
Potassium, Dissolved	20	0	0.07	1.58	0.817	0.474	0.601
Potassium, Total	75	33	0.05	1.5	0.710	0.383	0.560
Rubidium, Dissolved	2	1	0.001	0.0012	0.001	0.000	0.001
Rubidium, Total	4	2	0.001	0.0013	0.001	0.000	0.001
Scandium, Dissolved	2	0	0.0053	0.0054	0.005	0.000	0.005
Scandium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Selenium, Dissolved	3	3	0.001	0.005	0.002	0.002	0.002
Selenium, Total	100	100	0.0004	0.005	0.001	0.002	0.001
Silicon, Dissolved	1	0	4.9	4.9	4.900		4.900
Silicon, Total	80	2	0.6	39	3.819	4.314	2.960
Silver, Dissolved	3	3	0.0001	0.0001	0.000	0.000	0.000
Silver, Total	100	100	0.0001	0.001	0.000	0.000	0.000
Sodium, Dissolved	20	0	0.216	1.98	1.065	0.474	0.939
Sodium, Total	74	1	0.005	10.7	1.008	1.212	0.767
Strontium, Dissolved	3	0	0.0193	0.094	0.049	0.040	0.039
Strontium, Total	100	0	0.0089	0.1	0.032	0.021	0.026
Sulphate	96	3	1.5	8.3	4.157	1.425	3.918

Table A4: Stream 1 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Tannin & Lignin	92	19	0.27	2	1.016	0.331	0.958
Tellurium, Total	2	2	0.001	0.001	0.001	0.000	0.001
Temperature	38	0	2.1	22.6	11.147	5.610	9.533
Temperature, Field	46	0	0.1	18.4	9.074	4.906	6.996
Thallium, Dissolved	3	3	0.0001	0.0003	0.000	0.000	0.000
Thallium, Total	100	100	0.0001	0.003	0.000	0.000	0.000
Thorium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Thorium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Tin, Dissolved	3	2	0.001	0.0012	0.001	0.000	0.001
Tin, Total	100	96	0.001	0.01	0.001	0.001	0.001
Titanium, Dissolved	3	1	0.0016	0.0026	0.002	0.001	0.002
Titanium, Total	100	33	0.001	1.58	0.028	0.159	0.005
Total Dissolved Solids	98	4	6	292	95.541	67.718	70.484
Total Hardness as CaCO3	100	5	3.4	263	66.912	65.492	36.493
Total Kjeldahl Nitrogen	98	5	0.16	4.43	0.391	0.448	0.333
Total Organic Carbon	2	0	47	93	70.000	32.527	66.114
Total Particulate	2	1	0.002	0.011	0.007	0.006	0.005
Total Suspended Solids	100	44	0.015	884	20.495	89.914	4.834
Tungsten, Dissolved	3	3	0.001	0.01	0.004	0.005	0.002
Tungsten, Total	100	100	0.001	0.1	0.011	0.013	0.010
Turbidity	99	0	0.26	1080	16.977	109.447	2.445
Uranium, Dissolved	3	3	0.001	0.005	0.002	0.002	0.002
Uranium, Total	100	100	0.001	0.05	0.006	0.006	0.005
Vanadium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Vanadium, Total	100	83	0.001	0.07	0.002	0.007	0.001
Yttrium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Yttrium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Zinc, Dissolved	3	3	0.001	0.003	0.002	0.001	0.001
Zinc, Total	100	42	0.001	0.2	0.008	0.023	0.004
Zirconium, Dissolved	3	2	0.001	0.004	0.002	0.002	0.002
Zirconium, Total	100	98	0.001	0.04	0.004	0.005	0.003

Table A5: Stream 2 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Acidity	4	1	1	3	1.500	1.000	1.316
Alkalinity as CaCO3	160	33	5	340	34.399	54.674	16.755
Aluminum, Dissolved	76	0	0.00687	0.38	0.087	0.077	0.063
Aluminum, Total	161	0	0.018	25.6	0.619	2.733	0.177
Ammonia as N	157	61	0.000013	0.61	0.043	0.058	0.029
Ammonia, Unionized, as N	7	7	0.002	0.002	0.002	0.000	0.002
Antimony, Dissolved	5	5	0.0005	0.005	0.002	0.002	0.001
Antimony, Total	161	159	0.0005	0.05	0.005	0.007	0.003
Arsenic, Dissolved	6	5	0.001	0.0522	0.010	0.021	0.002
Arsenic, Total	161	156	0.001	0.01	0.001	0.001	0.001
Barium, Dissolved	5	1	0.0096	0.02	0.012	0.004	0.012
Barium, Total	161	31	0.0054	0.2	0.018	0.023	0.014
Beryllium, Dissolved	5	5	0.0005	0.001	0.001	0.000	0.001
Beryllium, Total	161	160	0.0005	0.01	0.001	0.001	0.001
Bismuth, Dissolved	5	5	0.001	0.001	0.001	0.000	0.001
Bismuth, Total	161	160	0.001	0.01	0.001	0.001	0.001
Boron, Dissolved	5	2	0.0061	0.05	0.024	0.024	0.015
Boron, Total	161	149	0.002	0.5	0.058	0.072	0.045
Cadmium, Dissolved	5	4	0.0001	0.0012	0.000	0.000	0.000
Cadmium, Total	161	147	0.00009	0.0009	0.000	0.000	0.000
Calcium, Dissolved	34	0	1.4	68	9.719	13.668	5.557
Calcium, Total	130	0	0.817	6230	61.349	546.018	5.946
Cerium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Cerium, Total	12	10	0.001	0.0032	0.001	0.001	0.001
Cesium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Cesium, Total	12	12	0.001	0.001	0.001	0.000	0.001
Chemical Oxygen Demand	2	0	8	28	18.000	14.142	14.967
Chloride	150	20	0.0368	6	0.639	0.730	0.399
Chromium, Dissolved	5	5	0.001	0.001	0.001	0.000	0.001
Chromium, Hexavalent	151	150	0.01	10	1.135	3.168	0.022
Chromium, Total	161	131	0.001	0.071	0.002	0.007	0.001
Cobalt, Dissolved	5	5	0.0001	0.0005	0.000	0.000	0.000
Cobalt, Total	161	121	0.0001	0.0167	0.001	0.002	0.001
Color, True	150	0	10.7	294	44.945	24.782	41.527
Copper, Dissolved	5	0	0.002	0.0051	0.004	0.001	0.003
Copper, Total	161	34	0.001	0.091	0.005	0.009	0.003
Dissolved Organic Carbon	153	0	4	21.7	7.316	2.431	7.023
Dissolved Oxygen	35	0	1	6.65	4.170	1.433	3.859
Dissolved Oxygen, Field	94	0	0.19	13.35	4.263	3.232	2.930
Electrical Conductivity	42	0	8	400	58.510	76.775	33.833
Electrical Conductivity, Field	77	0	0.19	377	74.166	90.749	38.108
Electrical Conductivity, Field	22	0	6	465	88.545	125.970	39.770
Europium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Europium, Total	12	12	0.001	0.001	0.001	0.000	0.001
Fluoride	153	50	0.03	0.736	0.068	0.062	0.058

