Knight Piésold CONSULTING

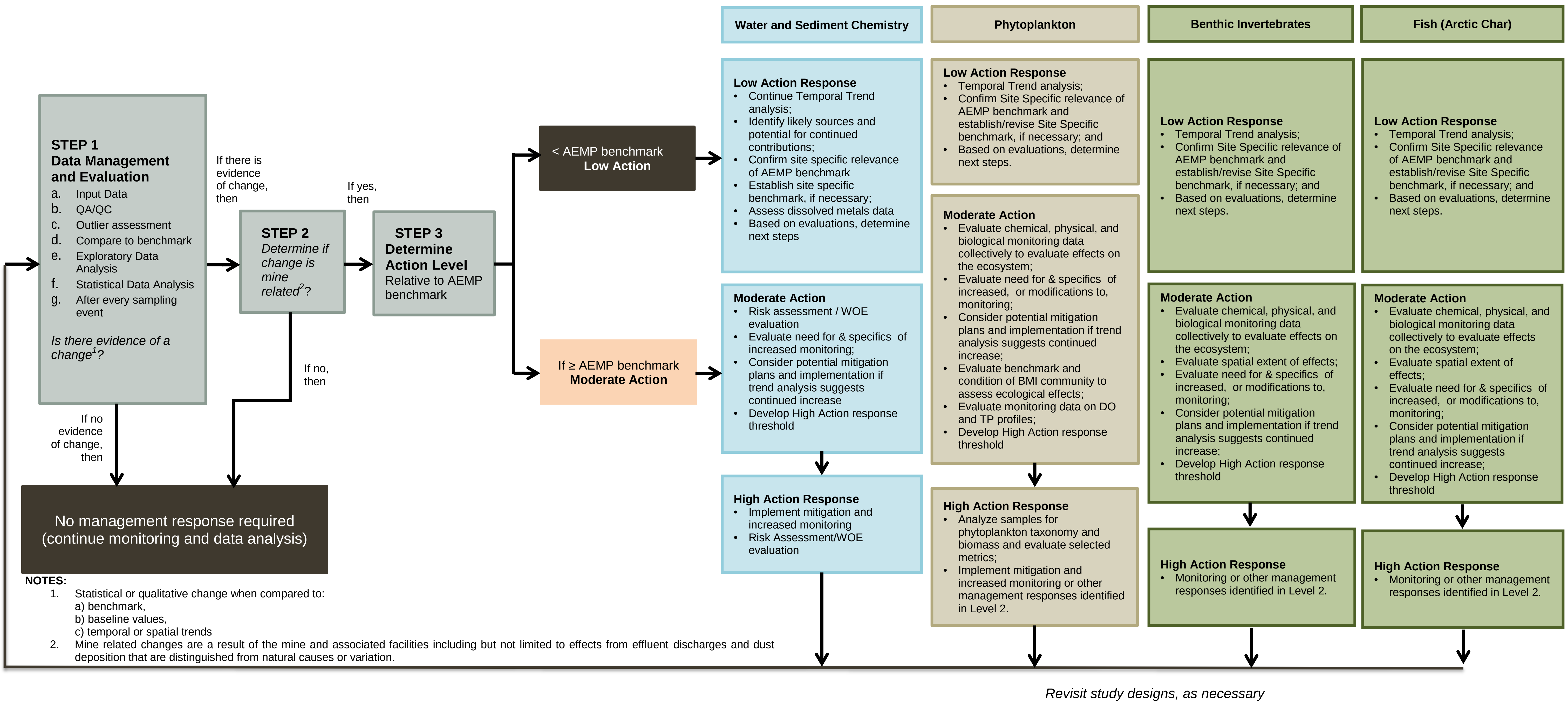


Figure 2.12 AEMP Assessment Approach and Response Framework

2.7.8.2 Step 2: Determine if Change is Mine Related

Step 2 involves determining if the changes in water quality parameters of concern are due to the Project or due to natural variability or other causes. This question will be addressed using exploratory data analysis (EDA) and subsequently using statistical data analysis (SDA), as described below.

Prior to conducting EDA and SDA, Project activities with the potential to alter water quality will be reviewed to identify potential Project-related causes or sources. This could include evaluating effluent quality, discharge regime/rates, and loading, dust deposition, and other point/non-point sources as required. Also, any evidence of potential natural causes (i.e., a major erosional event such as a slumping riverbank) will be investigated. Sampling data sheets and site personnel will be a source of this information.

Exploratory Data Analysis

Exploratory data analysis (EDA) will be completed to visualize overall data trends. This could include evaluating spatial patterns in water quality results for the Mine Area as a whole, including Mine Area lakes and streams, to evaluate if changes are widespread or specific to certain waterbodies, or proximate to mine-related sources, and to identify the spatial extent and pattern of observed changes.

Other exploratory data analyses could include comparisons of data from Mine Area streams to data from reference streams and comparisons of Mine Area Lakes to reference lake(s). This will further assist with determining whether the observed changes were due to natural variability or the Project.

Graphical analyses may be used to confirm assumptions required for statistical testing (normality, sample size, independence). Results of the EDA can be used in tandem with the Statistical Data Analysis (SDA) to evaluate the observed statistical trends and further assess whether the changes noted are mine related.

Statistical Data Analysis

Primary SDA consistent with the statistical methodology used for power analysis (BACI design) will be completed on total metals to determine the magnitude of change during post-mining. This step in the analysis tests the primary hypothesis for the effects of mine-related change and will be applied to the parameters of interest.

If the Step 2 analysis concludes that the changes in water quality parameters of concern are, or are likely, due to the Project, the assessment will proceed to Step 3. If it is concluded the observed differences relative to baseline conditions are not due to the Project, no management response will be required.

2.7.8.3 Step 3: Determine Action Level

Once EDA and primary SDA has indicated with some certainly that the measured change is project-related, Step 3 involves determination of the action level associated with the observed monitoring results through comparisons to the benchmark.

If the benchmark is not exceeded, a **low action response** would be undertaken and would include:

- Evaluate temporal trends
- Identify likely loading source(s) and potential for continued loading contributions
- Confirm the site-specific relevance of benchmark and establish a site-specific benchmark, if necessary
- Further evaluate data (for example, for water quality, review dissolved metals data and/or supporting variables)
- Based on evaluations, determine next steps

If the benchmark is exceeded and it is concluded to be Project-related, a **moderate action level response** would be undertaken and could include, in addition to analyses identified for a low action response, the following:

- Consider a weight-of-evidence (WOE) evaluation and/or risk assessment, considering other monitoring results collectively with water quality to evaluate effects on the ecosystem
- Evaluate the need for and specifics of increased monitoring
- Evaluate the need for additional monitoring (e.g., confirmation monitoring) and/or modifications to the CREMP
- Consider results of the trend analysis (i.e., trend analysis indicates an upward trend) and evaluation of potential pathways of effect (i.e., causes of observed changes) to determine if management/mitigation is required
- Identify next steps based on the above analyses. Next steps may include those identified for the high action level response.

A quantitative trigger for the **high action level response** has not been identified as the need for additional study and/or mitigation will depend on the ultimate effects of the observed increases in water quality parameters of concern on the lakes as a whole, as well as the monitoring results from the freshwater biota CREMP. Also, the benchmark may need to be revised in consideration of ongoing monitoring results. The precise relationships between water quality, sediment quality and lower trophic level changes and the collective effects on fish is difficult to predict and therefore actions undertaken under Step 3 will attempt to explore these relationships to advise on overall effects to the ecosystem. Results would be discussed with regulatory agencies and the next steps would be identified. Additional actions that may be implemented in a subsequent phase (i.e., high action level response) could include:

- Implementation of increased monitoring to further assess the potential for effects and/or define magnitude and spatial extent if warranted
- Implementation of mitigation measures or other management actions that may be identified under the moderate action level response

3 – SEDIMENT QUALITY REVIEW

3.1 SUMMARY OF SEDIMENT SAMPLING PROGRAM

The collection of baseline sediment quality samples for the Project was carried out between 2005 and 2008 and between 2001 and 2013 in conjunction with the water quality baseline program. Results up to and including 2011 were presented in the baseline reports referenced in Section 2.1. Sediment quality data collected in 2012 and 2013 are included in this review but were not previously reported.