Table A5: Stream 2 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Gallium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Gallium, Total	12	12	0.001	0.001	0.001	0.000	0.001
Iron, Dissolved	5	0	0.08	0.274	0.191	0.084	0.174
Iron, Total	161	0	0.071	35.2	1.626	4.299	0.781
Lanthanum, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Lanthanum, Total	12	11	0.001	0.0016	0.001	0.000	0.001
Lead, Dissolved	5	4	0.001	0.002	0.001	0.000	0.001
Lead, Total	161	138	0.001	0.016	0.001	0.002	0.001
Lithium, Dissolved	3	3	0.005	0.005	0.005	0.000	0.005
Lithium, Total	160	159	0.005	1	0.107	0.127	0.081
Magnesium, Dissolved	34	0	0.2	14.4	2.336	2.642	1.454
Magnesium, Total	130	12	0.165	1800	17.210	157.754	1.577
Manganese, Dissolved	5	0	0.0011	0.059	0.023	0.030	0.006
Manganese, Total	161	0	0.0064	1.69	0.100	0.207	0.051
Mercury, Dissolved	76	75	0.0001	0.0001	0.000	0.000	0.000
Mercury, Total	88	88	0.0001	0.0001	0.000	0.000	0.000
Molybdenum, Dissolved	5	5	0.001	0.001	0.001	0.000	0.001
Molybdenum, Total	161	158	0.001	0.01	0.001	0.001	0.001
Nickel, Dissolved	5	2	0.001	0.002	0.002	0.000	0.001
Nickel, Total	161	130	0.001	0.048	0.003	0.005	0.002
Niobium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Niobium, Total	12	12	0.001	0.001	0.001	0.000	0.001
Nitrate as N	153	44	0.03	1.09	0.133	0.142	0.093
Nitrite as N	4	4	0.03	0.03	0.030	0.000	0.030
pH	64	0	5.07	8.84	7.205	0.794	7.160
pH, Field	77	0	5.07	10.78	7.461	0.900	7.406
Phosphorus, Total	147	7	0.005	1.19	0.050	0.158	0.018
Potassium, Dissolved	31	0	0.08	1.35	0.506	0.283	0.427
Potassium, Total	118	53	0.09	10	0.865	1.065	0.645
Rubidium, Dissolved	3	1	0.001	0.0017	0.001	0.000	0.001
Rubidium, Total	12	6	0.001	0.0035	0.001	0.001	0.001
Scandium, Dissolved	3	0	0.0033	0.0047	0.004	0.001	0.004
Scandium, Total	12	9	0.001	0.0013	0.001	0.000	0.001
Selenium, Dissolved	5	5	0.001	0.005	0.003	0.002	0.002
Selenium, Total	161	159	0.0004	0.005	0.001	0.002	0.001
Silicon, Dissolved	2	0	0.7	2.3	1.500	1.131	1.269
Silicon, Total	126	3	0.36	42	3.378	3.971	2.578
Silver, Dissolved	5	5	0.0001	0.0001	0.000	0.000	0.000
Silver, Total	161	159	0.0001	0.001	0.000	0.000	0.000
Sodium, Dissolved	31	0	0.192	3.93	1.359	0.917	1.055
Sodium, Total	117	4	0.005	5.09	1.243	0.914	0.888
Strontium, Dissolved	5	0	0.006	0.076	0.034	0.026	0.026
Strontium, Total	161	0	0.0047	0.22	0.031	0.029	0.022
Sulphate	153	2	0.7	7	4.010	1.287	3.775
Tannin & Lignin	144	28	0.55	3	1.072	0.346	1.030

Table A5: Stream 2 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Tellurium, Total	8	8	0.001	0.001	0.001	0.000	0.001
Temperature	57	0	2.2	22.9	13.025	6.316	10.871
Temperature, Field	71	0	0.5	22.2	10.154	5.629	8.005
Thallium, Dissolved	5	5	0.0001	0.0003	0.000	0.000	0.000
Thallium, Total	161	160	0.0001	0.003	0.000	0.000	0.000
Thorium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Thorium, Total	12	12	0.001	0.001	0.001	0.000	0.001
Tin, Dissolved	5	4	0.001	0.0012	0.001	0.000	0.001
Tin, Total	161	148	0.001	0.01	0.001	0.001	0.001
Titanium, Dissolved	5	2	0.002	0.003	0.002	0.000	0.002
Titanium, Total	161	63	0.001	1.6	0.035	0.157	0.006
Total Dissolved Solids	154	2	10	296	68.039	56.729	52.652
Total Hardness as CaCO3	161	10	3	785	44.599	96.130	20.080
Total Kjeldahl Nitrogen	158	6	0.212	5.96	0.513	0.576	0.426
Total Organic Carbon	4	0	9	22.8	15.350	5.675	14.559
Total Particulate	7	0	0.0017	0.0348	0.014	0.011	0.009
Total Suspended Solids	162	56	1.3	1300	29.949	114.089	6.029
Tungsten, Dissolved	5	5	0.001	0.01	0.005	0.005	0.003
Tungsten, Total	161	160	0.001	0.1	0.012	0.014	0.009
Turbidity	160	0	0.48	1420	22.896	115.865	3.729
Uranium, Dissolved	5	5	0.001	0.005	0.003	0.002	0.002
Uranium, Total	161	160	0.001	0.05	0.006	0.007	0.005
Vanadium, Dissolved	5	5	0.001	0.001	0.001	0.000	0.001
Vanadium, Total	161	127	0.001	0.06	0.002	0.006	0.001
Yttrium, Dissolved	3	3	0.001	0.001	0.001	0.000	0.001
Yttrium, Total	12	12	0.001	0.001	0.001	0.000	0.001
Zinc, Dissolved	5	3	0.001	0.004	0.002	0.001	0.002
Zinc, Total	161	48	0.001	0.37	0.009	0.030	0.005
Zirconium, Dissolved	5	2	0.0021	0.0052	0.004	0.001	0.003
Zirconium, Total	161	152	0.001	0.04	0.004	0.006	0.003

Table A6: Stream 3 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Acidity	3	0	1	5	2.667	2.082	2.154
Alkalinity as CaCO3	129	5	1.6	241	23.429	31.380	15.981
Aluminum, Dissolved	62	3	0.01	0.589	0.088	0.089	0.063
Aluminum, Total	130	0	0.03	2.35	0.174	0.269	0.116
Ammonia as N	125	45	0.02	0.98	0.056	0.104	0.036
Ammonia, Unionized, as N	5	5	0.002	0.002	0.002	0.000	0.002
Antimony, Dissolved	4	4	0.0005	0.005	0.003	0.003	0.002
Antimony, Total	130	130	0.0005	0.005	0.004	0.002	0.003
Arsenic, Dissolved	4	4	0.001	0.001	0.001	0.000	0.001
Arsenic, Total	130	130	0.001	0.001	0.001	0.000	0.001
Barium, Dissolved	4	1	0.0044	0.03	0.013	0.012	0.010
Barium, Total	129	61	0.0041	0.034	0.012	0.004	0.011
Beryllium, Dissolved	4	4	0.0005	0.001	0.001	0.000	0.001
Beryllium, Total	129	129	0.0005	0.001	0.001	0.000	0.001
Bismuth, Dissolved	4	4	0.001	0.001	0.001	0.000	0.001
Bismuth, Total	130	130	0.001	0.001	0.001	0.000	0.001
Boron, Dissolved	4	2	0.0077	0.05	0.029	0.024	0.020
Boron, Total	129	126	0.002	0.05	0.047	0.011	0.042
Cadmium, Dissolved	4	3	0.0001	0.0012	0.000	0.001	0.000
Cadmium, Total	130	123	0.00009	0.00029	0.000	0.000	0.000
Calcium, Dissolved	30	0	2	75	8.273	14.156	4.769
Calcium, Total	103	0	1.74	55.6	6.748	8.442	4.696
Cerium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Cerium, Total	9	6	0.001	0.0015	0.001	0.000	0.001
Cesium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Cesium, Total	9	9	0.001	0.001	0.001	0.000	0.001
Chemical Oxygen Demand	2	0	6	21	13.500	10.607	11.225
Chloride	123	14	0.0235	8.8	1.169	1.807	0.500
Chromium, Dissolved	4	4	0.001	0.001	0.001	0.000	0.001
Chromium, Hexavalent	121	121	0.01	10	1.001	2.998	0.020
Chromium, Total	130	116	0.001	0.0052	0.001	0.000	0.001
Cobalt, Dissolved	4	3	0.0001	0.0005	0.000	0.000	0.000
Cobalt, Total	130	87	0.00015	0.02	0.001	0.002	0.001
Color, True	122	0	18.3	95.2	42.041	15.378	39.443
Copper, Dissolved	4	0	0.003	0.0115	0.008	0.004	0.007
Copper, Total	130	0	0.003	0.0707	0.011	0.007	0.010
Dissolved Organic Carbon	124	0	3.9	14.2	6.919	2.161	6.626
Dissolved Oxygen	29	0	1.66	6.82	4.040	1.452	3.776
Dissolved Oxygen, Field	3	0	5.65	9.46	7.257	1.974	7.087
Dissolved Oxygen, Field	67	0	0.24	108	5.647	13.119	2.847
Electrical Conductivity	35	0	16	390	67.406	80.264	46.139
Electrical Conductivity, Field	54	0	6.07	216	50.631	39.673	40.773
Electrical Conductivity, Field	17	0	19	158	50.176	39.149	39.751
Europium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Europium, Total	9	9	0.001	0.001	0.001	0.000	0.001

Table A6: Stream 3 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Fluoride	124	38	0.03	0.17	0.070	0.033	0.062
Gallium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Gallium, Total	8	8	0.001	0.001	0.001	0.000	0.001
Iron, Dissolved	4	1	0.05	0.35	0.136	0.143	0.097
Iron, Total	130	0	0.084	7.18	0.626	0.794	0.428
Lanthanum, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Lanthanum, Total	9	7	0.001	0.0011	0.001	0.000	0.001
Lead, Dissolved	4	4	0.001	0.001	0.001	0.000	0.001
Lead, Total	130	117	0.001	0.0106	0.001	0.001	0.001
Lithium, Dissolved	2	2	0.005	0.005	0.005	0.000	0.005
Lithium, Total	126	126	0.005	0.1	0.090	0.027	0.077
Magnesium, Dissolved	30	0	0.9	12.4	2.580	2.189	2.132
Magnesium, Total	101	0	0.83	10.2	2.374	1.534	2.066
Manganese, Dissolved	4	0	0.0034	0.165	0.045	0.080	0.012
Manganese, Total	130	0	0.0025	0.957	0.040	0.092	0.019
Mercury, Dissolved	65	65	0.00001	0.0001	0.000	0.000	0.000
Mercury, Total	67	67	0.0001	0.0001	0.000	0.000	0.000
Molybdenum, Dissolved	4	4	0.001	0.001	0.001	0.000	0.001
Molybdenum, Total	130	130	0.001	0.001	0.001	0.000	0.001
Nickel, Dissolved	4	0	0.0019	0.003	0.003	0.001	0.003
Nickel, Total	130	51	0.001	0.0194	0.003	0.002	0.003
Niobium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Niobium, Total	9	9	0.001	0.001	0.001	0.000	0.001
Nitrate as N	125	41	0.03	1	0.137	0.150	0.091
Nitrite as N	4	4	0.03	0.05	0.035	0.010	0.034
pH	52	0	6.47	8.86	7.300	0.564	7.279
pH, Field	55	0	5.39	9.84	7.268	0.701	7.235
Phosphorus, Total	119	17	0.005	0.15	0.016	0.019	0.011
Potassium, Dissolved	27	0	0.3	1.22	0.563	0.180	0.540
Potassium, Total	95	52	0.119	1.2	0.752	0.302	0.671
Rubidium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Rubidium, Total	9	5	0.001	0.0018	0.001	0.000	0.001
Scandium, Dissolved	2	0	0.0018	0.0048	0.003	0.002	0.003
Scandium, Total	9	9	0.001	0.001	0.001	0.000	0.001
Selenium, Dissolved	4	4	0.001	0.005	0.003	0.002	0.002
Selenium, Total	130	129	0.0004	0.005	0.001	0.002	0.001
Silicon, Dissolved	2	0	0.4	2	1.200	1.131	0.894
Silicon, Total	103	8	0.2	5.44	2.194	1.335	1.725
Silver, Dissolved	4	4	0.0001	0.0001	0.000	0.000	0.000
Silver, Total	130	130	0.0001	0.0001	0.000	0.000	0.000
Sodium, Dissolved	27	0	0.317	4.49	1.220	1.052	0.917
Sodium, Total	91	5	0.005	3.56	1.014	0.783	0.687
Strontium, Dissolved	4	0	0.0164	0.115	0.048	0.046	0.036
Strontium, Total	130	0	0.0118	0.116	0.029	0.015	0.026
Sulphate	124	1	1.83	8.7	4.148	1.178	3.997