Sampling of sediment in streams and lakes around the mine site was typically conducted once in the fall (late August/early September) in conjunction with and at the same stations as the water quality and benthic invertebrate sampling. Table 3.1 summarizes the sediment quality baseline program by year and location around the mine site. The Mine site sediment sampling locations are shown on Figure 1.3.

Table 3.1 Number of Sediment Samples by Year and Location

Grouping	2005	2006	2007	2008	2011	2012	2013
Camp Lake	0	0	6	0	0	3	3
Camp Lake Tributary	3	0	4	0	3	7	5
Mary River Downstream	2	1	5	0	10	4	3
Mary Lake	0	2	5	0	0	1	1
Sheardown Lake NW	0	0	7	12	3	4	6
Sheardown Lake SE	0	0	5	0	0	1	1
Sheardown Lake Tributary	2	0	5	3	4	3	1
Mary River Upstream	1	1	1	0	0	0	1

Sampling and analytical methods, and quality assurance/quality control (QA/QC) procedures applied during the sampling period are described in the sampling protocol included as Appendix A. In the initial years, sediment sampling was carried out using of a Petite Ponar dredge sampler to collect a maximum sample collection thickness of 5 cm. This depth is appropriate for monitoring studies where historical contamination is not a priority (Environment Canada, 2012). During the NIRB review, Baffinland agreed to a recommendation from Environment Canada that the upper 1 to 2 cm of sediment be collected as part of Project monitoring. Most infaunal organisms and the most recently introduced sediment (including any contaminants of concern) are found in the upper 2 cm of the sediment. Arctic lakes experience low sedimentation rates and therefore collection of a thinner sample on surface using a sediment core sampler should provide better resolution of changes in sediment quality. Collection of thinner (2 cm) sediment samples was implemented by Baffinland starting in 2012.

Laboratory analysis of the sediment samples included physical tests, as well as tests for nutrients, carbon and metal concentrations (Table 3.2). Specific metal parameters have been identified as parameters of interest due to their potentially toxic effects when present at defined concentrations. These are the parameters for which sediment quality criteria have been established in order to protect aquatic life. It is important to establish baseline concentrations for these parameters prior to development of the Project for post-Project comparison.

Table 3.2 Summary of Baseline Sediment Quality Analytical Parameters

Parameter Category	Analytes
Physical Tests	Moisture, Particle Size (% Sand, % Silt, % Clay)
Nutrients	Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen (TKN)
Carbon	Total Organic Carbon (TOC)
Metals	Aluminium, Antimony, **Arsenic**, Barium, Beryllium, Boron, Cadmium, Calcium, **Chromium**, Cobalt, **Copper**, Gold, **Iron**, Lead, Magnesium, **Manganese**, Mercury, Molybdenum, **Nickel**, Potassium, Selenium, Sodium, Strontium, Thallium, Vanadium, Zinc

NOTES:
1. THE PARAMETERS OF INTEREST ARE INDICATED IN BOLD FONT.

Baseline analytical sediment quality data were compared to relevant guidelines for the Project that include:

- Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (CSQG-PAL) established by the CCME (CCME, 2001)
- MOE Ontario Provincial Sediment Quality Guidelines (PSQG) (Fletcher et al., 2008)ss

The CSQG established Interim Sediment Quality Guidelines (ISQGs) for select parameters. These guidelines correspond to the concentration thresholds below which adverse biological effects are not expected. The Probable Effect Level (PEL) corresponds to the concentration above which adverse biological effects are frequently found (CCME, 2001).

The PSQG established a Lowest Effect Level (LEL) threshold for parameters that correspond to concentrations that can be tolerated by the majority of sediment dwelling organisms. The Severe Effect Level (SEL) corresponds with concentrations expected to be detrimental to the majority of sediment dwelling organisms (Fletcher et al., 2008).

The laboratory detection limits for many metals improved over the duration of the testing program (i.e., between 2005 and 2013). All laboratory results and their respective detection limits for each year are presented in Section 3.3.

3.2 RELATED STUDIES

Other studies that have been undertaken that provide information on sediment quality, include:

- Substrate mapping associated with aquatic biota studies
- Monitoring of water and sediment quality and benthic invertebrates in Sheardown Lake and its tributary. This work was related to dust emissions associated with an ore crushing operation in 2008 during a bulk sampling program.
- Measurements of baseline sedimentation rates in Sheardown Lake

Each of these studies is described in the following sub-sections.

3.2.1 Substrate Mapping

Bathymetry and substrate mapping of Camp Lake, Sheardown Lake and Mary Lake are shown in Figures 3.1, 3.2 and 3.3, respectively. Substrate was described by North/South (2012) as either:

Cobble/boulder
Gravel/pebble
Sand
Fine sand/silt/clay

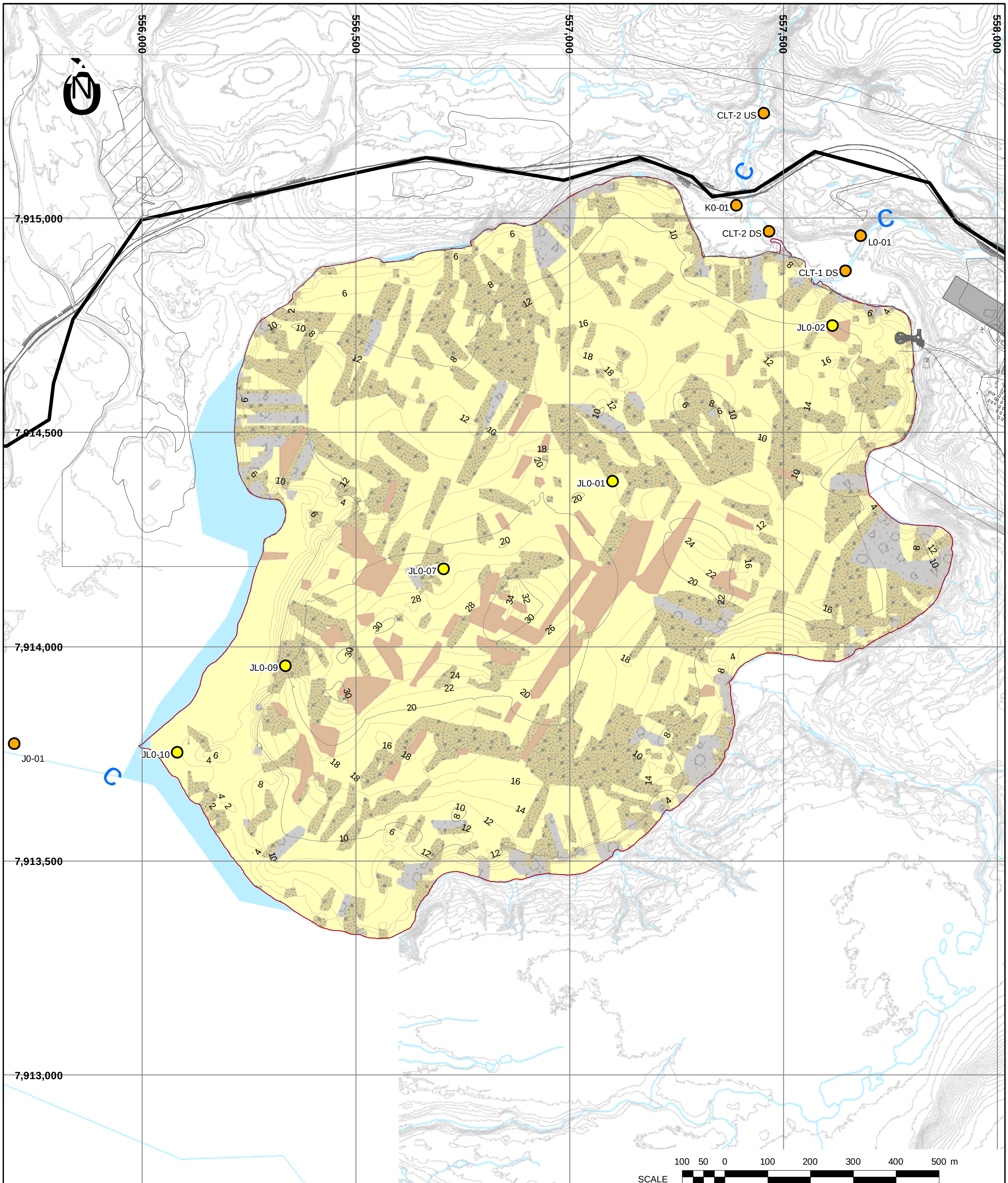
Substrate mapping provides a coarse representation of the substrate. Substrate conditions within each of the study lakes (Mary Lake, Camp Lake and Sheardown Lake), described by North/South (2012):

Camp Lake In this lake the shoreline, littoral/euphotic, and profundal zones occupy approximately 16 ha (8%), 117 ha (37%), and 78 ha (55%), respectively. Camp Lake has a maximum depth of 35.1 m and a mean depth of 13.0 m. In general, depth extends to 10 m within approximately 100 to 200 m of the shoreline with a relatively uniform depth (10 to 20 m) throughout the majority of the lake (Figure 3.1). The shoreline in Camp Lake consists primarily of gravel/pebble (or smaller-sized substrate, particularly in the southwest), with small, isolated areas of cobble/boulder shoreline in the east, southeast, and northwest sections of the lake. Sand is the dominant substrate in Camp Lake and is found throughout the near shore and offshore areas. Small patches of finer substrates are dispersed primarily in deeper, offshore areas, while patches of cobble/boulder substrate are found primarily in shallower, near shore areas (i.e., shoreline zone). Gravel/ pebble sized substrates are dispersed throughout the lake.

Sheardown Lake NW Within the northwest basin of Sheardown Lake, the shoreline, littoral/euphotic, and profundal zones occupy approximately 8 ha (12%), 28 ha (42%), and 32 ha (46%), respectively. Sheardown Lake NW is characterized by maximum and mean depths of 30.1 m and 12.1 m, respectively. This basin typically reaches depths of greater than 10 m at distances of less than 50 m from shore (Figure 3.2). The exception to this is a broad, shallow area in the southeast section of this basin. The shoreline in Sheardown Lake NW is primarily sand or gravel/pebble with a few areas of cobble/boulder. Substrate in the northwest basin consists primarily of sand or gravel/pebble with some cobble/boulder areas (usually in the littoral zone) and a few, small patches of fine substrates (typically in the profundal zone).

Sheardown Lake SE The southeast basin of Sheardown Lake is shallower than the northeast basin with maximum and mean depths of 26.7 m and 7.4 m, respectively. The shoreline, littoral/euphotic, and profundal zones occupy approximately 5 ha (19%), 16 ha (65%), and 4 ha (15%), respectively. Relatively large areas of this basin are less than 10 m in depth (Figure 3.2). This characteristic, combined with high water clarity, results in the lake being dominated by the littoral/euphotic zone.

The southeast basin has a similar proportion of sand to the northwest basin, but lacks finer substrates. An area of relatively dense aquatic macrophyte growth was observed in the southern extent of this basin. This macrophyte growth likely consists of non-vascular plants, such as macroalgae (e.g., *Chara*sp).



LEGEND:

- LAKE SEDIMENT SAMPLE STATION
- STREAM SEDIMENT SAMPLE STATION
- FLOW DIRECTION
- EXISTING TOTE ROAD
- CAMP LAKE SHORELINE
- 2 METRE INTERVAL
- 10 METRE INTERVAL
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SEDIMENT SAMPLE LOCATIONS CAMP LAKE

Knight Piésold CONSULTING

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM

P/A NO. NB102-181/33 | REF NO. 1

FIGURE 3.1 REV 1

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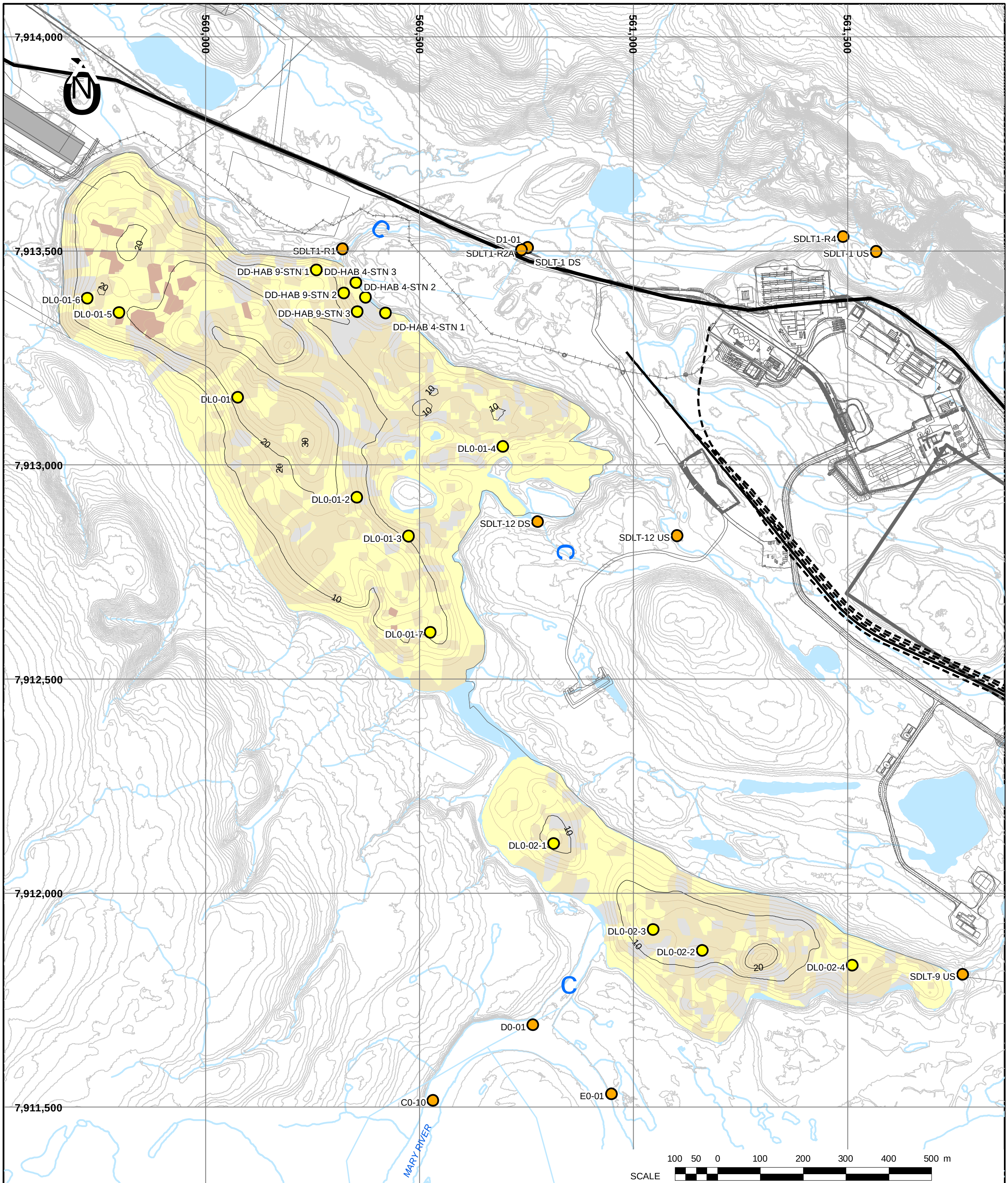

LEGEND:

- LAKE SEDIMENT SAMPLE STATION
- STREAM SEDIMENT SAMPLE STATION
- FLOW DIRECTION
- EXISTING TOTE ROAD
- CAMP LAKE SHORELINE
- 2 METRE INTERVAL
- 10 METRE INTERVAL
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SEDIMENT SAMPLE LOCATIONS
SHEARDOWN LAKE

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 3.2 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM

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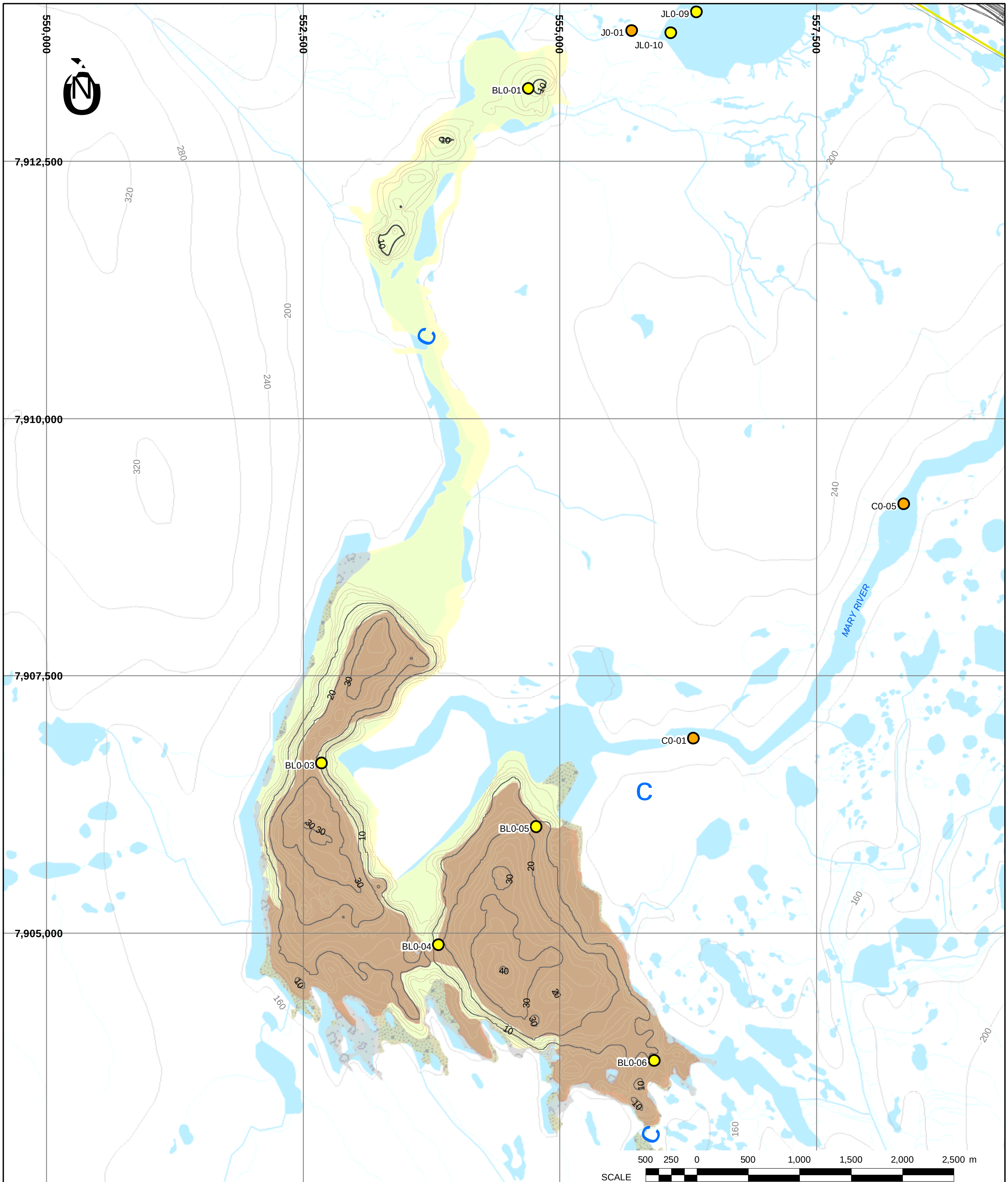

LEGEND:

- LAKE SEDIMENT SAMPLE STATION
- STREAM SEDIMENT SAMPLE STATION
- FLOW DIRECTION
- EXISTING TOTE ROAD
- CAMP LAKE SHORELINE
- 2 METRE INTERVAL
- 10 METRE INTERVAL
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SEDIMENT SAMPLE LOCATIONS MARY LAKE AREA

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 3.3 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM

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Mary Lake Similar to Camp Lake, Mary Lake is relatively deep with a maximum depth of 41.1 m in the large south basin. The mean depth of 12.0 m is shallower than Camp Lake and more similar to the NW basin of Sheardown Lake. The shoreline, littoral/euphotic, and profundal zones occupy approximately 493 ha (36%), 365 ha (26%), and 522 ha (38%), respectively. Expansive, shallow, near shore areas at the north end of the south basin (in proximity to the Mary River inlet and outlet) contribute to the comparatively shallow mean depth (Figure 3.3). Near shore substrate in Mary Lake, like the other lakes that have been surveyed for sediment quality, consists primarily of sand with patches of finer substrates and cobble/boulder. The substrata type in the shallower north arm is sand, while relatively fine sand mixed with silt/clay predominates throughout the deeper south basin.

3.2.2 Aquatic Effects Monitoring of Dust from Bulk Sample Ore Crushing

A small, single season study was completed in 2008 that sampled sediment (as well as water quality and lower trophic level components) to monitor dust emissions from ore crushing during the bulk sampling program (North/South, 2010). As part of the bulk sampling program, crushing and screening of ore occurred during the winter and spring of 2008 near Sheardown Lake NW and Tributary SDLT-1 (Tributary 1, which is a main tributary supporting the lake). The above study evaluated the water and sediment quality as well as periphyton, drifting invertebrates and benthic invertebrates within SDLT-1. The near shore environment at the mouth of SDLT-1, and control stations, were also evaluated.

Collectively, the results of the chemical and biological samples obtained did not indicate a definitive effect of dust deposition on the benthic invertebrate density or composition. Water quality monitoring results indicate that aluminum and lead may have been measurably increased in spring near the mouth of the tributary to Sheardown Lake NW, but other effects on sediment quality and lower trophic level biota were not definitive (North/South, 2010). North/South noted that the assessment was hampered by a lack of data collected in the immediately affected area prior to dust deposition and by other confounding factors such as substrate differences that limited direct comparisons.

3.2.3 AEMP Target Study on Lake Sedimentation Rates

A targeted study identified completed in the open-water season of 2013 to measure sedimentation in Sheardown Lake NW. This study was part of Baffinland's Updated AEMP Framework (Baffinland, 2013) and was designed to generate baseline information on lake sedimentation rates for post-Project comparison. Sediment traps were deployed at three stations in the lake, with five replicates at each station. This configuration was utilized to ensure adequate sediment was obtained for laboratory analysis and to provide sufficient information to evaluate variability at each station. The stations were selected to generate measurements of sedimentation rates at a deep station (where sedimentation is typically greatest) and at two shallower locations. This ongoing study may support the interpretation of results generated from CREMP sediment quality monitoring.

3.3 REVIEW OF SEDIMENT QUALITY DETECTION LIMITS

The yearly laboratory MDLs for sediment quality parameters of interest are presented in Table 3.3 and compared to the CSQG limits and PSQG criteria. In general, the detection limits were well below the relevant quality guidelines concentrations, and MDLs did not change meaningfully over the sampling period. The MDL reported for mercury is very close to the CSQG-PAL ISQG concentration. In addition, the MDL reported for cadmium is 0.1 µg/g below the CSQG-PAL ISQG and PSQG-LEL concentrations (the MDL is 0.5 µg/g compared to the guideline value of 0.6 µg/g). Increased resolution for these parameters would better define areas with concentrations above the quality guidelines.

As with the water quality, power analysis can be utilized to calculate the minimum sample size required to be reasonably sure that an effect of a given size can be detected. The ability to detect change during future monitoring is a function of the number of sampling events and the spread in results. Baffinland is interested in utilizing its existing baseline dataset to the maximum extent possible. This approach should reduce the number of monitoring events that will be required to detect a given change.