Table A6: Stream 3 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Tannin & Lignin	116	17	0.37	2.76	1.179	0.454	1.103
Tellurium, Total	6	6	0.001	0.001	0.001	0.000	0.001
Temperature	46	0	1.4	23.1	12.980	6.416	10.663
Temperature, Field	52	0	0.2	20.1	10.363	5.470	7.920
Thallium, Dissolved	4	4	0.0001	0.0003	0.000	0.000	0.000
Thallium, Total	130	130	0.0001	0.0003	0.000	0.000	0.000
Thorium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Thorium, Total	9	9	0.001	0.001	0.001	0.000	0.001
Tin, Dissolved	4	4	0.001	0.001	0.001	0.000	0.001
Tin, Total	130	125	0.001	0.0296	0.001	0.003	0.001
Titanium, Dissolved	4	2	0.0014	0.0025	0.002	0.000	0.002
Titanium, Total	130	75	0.001	0.141	0.007	0.016	0.003
Total Dissolved Solids	125	0	10	270	58.840	36.434	51.301
Total Hardness as CaCO3	130	0	7.8	238	27.597	31.767	20.481
Total Kjeldahl Nitrogen	126	4	0.05	1.35	0.439	0.194	0.404
Total Organic Carbon	3	0	13.5	17.9	15.133	2.409	15.012
Total Particulate	5	0	0.0025	0.015	0.009	0.006	0.007
Total Suspended Solids	131	58	2	162	7.308	18.625	3.683
Tungsten, Dissolved	4	4	0.001	0.01	0.006	0.005	0.003
Tungsten, Total	130	130	0.001	0.01	0.009	0.002	0.009
Turbidity	126	0	0.37	101	4.064	10.553	1.796
Uranium, Dissolved	4	4	0.001	0.005	0.003	0.002	0.002
Uranium, Total	130	130	0.001	0.005	0.005	0.001	0.004
Vanadium, Dissolved	4	3	0.001	0.001	0.001	0.000	0.001
Vanadium, Total	129	111	0.001	0.006	0.001	0.001	0.001
Yttrium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Yttrium, Total	8	8	0.001	0.001	0.001	0.000	0.001
Zinc, Dissolved	4	4	0.001	0.003	0.002	0.001	0.002
Zinc, Total	130	33	0.001	0.151	0.006	0.013	0.004
Zirconium, Dissolved	4	3	0.001	0.004	0.003	0.001	0.003
Zirconium, Total	130	126	0.001	0.004	0.003	0.001	0.003

Table A7: Stream 4 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Acidity	3	1	1	4	2.000	1.732	1.587
Alkalinity as CaCO3	54	2	5	75	18.991	14.685	15.478
Aluminum, Dissolved	32	2	0.0051	0.18	0.061	0.057	0.039
Aluminum, Total	54	0	0.017	2.2	0.145	0.304	0.082
Ammonia as N	49	19	0.000003	0.1	0.028	0.025	0.008
Antimony, Dissolved	13	13	0.0005	0.005	0.002	0.002	0.001
Antimony, Total	54	53	0.0005	0.005	0.004	0.002	0.003
Arsenic, Dissolved	13	13	0.001	0.001	0.001	0.000	0.001
Arsenic, Total	54	54	0.001	0.001	0.001	0.000	0.001
Barium, Dissolved	13	0	0.0067	0.0201	0.013	0.004	0.012
Barium, Total	54	1	0.0083	0.067	0.017	0.009	0.016
Beryllium, Dissolved	13	13	0.0005	0.001	0.001	0.000	0.001
Beryllium, Total	54	54	0.0005	0.001	0.001	0.000	0.001
Bismuth, Dissolved	13	13	0.001	0.001	0.001	0.000	0.001
Bismuth, Total	54	54	0.001	0.001	0.001	0.000	0.001
Boron, Dissolved	13	10	0.002	0.05	0.014	0.021	0.005
Boron, Total	54	44	0.002	0.05	0.041	0.018	0.031
Cadmium, Dissolved	13	10	0.0001	0.0013	0.000	0.000	0.000
Cadmium, Total	54	52	0.00009	0.000189	0.000	0.000	0.000
Calcium, Dissolved	20	0	0.806	30	4.534	6.084	3.293
Calcium, Total	54	0	0.911	4030	79.469	547.771	4.378
Cerium, Dissolved	10	10	0.001	0.001	0.001	0.000	0.001
Cerium, Total	11	7	0.001	0.0065	0.002	0.002	0.001
Cesium, Dissolved	10	10	0.001	0.001	0.001	0.000	0.001
Cesium, Total	11	11	0.001	0.001	0.001	0.000	0.001
Chemical Oxygen Demand	3	0	23	25	24.000	1.000	23.986
Chloride	44	5	0.027	2	0.291	0.394	0.203
Chromium, Dissolved	13	13	0.001	0.001	0.001	0.000	0.001
Chromium, Hexavalent	43	43	0.01	10	0.475	2.129	0.014
Chromium, Total	54	51	0.001	0.0049	0.001	0.001	0.001
Cobalt, Dissolved	13	10	0.0001	0.0005	0.000	0.000	0.000
Cobalt, Total	54	39	0.0001	0.0102	0.001	0.001	0.001
Color, True	43	0	17.9	70.5	36.888	11.409	35.151
Copper, Dissolved	13	4	0.001	0.008	0.003	0.002	0.002
Copper, Total	54	3	0.001	0.022	0.005	0.004	0.004
Dissolved Organic Carbon	54	0	4.7	22.3	7.634	3.088	7.204
Dissolved Oxygen	11	0	0.81	5.88	4.006	1.871	3.415
Dissolved Oxygen, Field	37	0	0.47	10.45	4.558	3.405	3.040
Electrical Conductivity	11	0	25	33	28.545	2.806	28.423
Electrical Conductivity, Field	33	0	8	940	65.394	158.817	36.174
Electrical Conductivity, Field	6	0	32	40	37.167	2.994	37.062
Europium, Dissolved	10	10	0.001	0.001	0.001	0.000	0.001
Europium, Total	11	11	0.001	0.001	0.001	0.000	0.001
Fluoride	54	18	0.03	0.206	0.077	0.036	0.069
Gallium, Dissolved	10	10	0.001	0.001	0.001	0.000	0.001

Table A7: Stream 4 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Gallium, Total	11	10	0.001	0.0013	0.001	0.000	0.001
Iron, Dissolved	13	2	0.02	0.501	0.244	0.156	0.170
Iron, Total	54	0	0.115	5.31	0.801	0.834	0.580
Lanthanum, Dissolved	10	10	0.001	0.001	0.001	0.000	0.001
Lanthanum, Total	11	10	0.001	0.0033	0.001	0.001	0.001
Lead, Dissolved	13	13	0.001	0.001	0.001	0.000	0.001
Lead, Total	54	53	0.001	0.001	0.001	0.000	0.001
Lithium, Dissolved	10	10	0.005	0.005	0.005	0.000	0.005
Lithium, Total	52	52	0.005	0.1	0.078	0.039	0.052
Magnesium, Dissolved	20	0	0.185	4.55	1.355	0.889	1.098
Magnesium, Total	54	0	0.211	1390	27.409	188.929	1.556
Manganese, Dissolved	13	1	0.001	0.366	0.045	0.101	0.007
Manganese, Total	54	0	0.0117	1.4	0.090	0.201	0.045
Mercury, Dissolved	31	31	0.0001	0.0001	0.000	0.000	0.000
Mercury, Total	33	33	0.0001	0.0001	0.000	0.000	0.000
Molybdenum, Dissolved	11	11	0.001	0.001	0.001	0.000	0.001
Molybdenum, Total	54	54	0.001	0.001	0.001	0.000	0.001
Nickel, Dissolved	13	11	0.001	0.006	0.002	0.001	0.001
Nickel, Total	54	45	0.001	0.0048	0.002	0.001	0.002
Niobium, Dissolved	10	10	0.001	0.001	0.001	0.000	0.001
Niobium, Total	11	11	0.001	0.001	0.001	0.000	0.001
Nitrate as N	54	39	0.03	0.22	0.073	0.054	0.057
Nitrite as N	11	11	0.03	0.03	0.030	0.000	0.030
pH	17	0	6.89	10.26	7.653	0.794	7.619
pH, Field	33	0	5.82	8.41	7.045	0.657	7.015
Phosphorus, Total	48	7	0.000011	0.132	0.014	0.022	0.005
Potassium, Dissolved	10	0	0.23	0.42	0.313	0.063	0.308
Potassium, Total	35	16	0.23	1	0.627	0.358	0.520
Rubidium, Dissolved	10	9	0.001	0.002	0.001	0.000	0.001
Rubidium, Total	10	9	0.001	0.0061	0.002	0.002	0.001
Scandium, Dissolved	10	7	0.001	0.0052	0.002	0.001	0.001
Scandium, Total	11	10	0.001	0.0016	0.001	0.000	0.001
Selenium, Dissolved	7	7	0.001	0.005	0.003	0.002	0.002
Selenium, Total	54	52	0.0004	0.005	0.001	0.001	0.001
Silicon, Dissolved	3	0	1.3	1.4	1.367	0.058	1.366
Silicon, Total	39	2	0.94	4.3	1.882	0.780	1.747
Silver, Dissolved	13	13	0.0001	0.0001	0.000	0.000	0.000
Silver, Total	54	54	0.0001	0.0001	0.000	0.000	0.000
Sodium, Dissolved	10	0	0.281	0.728	0.578	0.177	0.548
Sodium, Total	33	3	0.005	1.5	0.550	0.358	0.319
Strontium, Dissolved	11	0	0.0046	0.0314	0.020	0.010	0.016
Strontium, Total	46	0	0.011	0.0603	0.024	0.007	0.023
Sulphate	54	1	0.3	9.17	3.919	1.282	3.623
Tannin & Lignin	39	6	0.59	2	1.023	0.300	0.987
Temperature	17	0	5.2	24.5	15.571	6.961	13.870

Table A7: Stream 4 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Temperature, Field	31	0	0.1	20.11	11.545	6.659	7.697
Thallium, Dissolved	13	13	0.0001	0.0003	0.000	0.000	0.000
Thallium, Total	54	54	0.0001	0.0003	0.000	0.000	0.000
Thorium, Dissolved	10	10	0.001	0.001	0.001	0.000	0.001
Thorium, Total	11	11	0.001	0.001	0.001	0.000	0.001
Tin, Dissolved	13	12	0.001	0.0028	0.001	0.000	0.001
Tin, Total	54	51	0.001	0.0015	0.001	0.000	0.001
Titanium, Dissolved	13	11	0.001	0.0027	0.001	0.001	0.001
Titanium, Total	54	38	0.001	0.138	0.005	0.019	0.002
Total Dissolved Solids	54	0	10	140	47.148	18.477	44.031
Total Hardness as CaCO3	54	0	3.16	77.4	17.478	10.302	15.620
Total Kjeldahl Nitrogen	43	1	0.25	1.89	0.415	0.241	0.388
Total Organic Carbon	11	0	9.48	23.3	12.975	3.950	12.536
Total Suspended Solids	45	22	2	78	5.176	11.915	2.960
Tungsten, Dissolved	13	13	0.001	0.01	0.003	0.004	0.002
Tungsten, Total	54	54	0.001	0.01	0.008	0.004	0.006
Turbidity	43	0	0.43	6.31	1.871	1.156	1.664
Uranium, Dissolved	13	13	0.001	0.005	0.002	0.002	0.001
Uranium, Total	54	54	0.001	0.005	0.004	0.002	0.004
Vanadium, Dissolved	13	13	0.001	0.001	0.001	0.000	0.001
Vanadium, Total	54	52	0.001	0.005	0.001	0.001	0.001
Yttrium, Dissolved	10	10	0.001	0.001	0.001	0.000	0.001
Yttrium, Total	11	10	0.001	0.0015	0.001	0.000	0.001
Zinc, Dissolved	13	8	0.001	0.0063	0.003	0.002	0.002
Zinc, Total	54	18	0.001	0.104	0.009	0.015	0.005
Zirconium, Dissolved	13	13	0.001	0.004	0.002	0.001	0.001
Zirconium, Total	54	52	0.001	0.0106	0.003	0.002	0.003