Table 3.3 Summary of Sediment Quality Laboratory Detection Limits

Parameter	As	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Zn
Units	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**
CSQG-PAL ISQG	5.9	0.6	37.3	35.7	--	0.17	--	--	35	123
CSQG-PEL	17	3.5	90	197	--	0.486	--	--	91.3	315
PSQG-LEL	6	0.6	26	16	20,000	0.2	460	16	31	120
PSQG-SEL	33	10	110	110	40,000	2	1100	75	250	820
Method Detection Limits (by year)										
2005	0.03	0.006	0.5	0.1	0.5	0.1	0.05	1	0.7	0.1
2006	1.0	0.5	1	1	1	0.1	1	1	1	1
2007	1	0.5	1	1	1	0.1	1	1	1	1
2008	1	0.5	1	0.1	1	0.1	1	1	1	1
2011	1	0.5	1	1	5	0.1	1	1	1	2
2012	1	0.5	1	1	5	0.1	1	1	1	2
2013	1	0.5	1	1	5	0.1	1	1	1	2

3.4 SEDIMENT QUALITY STRESSORS OF POTENTIAL CONCERN

The FEIS for the Project (Baffinland, 2012) identified the following stressors of potential concern for sediment quality given the average geochemical composition of the iron ore:

- Arsenic
- Cadmium

Iron
Nickel

The following metals have been noted to be naturally elevated in the sediment in the streams and lakes within the mine site area (see Section 3.5 and Table 3.4):

Arsenic
Cadmium
Chromium
Copper
Iron
Manganese
Nickel

It is expected that the metals found to be naturally elevated in the sediment is due to the mineralization associated with the ore body. As such, it is possible that these same metals will accumulate in sediment during the Project. On that basis, the metals listed immediately above are the identified sediment quality stressors of potential concern.

Lead and zinc were noted at one location in Sheardown Lake in recent (2012 and 2013) sediment testing. These two metals are not consistently elevated in sediment within the mine site streams and lakes and are, therefore, not carried forward as sediment quality stressors of potential concern. Lead and zinc will still be tested for in sediment as part of the monitoring program.

3.5 REVIEW OF SEDIMENT QUALITY BASELINE

A detailed review of the available sediment quality data using various graphical analysis tools is presented in Appendix D.

3.5.1 Metals Accumulation in Sediment and Total Organic Carbon and Fines

Metals concentrations in sediment are positively correlated with both finer grained particles as well as higher organic carbon content (Horowitz, 1991). Smaller particles have more binding sites and a higher affinity for metals than coarser grained material. Organic carbon within sediment decreases the dissolved oxygen and creates a more anoxic environment. Depending on pH, an anoxic environment may influence metal solubility and speciation. Within depositional areas of the lake that are characterized by higher concentrations of TOC and/or greater proportions of fine grained sediment, concentrations of several metals regularly exceeded the CSQG-PAL ISQGs or the PSQG-LEL. This includes chromium, copper, iron, manganese, nickel and phosphorus, and sometimes arsenic. Iron in some instances exceeded the PSQG-SEL. Most metals correlated well; in samples where one of the metals was elevated, all others were also elevated, except arsenic and manganese.

At the Mary River mine site, depositional environments were predominantly found within the lakes. The main exception to this is the stations within the main tributary of Sheardown Lake (Tributary 1). Streams at the mine site are mostly high gradient, high energy depositional environments that are not likely to have substantial amounts of fine grained sediment or sediment with high organic carbon content. The accumulation of metals in the depositional environments of the lakes is observed when reviewing mean concentrations of key metals as presented in Table 3.4 (numbers have been rounded). Stream versus lake sediment sample groupings are shaded different colours.

Table 3.4 Mean Concentrations of Key Metals in Sediment at the Mine Site

Sample ID		As µg/g	Cd µg/g	Cr µg/g	Cu µg/g	Fe µg/g	Mn µg/g	Ni µg/g	Pb µg/g	Zn µg/g
CCME	ISQG	5.9	0.6	37.3	35.7				35	123
	PEL	17	3.5	90	197				91.3	315
Ontario Sediment Quality Guidelines	LEL	6	0.6	26	16	20,000	460	16	31	120
	SEL	33	10	110	110	40,000	1,100	75	250	820
	n									
Upstream of Deposits	4	0.9	0.4	12.8	1.9	9,446	41	5	1.6	5.9
Downstream of Deposits	22	<1	<0.5	22.9	4.5	11,795	83	13	2.4	8.5
Drainages Off the Deposits	10	<1	<0.5	28.3	12.8	9,688	135	21	2.9	15.1
Mary River Tributary E2	7	1.0	0.4	18.5	3.8	9,507	64	12	2.5	7.0
Mary River Downstream of Mary Lake	2	0.7	0.3	74.5	7.0	6,050	90	29	1.5	7.8
Sheardown Lake Tributaries	18	1.4	0.65	45.2	27.0	13,524	235	39	12.1	47.6
Camp Lake Tributaries	12	0.9	0.4	27.0	12.3	8,501	95	22	3.7	13.3
Tom River	4	<1	<0.5	14.5	2.3	6,993	48	7	1.5	5.8
Mary Lake	9	2.5	<0.5	54.6	21.7	27,469	1,099	40	13.4	51.6
Camp Lake	12	2.7	<0.5	60.2	33.2	27,748	700	52	14.7	48.8
Sheardown Lake NW	32	3.1	<0.5	59.6	36.8	30,687	1,149	54	14.6	56.6
Sheardown Lake SE	7	1.5	0.6	68.0	23.4	27,462	397	57	13.3	46.3

Table 3.4 shows that the metal concentrations in depositional environments tended to be consistently higher in the same metals. In most of the mine site lakes, the mean concentrations of chromium, copper, iron, manganese and nickel exceeded the referenced guidelines.

Metals concentrations in depositional lake samples are relatively consistent between samples, between sample stations within a given lake, and between each of the three mine site lakes (Camp, Mary, Sheardown). The Sheardown Lake Tributary 1 sample location (D1-05) also exhibited the same substrate characteristics and elevated metals concentrations.

Conversely, metals concentrations in lake sediment and most stream sediment stations which were low in fines and/or TOC contained relatively low concentrations of metals. These locations also had a high degree of variability in metals concentrations between sampling events and between nearby sampling stations.

In terms of long-term monitoring, it is recommended that sediment sampling stations in depositional environments be the focus of monitoring along with the application of the Assessment Approach and Response Framework (Figure 2.12):

Detection of a change[3]
Establishing if the change is mine related
Comparison to benchmark
Undertaking a low or moderate action depending on the result compared to the benchmark

The high level of variability within sediment samples characterized by low TOC and/or low fines (high proportion of sand) do not allow for the detection of statistically significant changes as the variability between samples is likely to be greater than any project-related changes and collection of a sufficient number of samples to obtain statistical power is likely not possible.

As such, further evaluation of the sediment quality database was undertaken to understand the relationship between TOC, the proportion of fines, and metals concentrations.

Figure 3.4 shows the entire sediment quality dataset plotted as percent clay vs percent sand with the circle size representing the proportion of silt. Figure 3.5 shows the same information in another way, plotting the proportion of clay/clay+silt versus the percent sand. The figures show the 3-way relationship between sand, silt and clay and the negative association between sand and clay.

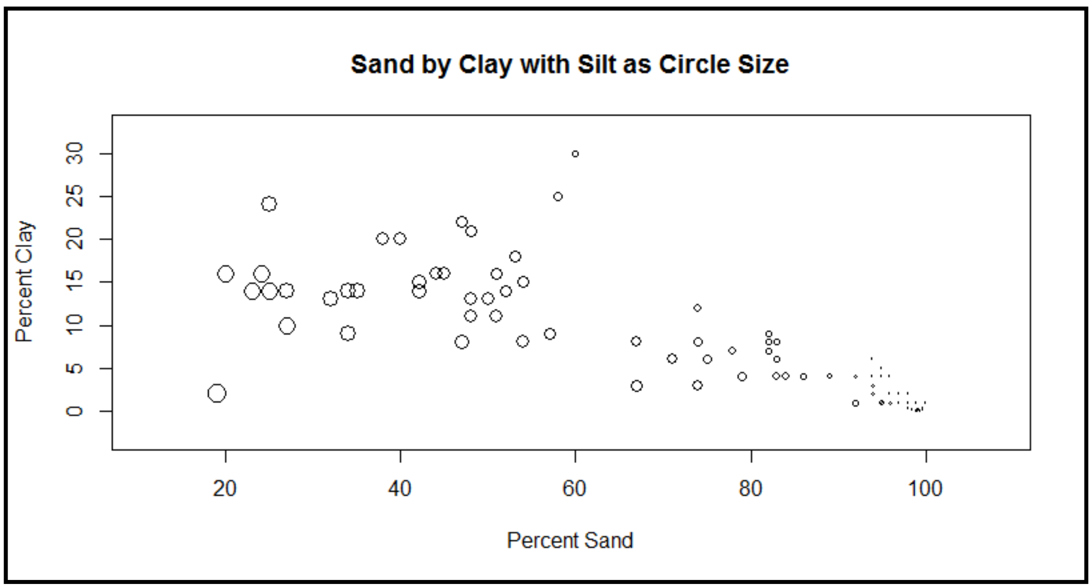


Figure 3.4 Clay by Sand with Silt as Circle Size

1. A change in this instance may be a statistical or qualitative change when compared to: a benchmark, baseline values, or temporal or spatial trends