Table A8: Stream 5 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Acidity	4	0	2	7	4.500	2.380	3.984
Alkalinity as CaCO3	285	111	1.6	48	9.150	6.982	7.668
Aluminum, Dissolved	128	0	0.018	0.451	0.147	0.100	0.117
Aluminum, Total	285	0	0.037	18.7	0.315	1.153	0.190
Ammonia as N	283	174	0.000014	0.32	0.030	0.031	0.023
Ammonia, Unionized, as N	1	1	0.002	0.002	0.002		0.002
Antimony, Dissolved	11	10	0.0005	0.005	0.003	0.002	0.002
Antimony, Total	285	284	0.0005	0.05	0.005	0.006	0.004
Arsenic, Dissolved	11	11	0.001	0.001	0.001	0.000	0.001
Arsenic, Total	285	282	0.001	0.012	0.001	0.001	0.001
Barium, Dissolved	11	5	0.0075	0.0131	0.010	0.002	0.010
Barium, Total	285	145	0.001	0.43	0.015	0.031	0.011
Beryllium, Dissolved	11	11	0.0005	0.001	0.001	0.000	0.001
Beryllium, Total	285	285	0.0005	0.01	0.001	0.001	0.001
Bismuth, Dissolved	11	11	0.001	0.001	0.001	0.000	0.001
Bismuth, Total	285	285	0.001	0.01	0.001	0.001	0.001
Boron, Dissolved	11	8	0.002	0.05	0.029	0.024	0.016
Boron, Total	285	279	0.002	0.5	0.055	0.054	0.049
Cadmium, Dissolved	11	5	0.0001	0.0011	0.001	0.000	0.000
Cadmium, Total	285	273	0.00009	0.0028	0.000	0.000	0.000
Calcium, Dissolved	47	0	1.1	17.9	4.319	3.959	3.161
Calcium, Total	237	2	0.32	2370	12.998	153.766	2.633
Carbonate	1	0	0.03	0.03	0.030		0.030
Cerium, Dissolved	5	3	0.001	0.0016	0.001	0.000	0.001
Cerium, Total	7	1	0.001	0.0028	0.002	0.001	0.002
Cesium, Dissolved	5	5	0.001	0.001	0.001	0.000	0.001
Cesium, Total	7	7	0.001	0.001	0.001	0.000	0.001
Chemical Oxygen Demand	9	3	1.14	39	15.360	15.482	7.943
Chloride	280	42	0.0564	14.7	0.619	1.513	0.270
Chromium, Dissolved	11	11	0.001	0.001	0.001	0.000	0.001
Chromium, Hexavalent	277	277	0.01	10	0.912	2.868	0.019
Chromium, Total	285	278	0.001	0.01	0.001	0.001	0.001
Cobalt, Dissolved	11	9	0.0001	0.0012	0.000	0.000	0.000
Cobalt, Total	285	261	0.0001	0.0443	0.001	0.003	0.001
Color, True	282	0	5.9	152	44.871	24.034	37.936
Copper, Dissolved	11	4	0.001	0.005	0.002	0.001	0.002
Copper, Total	285	170	0.001	0.03	0.002	0.003	0.001
Dissolved Organic Carbon	284	1	2	15.6	7.199	2.193	6.866
Dissolved Oxygen	53	0	1.15	7.26	4.040	1.772	3.582
Dissolved Oxygen, Field	178	0	0.02	22	4.589	4.164	2.803
Electrical Conductivity	54	0	6	115	26.970	26.375	18.418
Electrical Conductivity, Field	150	0	2	86	18.884	15.165	14.818
Electrical Conductivity, Field	29	0	5	106	21.966	21.072	16.591
Europium, Dissolved	5	5	0.001	0.001	0.001	0.000	0.001
Europium, Total	7	7	0.001	0.001	0.001	0.000	0.001

Table A8: Stream 5 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Fluoride	283	73	0.03	0.465	0.088	0.092	0.064
Gallium, Dissolved	5	5	0.001	0.001	0.001	0.000	0.001
Gallium, Total	7	7	0.001	0.001	0.001	0.000	0.001
Iron, Dissolved	11	1	0.05	0.985	0.369	0.315	0.266
Iron, Total	285	13	0.02	49.1	1.111	3.918	0.411
Lanthanum, Dissolved	5	5	0.001	0.001	0.001	0.000	0.001
Lanthanum, Total	7	5	0.001	0.0017	0.001	0.000	0.001
Lead, Dissolved	11	8	0.001	0.003	0.001	0.001	0.001
Lead, Total	285	274	0.001	0.06	0.001	0.004	0.001
Lithium, Dissolved	5	5	0.005	0.005	0.005	0.000	0.005
Lithium, Total	281	281	0.005	1	0.109	0.109	0.094
Magnesium, Dissolved	47	0	0.15	2.52	0.734	0.622	0.537
Magnesium, Total	229	52	0.095	382	2.358	25.205	0.577
Manganese, Dissolved	11	1	0.001	0.817	0.114	0.237	0.026
Manganese, Total	284	3	0.001	5.96	0.094	0.382	0.033
Mercury, Dissolved	128	127	0.0001	0.0001	0.000	0.000	0.000
Mercury, Total	161	161	0.0001	0.001	0.000	0.000	0.000
Molybdenum, Dissolved	9	9	0.001	0.001	0.001	0.000	0.001
Molybdenum, Total	285	284	0.0001	0.01	0.001	0.001	0.001
Nickel, Dissolved	11	11	0.001	0.002	0.002	0.001	0.001
Nickel, Total	285	281	0.001	0.02	0.002	0.002	0.002
Niobium, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Niobium, Total	7	7	0.001	0.001	0.001	0.000	0.001
Nitrate as N	258	81	0.03	0.499	0.094	0.075	0.073
Nitrite as N	15	7	0.03	2.92	0.305	0.731	0.103
pH	83	0	3.29	8.98	6.839	1.061	6.743
pH, Field	149	0	3.66	10.27	6.901	1.144	6.797
Phosphorus, Dissolved	2	2	0.001	0.001	0.001	0.000	0.001
Phosphorus, Total	250	66	0.005	1.06	0.024	0.081	0.010
Potassium, Dissolved	42	0	0.03	0.47	0.258	0.112	0.222
Potassium, Total	228	143	0.05	10	0.785	1.142	0.483
Rubidium, Dissolved	5	4	0.001	0.0011	0.001	0.000	0.001
Rubidium, Total	7	7	0.00002	0.001	0.001	0.000	0.001
Scandium, Dissolved	5	2	0.001	0.0073	0.003	0.003	0.002
Scandium, Total	4	4	0.001	0.001	0.001	0.000	0.001
Selenium, Dissolved	11	11	0.0001	0.005	0.003	0.002	0.002
Selenium, Total	285	284	0.0004	0.005	0.001	0.001	0.001
Silicon, Dissolved	6	0	0.5	4.3	1.367	1.485	0.958
Silicon, Total	253	4	0.28	11	2.558	1.397	2.242
Silver, Dissolved	11	9	0.0001	0.00975	0.002	0.004	0.000
Silver, Total	285	283	0.0001	0.001	0.000	0.000	0.000
Sodium, Dissolved	42	0	0.117	9.01	1.154	1.737	0.715
Sodium, Total	224	4	0.005	8.17	0.870	0.935	0.673
Strontium, Dissolved	11	2	0.0001	0.027	0.009	0.007	0.004
Strontium, Total	285	1	0.0001	0.105	0.011	0.008	0.010

Table A8: Stream 5 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Sulphate	282	7	0.36	5.3	3.145	0.835	3.018
Tannin & Lignin	275	31	0.27	3	1.226	0.504	1.125
Tellurium, Total	1	1	0.001	0.001	0.001		0.001
Temperature	82	0	2.8	26.6	12.785	5.799	11.135
Temperature, Field	145	0	0.1	20.9	10.230	5.583	7.805
Thallium, Dissolved	11	11	0.0001	0.001	0.000	0.000	0.000
Thallium, Total	285	284	0.0001	0.0164	0.000	0.001	0.000
Thorium, Dissolved	5	5	0.001	0.001	0.001	0.000	0.001
Thorium, Total	7	7	0.0001	0.001	0.001	0.000	0.001
Tin, Dissolved	11	10	0.001	0.0019	0.001	0.000	0.001
Tin, Total	285	281	0.001	0.01	0.001	0.001	0.001
Titanium, Dissolved	11	8	0.001	0.002	0.002	0.000	0.002
Titanium, Total	285	183	0.001	0.27	0.004	0.017	0.002
Total Dissolved Solids	288	7	10	90	39.878	15.909	36.442
Total Hardness as CaCO3	285	71	1.2	55	11.302	7.542	9.554
Total Kjeldahl Nitrogen	280	8	0.005	11.4	0.436	0.778	0.324
Total Organic Carbon	6	0	13.9	52	21.717	14.953	19.018
Total Particulate	1	0	0.013	0.013	0.013		0.013
Total Suspended Solids	283	171	0.5	1990	13.829	121.839	3.002
Tungsten, Dissolved	11	11	0.001	0.01	0.006	0.005	0.004
Tungsten, Total	285	284	0.001	0.1	0.011	0.011	0.010
Turbidity	283	0	0.12	469	3.555	28.119	1.024
Uranium, Dissolved	11	11	0.001	0.005	0.003	0.002	0.002
Uranium, Total	285	285	0.001	0.05	0.006	0.005	0.005
Vanadium, Dissolved	11	11	0.001	0.001	0.001	0.000	0.001
Vanadium, Total	285	276	0.001	0.03	0.001	0.002	0.001
Yttrium, Dissolved	5	4	0.001	0.0011	0.001	0.000	0.001
Yttrium, Total	7	7	0.001	0.001	0.001	0.000	0.001
Zinc, Dissolved	11	5	0.001	0.005	0.003	0.002	0.002
Zinc, Total	285	56	0.001	0.21	0.007	0.015	0.005
Zirconium, Dissolved	9	6	0.0012	0.004	0.003	0.001	0.003
Zirconium, Total	285	278	0.001	0.04	0.004	0.004	0.004

Table A9: Stream 6 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Acidity	2	0	5	12	8.500	4.950	7.746
Alkalinity as CaCO3	92	21	1.6	99	19.049	18.923	12.812
Aluminum, Dissolved	47	0	0.028	0.601	0.217	0.162	0.163
Aluminum, Total	93	0	0.058	2.44	0.370	0.301	0.301
Ammonia as N	93	35	0.000093	0.13	0.031	0.019	0.025
Antimony, Dissolved	1	1	0.005	0.005	0.005		0.005
Antimony, Total	93	92	0.0005	0.351	0.008	0.036	0.004
Arsenic, Dissolved	1	1	0.001	0.001	0.001		0.001
Arsenic, Total	93	88	0.001	0.0043	0.001	0.000	0.001
Barium, Dissolved	1	0	0.01	0.01	0.010		0.010
Barium, Total	93	31	0.001	0.072	0.013	0.007	0.011
Beryllium, Dissolved	1	1	0.001	0.001	0.001		0.001
Beryllium, Total	93	93	0.0005	0.001	0.001	0.000	0.001
Bismuth, Dissolved	1	1	0.001	0.001	0.001		0.001
Bismuth, Total	93	93	0.001	0.001	0.001	0.000	0.001
Boron, Dissolved	1	1	0.05	0.05	0.050		0.050
Boron, Total	93	91	0.0021	0.05	0.048	0.008	0.046
Cadmium, Dissolved	1	0	0.0007	0.0007	0.001		0.001
Cadmium, Total	93	89	0.00009	0.00131	0.000	0.000	0.000
Calcium, Dissolved	19	0	1.1	33	9.500	8.120	6.614
Calcium, Total	71	0	0.25	4940	96.515	609.412	4.955
Cerium, Total	2	0	0.0021	0.0026	0.002	0.000	0.002
Cesium, Total	2	2	0.001	0.001	0.001	0.000	0.001
Chemical Oxygen Demand	1	0	27	27	27.000		27.000
Chloride	91	16	0.1	24.2	2.540	5.027	0.601
Chromium, Dissolved	1	1	0.001	0.001	0.001		0.001
Chromium, Hexavalent	91	91	0.0005	10	1.437	3.515	0.026
Chromium, Total	93	87	0.001	0.0017	0.001	0.000	0.001
Cobalt, Dissolved	1	1	0.0005	0.0005	0.001		0.001
Cobalt, Total	93	78	0.00022	0.01	0.001	0.001	0.001
Color, True	92	0	32.8	216	92.077	33.929	86.399
Copper, Dissolved	1	0	0.006	0.006	0.006		0.006
Copper, Total	93	73	0.001	0.0188	0.002	0.002	0.001
Dissolved Organic Carbon	93	0	5	23	11.219	3.568	10.723
Dissolved Oxygen	24	0	1.19	6.8	4.018	1.579	3.627
Dissolved Oxygen, Field	55	0	0.27	38	5.729	6.755	3.570
Electrical Conductivity	24	0	9	261	61.458	63.118	39.078
Electrical Conductivity, Field	41	0	8	171	35.139	36.149	25.592
Electrical Conductivity, Field	15	0	10	230	62.000	62.664	40.083
Europium, Total	2	2	0.001	0.001	0.001	0.000	0.001
Fluoride	92	15	0.03	0.2	0.094	0.041	0.083
Gallium, Total	2	2	0.001	0.001	0.001	0.000	0.001
Iron, Dissolved	1	0	0.55	0.55	0.550		0.550
Iron, Total	93	0	0.155	19	1.514	2.197	1.039
Lanthanum, Total	2	0	0.0012	0.0013	0.001	0.000	0.001