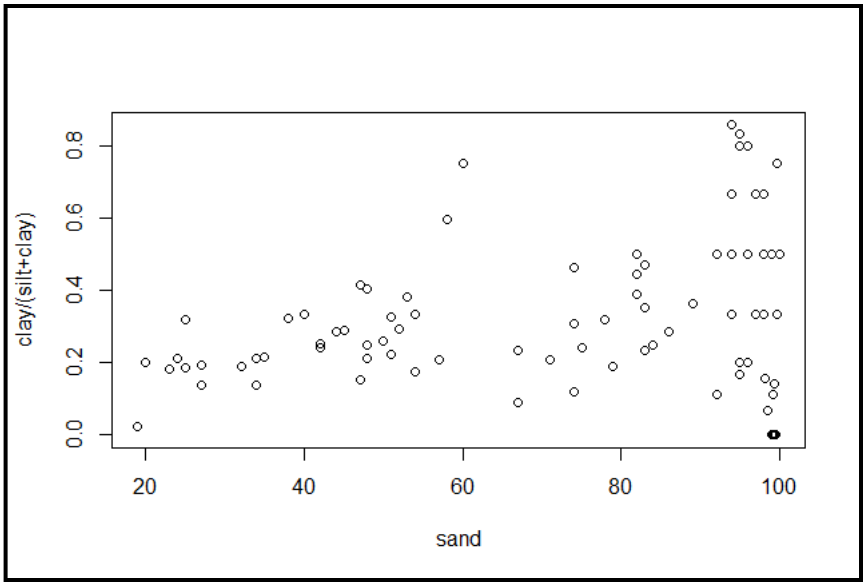


Figure 3.5 Dependent Relationship between Sand, Silt and Clay in Sediment

Colored scatter plots (Figure 3.6) show the relationship between TOC (or log TOC) and sand for lakes, streams and tributaries. Lakes are plotted using circles, streams and tributaries with triangles. Colors are used to identify the specific water bodies. Note that the x axis limits for streams and tributaries were adjusted because all the stream data is clumped at high proportions of sand (minimum of 82%). The figure shows that as expected the majority of lake sediment samples contain elevated TOC and higher proportions of fines (a lower proportion of sand), and conversely, the majority of stream samples are low in TOC and low in fines (predominantly sand).

A further evaluation was undertaken to identify cut offs in TOC and percent sand that could be applied to identify sediment samples in the baseline data. These same cut offs would be applied to sediment samples collected for monitoring.

3.5.2 Cut Point Analysis

Percent sand and TOC are generally related to metals concentrations. Deposition seems to be limited in sediment samples with a lot of sand and very little TOC. The focus of monitoring as part of the CREMP will be on identifying mine-related changes in metals concentrations. Variability due to TOC and particle size introduces extraneous noise. As such, it is generally better to control confounding factors in the study design rather than adjust for them during the data analysis. The data was reviewed to determine appropriate TOC and particle size cut-offs in order to identify sensitive depositional environments and minimize variability related to TOC and particle size. It was clear from the graphical analyses presented in Appendix D that establishing cut-offs in the vicinity of 80 to 90% sand (10 to 20% fines) and around 0.5% to 1% TOC would remove the non-depositional samples with high variability and comparatively low metals accumulation. Analyses were completed for four key parameters: arsenic, cadmium, iron and nickel.

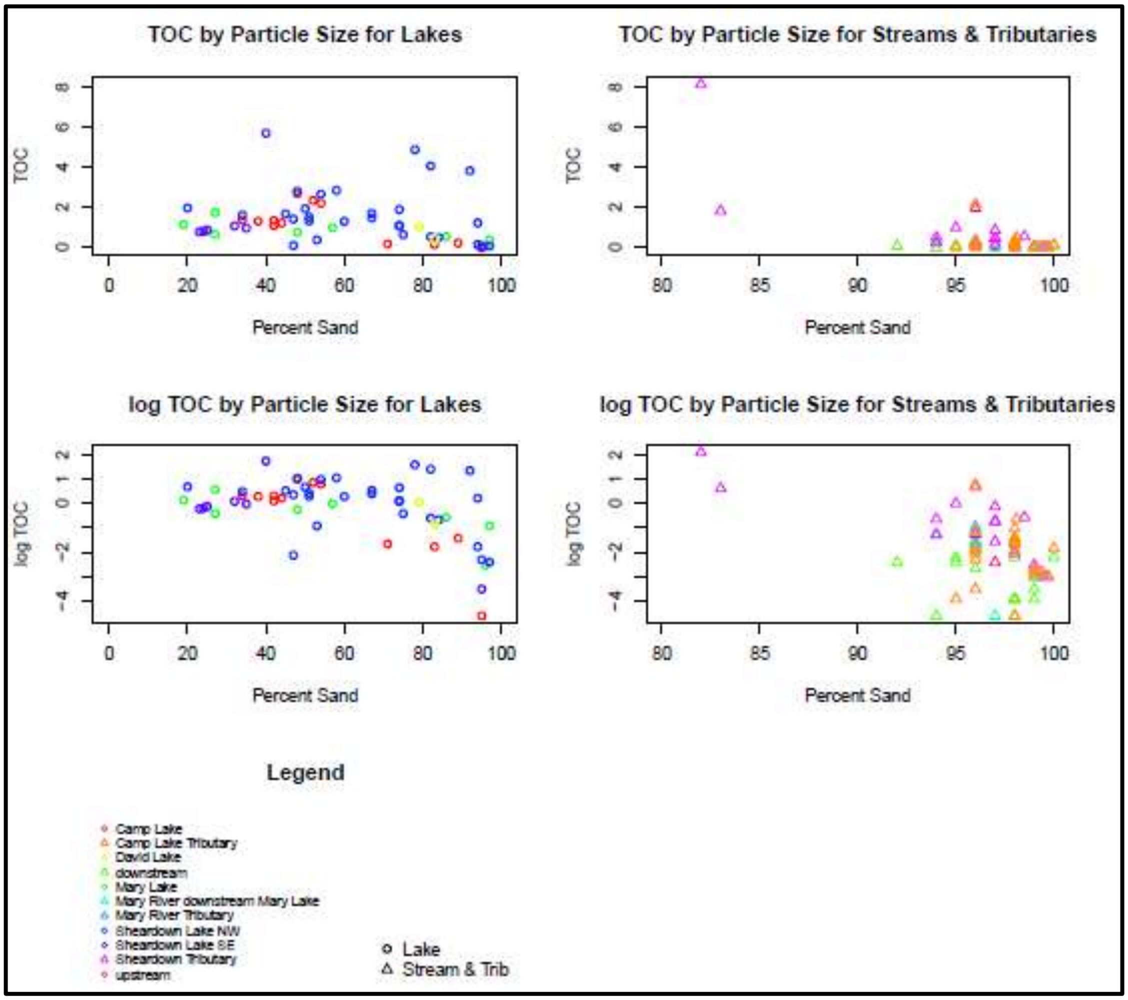


Figure 3.6 Sediment TOC versus Particle Size for Lakes and Streams

Analyses presented in Appendix D helped to identify cut points in the vicinity of inflection points on the curves. These cut points were used in subsequent linear regression analyses to explore the linear relationship above and below the cut off points.

A subset of the data was defined that excluded all samples with greater than 90% sand as well as samples with less than 0.6% TOC and greater than 80% sand (indicated in orange in Figure 3.7). Alternatively, a cut off could be established such as the sloped black line in Figure 3.7. It may be useful to carry out future research with additional data to develop such a rule.

The selection criterion reduces variability associated with TOC and particle size. For post-mining data, using only samples which meet the criterion is expected to be a conservative approach since samples with more than 80% sand and low TOC tend to have the smallest parameter concentration.

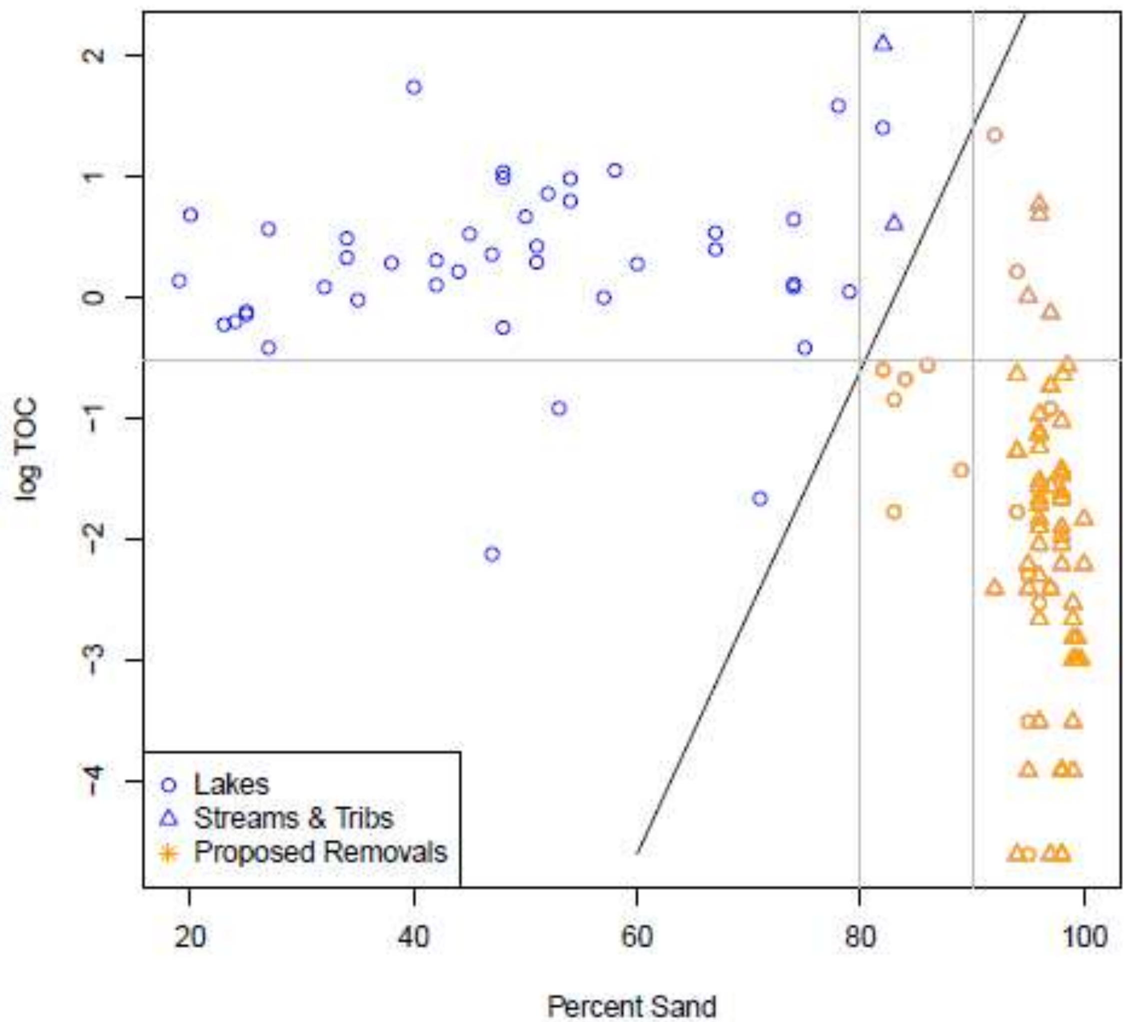


Figure 3.7 Results of Cut Point Analysis for Sediment

Environment Canada (2012) recommends that normalized metal concentrations be used to account for the effects of particle size and organic carbon. This method was considered, but it was found that the best way to minimize the relationship to organic carbon and fines involved creating data cut-offs. Additionally, normalized metals concentrations do not reflect the actual toxicity exposure in the environment.

Cut-off points have been identified for TOC and % sand based on metals accumulation in sediment in the baseline lake sediment samples. Baseline sediment samples with a TOC ≥0.6% and a minimum of 20% fines (or less than 80% sand) have been used for the development of the benchmarks and to calculate mean baseline concentrations (for "before" comparisons). Sediment samples with TOC <0.6% or with >80% sand (<20% fines) have not been included in the calculation of benchmarks, baseline means, and a priori power analyses. The same cut-off points will be applied to CREMP monitoring samples, with samples not meeting these cut-off points being excluded from exploratory and statistical analysis during monitoring.

3.5.3 Overview of Lake Sediment Results

Lakes are depositional environments that receive sediment inputs from airborne dust and surface runoff from adjacent shorelines as well as material transported into the lakes from upland areas due to seasonal stream inflows. Concentrations of metals in sediment are greatly influenced by the presence of organic carbon and/or fine sediment particle size in the substrate as described above. Substrate in depositional areas of the lake characterized by higher organic carbon content and/or higher fine sediment particle sizes are well suited for long-term monitoring since:

- These areas tend to accumulate metals due to the substrate characteristics and are therefore expected to be the most consistent with respect to elevated metals as well as the most sensitive to change (increasing accumulation of metals)
- The baseline data between lakes was similar

Each of the mine area lakes (Camp, Mary, Sheardown) showed considerable similarities in metals concentrations in sediment as well as the observed trends regarding metals accumulation at stations with high TOC and higher fines substrates. The variability in substrates that are predominantly sand and their limited TOC concentrations were also evident.

3.5.4 Overview of Stream Sediment Results

Concentrations of metals in sediments were generally highly variable within the streams, which tend to be higher energy environments with limited depositional areas. As such, these environments provide limited amounts of sediment quality data. Two sampling stations on Sheardown Lake (Tributary 1 D1-10 and D1-05) are depositional areas that show slightly higher fine sediments and elevated concentrations of cadmium, chromium, copper, iron, nickel, lead and zinc. These concentrations were above the applicable sediment quality guidelines.

Select near-field stream sediment sampling stations will continue to be monitored as described below:

- Sediment stations within Sheardown Tributary 1 that meet the TOC and % sand cut-offs will be monitored following the lake sediment monitoring program
- All other retained stream sediment stations will be monitored for comparison against previous results. These stations will be evaluated, but the higher energy, non-depositional environment may not be useful for a statistical comparison against CSQG-PAL and AEMP benchmarks. The results may support conclusions of lake samples or may trigger action using a different protocol.

3.6 SEDIMENT QUALITY CREMP STUDY DESIGN

Sediments are frequently part of environmental monitoring programs due to their importance in aquatic ecosystems. Sediments originate from particulates and precipitates that are generated from chemical and biological processes within aquatic systems. The determination of total metal concentrations in sediments is not required as part of the EEM program; however, mines are encouraged to determine total metal concentrations in sediments when completing benthic invertebrate community surveys (Environment Canada, 2012). For EEM monitoring programs where benthic invertebrate sampling is conducted in erosional habitat (e.g., streams), sediment sampling may not be possible and would not be reported. The spring freshet near the mine typically flushes fine grained sediment downstream into depositional areas (e.g., lakes). A summary of the existing baseline sediment data is provided below, in addition to the sampling plan.

The baseline sediment quality monitoring program results from the stream and lake environments surrounding the Project site show naturally elevated concentrations above the CSQG-PAL ISQGs or PSQG-LEL criteria for parameters of concern such as chromium, copper, iron, manganese and nickel (Section 3.5 and Appendix D). Iron and manganese concentrations were also occasionally above Ontario's severe effect levels in the lake environments.

The relationship between fine grained sediments and the accumulation of the parameters of concern suggests that the sediment monitoring program will focus on the depositional lake environments, since they are the end receiver of stream sediments. The proposed assessment protocol of establishing a change will be applied to lake sediment monitoring stations. Limited stream sampling will be undertaken in the Mary River and main tributaries of Camp Lake and Sheardown Lake, and the results compared to benchmarks.