Table A9: Stream 6 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Lead, Dissolved	1	1	0.001	0.001	0.001		0.001
Lead, Total	93	86	0.001	0.008	0.001	0.001	0.001
Lithium, Total	92	92	0.005	0.1	0.096	0.016	0.092
Magnesium, Dissolved	19	0	0.09	5.64	2.250	1.453	1.555
Magnesium, Total	71	5	0.055	1290	22.980	155.146	1.228
Manganese, Dissolved	1	0	0.223	0.223	0.223		0.223
Manganese, Total	93	0	0.01	1.25	0.125	0.163	0.086
Mercury, Dissolved	49	49	0.0001	0.0001	0.000	0.000	0.000
Mercury, Total	44	44	0.0001	0.001	0.000	0.000	0.000
Molybdenum, Dissolved	1	1	0.001	0.001	0.001		0.001
Molybdenum, Total	93	93	0.0001	0.001	0.001	0.000	0.001
Nickel, Dissolved	1	1	0.002	0.002	0.002		0.002
Nickel, Total	93	88	0.001	0.0796	0.003	0.008	0.002
Niobium, Total	2	2	0.001	0.001	0.001	0.000	0.001
Nitrate as N	85	53	0.03	0.182	0.055	0.037	0.047
Nitrite as N	6	4	0.03	0.479	0.142	0.169	0.089
pH	39	0	2.89	9.72	7.061	1.094	6.955
pH, Field	42	0	4.3	8.65	7.045	0.993	6.964
Phosphorus, Total	81	10	0.005	0.513	0.027	0.076	0.012
Potassium, Dissolved	19	3	0.02	0.6	0.215	0.179	0.138
Potassium, Total	69	43	0.03	1.3	0.627	0.444	0.374
Rubidium, Total	1	1	0.001	0.001	0.001		0.001
Scandium, Total	2	2	0.001	0.001	0.001	0.000	0.001
Selenium, Dissolved	1	1	0.005	0.005	0.005		0.005
Selenium, Total	93	93	0.0004	0.005	0.001	0.002	0.001
Silicon, Dissolved	1	0	1.9	1.9	1.900		1.900
Silicon, Total	77	0	0.77	5.2	3.001	1.053	2.798
Silver, Dissolved	1	1	0.0001	0.0001	0.000		0.000
Silver, Total	93	89	0.0001	0.00045	0.000	0.000	0.000
Sodium, Dissolved	19	0	0.3	15	2.859	4.452	1.165
Sodium, Total	68	3	0.1	11.6	1.853	2.838	0.918
Strontium, Dissolved	1	0	0.021	0.021	0.021		0.021
Strontium, Total	93	0	0.0034	0.052	0.012	0.008	0.010
Sulphate	92	6	0.3	5.81	2.822	1.053	2.582
Tannin & Lignin	91	1	0.82	4.11	2.024	0.624	1.933
Temperature	39	0	1.5	24.3	13.538	5.842	11.799
Temperature, Field	37	0	1.7	19.6	10.811	4.894	9.246
Thallium, Dissolved	1	1	0.0003	0.0003	0.000		0.000
Thallium, Total	93	93	0.0001	0.0003	0.000	0.000	0.000
Thorium, Total	2	2	0.001	0.001	0.001	0.000	0.001
Tin, Dissolved	1	1	0.001	0.001	0.001		0.001
Tin, Total	93	92	0.001	0.0018	0.001	0.000	0.001
Titanium, Dissolved	1	1	0.002	0.002	0.002		0.002
Titanium, Total	93	20	0.002	0.0368	0.005	0.006	0.003
Total Dissolved Solids	93	0	13	180	66.473	30.927	60.009

Table A9: Stream 6 Watershed

Parameter Name	n	ND	Min	Max	Mean	Std Dev	GeoMean
	-	-	mg/L	mg/L	mg/L	mg/L	mg/L
Total Hardness as CaCO3	93	8	0.99	106	23.450	20.221	16.528
Total Kjeldahl Nitrogen	91	3	0.0076	9.95	0.574	1.069	0.406
Total Organic Carbon	2	0	17	22	19.500	3.536	19.339
Total Suspended Solids	92	39	0.5	584	12.941	61.608	3.749
Tungsten, Dissolved	1	1	0.01	0.01	0.010		0.010
Tungsten, Total	93	93	0.001	0.01	0.010	0.001	0.010
Turbidity	91	0	0.33	118	3.270	12.384	1.590
Uranium, Dissolved	1	1	0.005	0.005	0.005		0.005
Uranium, Total	93	93	0.001	0.005	0.005	0.001	0.005
Vanadium, Dissolved	1	1	0.001	0.001	0.001		0.001
Vanadium, Total	93	84	0.001	0.0069	0.001	0.001	0.001
Yttrium, Total	2	2	0.001	0.001	0.001	0.000	0.001
Zinc, Dissolved	1	1	0.003	0.003	0.003		0.003
Zinc, Total	93	12	0.003	0.13	0.008	0.013	0.006
Zirconium, Dissolved	1	1	0.004	0.004	0.004		0.004
Zirconium, Total	93	90	0.001	0.0117	0.004	0.001	0.003