3.6.1 Pathways of Effect and Key Questions

Key questions were developed for the CREMP to guide the review of baseline data adequacy and, ultimately, design of the monitoring program. These questions and metrics focus upon key potential effects identified in the Final Environmental Impact Statement (FEIS) and the Early Revenue Phase (ERP) addendum, as well as metrics commonly applied for characterizing water quality.

The key pathways of potential effects of the Project on sediment quality include:

- Sediment quality changes related to discharge of ore or stockpile runoff to freshwater systems (immediate receiving environments: Mary River and Camp Lake Tributary 1)
- Sediment quality changes (primarily nutrients and TSS) related to discharge of treated sewage effluent (immediate receiving environments: Mary River and Sheardown Lake NW)
- Sediment quality changes due to direct deposition of dust in lakes and streams (Mine Area in zone of dust deposition)
- Sediment quality changes due to dust deposition on land and subsequent runoff into lakes and streams (Mine Area in zone of dust deposition)

The key question related to the pathways of effect is:

- What is the estimated mine-related change in contaminant concentrations in the exposed area?

The primary issue of concern with respect to sediment quality is related to the effect of ore dust containing elevated metals being deposited on or running off into lakes and streams. As such, the CREMP and the baseline data review focused upon waterbodies that are closest to the sources of ore dust. Sheardown Lake and its tributaries, Camp Lake and its closest tributaries, as well as the Mary River and the north arm of Mary Lake are located within the zone of influence for ore dust deposition and non-point sources of fugitive dust (i.e., road dust). The main basin of Mary Lake receives sediment loading from the Mary River.

3.6.2 Parameters and Metrics

Sediment quality parameters identified for monitoring include various physical parameters, metals and nutrients. They were selected on the basis of the following:

- The potential to be naturally elevated in the environment
- The potential to become elevated in the environment as a result of future mine site activities
- An established criterion exists for the protection of freshwater aquatic life
- Regulation under the MMER, or potential regulation as a result of the current re-evaluation of the regulations
- The parameter affects the attenuation of metals (i.e., particle size and total organic carbon)

The contaminants of potential concern and supporting parameters are listed in Table 3.5. Those SOPCs with local enrichment are noted in the table.

Table 3.5 Sediment Quality Parameters Selected for Monitoring

Contaminants of Potential Concern	Exploratory Data Analysis Only
Arsenic	Moisture content
Cadmium	Particle Size
Chromium *	Total Organic Carbon (TOC)
Copper *	Nitrite
Iron *	Nitrate
Lead	Total Kjeldahl Nitrogen
Manganese *	
Mercury	
Nickel *	
Phosphorus *	
Zinc	

3.6.3 Benchmarks

Since the mine site occurs within an area of metals enrichment, generic sediment quality guidelines established for all areas within Canada may naturally be exceeded near the mine site. Therefore, the selection of appropriate benchmarks must consider established sediment quality guidelines, such as those developed by the Canadian Council of Ministers of the Environment (CCME) and the Ontario Ministry of the Environment (MOE), as well as site-specific natural enrichment in the selection or development of final benchmarks for monitoring data comparison (CCME, 2007).

Intrinsik Environmental Sciences Inc. was retained by Baffinland to develop water and sediment quality benchmarks to be applied in the CREMP (Intrinsik, 2014; see Appendix F of the AEMP). The sediment quality data utilized in benchmark development met the TOC and % sand cut-off points described in Section 3.5.2. The development of sediment quality benchmarks follows the same process identified for the water quality benchmarks (Section 2.7.3), considering the higher of the generic sediment quality objective (i.e., CCME or other jurisdiction) or the 97.5th percentile of baseline concentrations. For parameters that are mostly below MDL (less than 5% detected values), either the generic sediment quality guideline was selected (if available), or 3 * MDL was adopted as the benchmark, as follows:

Method A: Sediment Quality Guideline was higher than 97.5%ile, and therefore was selected

Method B: 97.5%ile was higher than the Sediment Quality Guideline, and therefore was selected

Method C: Parameter has < 5% detected values, and either the Sediment Quality Guideline was selected (if available), or 3 * MDL was used to derive benchmark

If Method B was selected, additional assessment of the data was conducted to ensure the percentile calculations were not being driven by elevated detection limits, or other factors.

Area-wide interim sediment quality benchmarks have been identified for mine site lakes and streams collectively (Table 3.6). Based on the available data, final sediment quality benchmarks cannot be selected at this time, as there are insufficient data within several of the lakes to adequately characterize baseline and confirm that area-wide benchmarks would not underestimate natural levels in several of the lakes (Camp Lake, Mary Lake, Tributaries of Sheardown Lake, and Sheardown Lake SE). Therefore, the area-wide interim benchmarks identified in Table 3.6 will be re-evaluated following additional sediment quality data collection in 2014.

In the case of mercury, lead and zinc, the selected benchmark is the generic sediment quality guideline, as area-wide data were less than or equal to this value. The selection of the generic guideline at this time for these substances appears reasonable. Further sediment characterization in area lakes in 2014 may result in changes to this decision. In the case of arsenic, chromium, copper, iron, manganese, nickel and phosphorus, the suggested area-wide Interim AEMP benchmark is the 97.5th percentile of baseline. The use of the area-wide percentiles as an interim benchmark appears reasonable, based on comparisons to both the existing guidelines, and characterization data for the lakes.

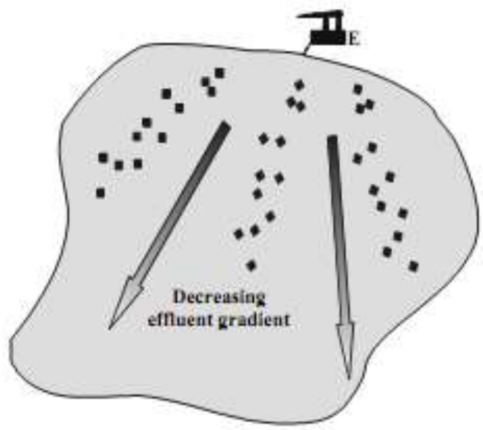
As discussed earlier, further data collection will assist in better understanding baseline within the lakes, and will assist in final benchmark development. With respect to the temporal analysis conducted for Sheardown Lake NW: chromium, copper, and nickel showed some increased trends over time in this basin (see Intrinsik, 2014; AEMP Appendix F). Based on the 97.5th percentile calculations presented in Table 3.6 for this basin, these trends are not considered to substantially influence the outcome of the recommended interim benchmark. This issue will be re-assessed with 2014 data, for final benchmark development. For cadmium, the data are largely non-detect, at an MDL of 0.5 mg/kg. The ISQG is 0.6 mg/kg, and due to the close proximity of the MDL to the ISQG, the 3 times MDL approach was applied for AEMP benchmark development.

As noted in Section 2.7.3 in regard to water quality benchmarks, the assessment of sediment quality data over the life of the project will be on-going, and the recommended benchmarks of comparison throughout this process may change, as more data become available. For example, a site-specific sediment quality guideline established early on in the life of the mine may require updating in 10 years, based on new published literature which has become available, or site-specific toxicity tests conducted to further understand ETMF or resident species toxicity. The iterative, cyclical nature of modification of benchmarks under an AEMP is well established (MacDonald et al., 2009).

3.6.4 Monitoring Area and Sampling Stations

The monitoring area for sediment quality includes mine area lakes, specifically Camp Lake, Sheardown Lake NW and SE; selected tributaries of each lake; Mary Lake; and the Mary River.

Environment Canada (2012) recommends a Control-Impact (CI) or Gradient Sample design for detection of effects in the lake environment benthic invertebrate community (Figure 3.8). A gradient sample design has been defined for the CREMP lake sediment stations that is integrated with benthic invertebrate sampling and utilizes existing sediment sampling locations that meet the cut-off criteria (Section 3.5.2).



c) Radial gradient design for lake or coastal situations

Figure 3.8 Gradient Sampling Design to Lake Sediment Monitoring

Preliminary sediment sampling locations in each of Camp Lake, Sheardown Lake and Camp Lake are shown on Figures 3.9, 3.10 and 3.11, respectively, and are listed in Table 3.7. The lake sediment stations make use of existing and new (proposed) stations as follows:

- Camp Lake - 14 stations including three historic stations and 11 new stations
- Sheardown Lake NW - 14 stations including six historic stations and eight new stations
- Sheardown Lake SE - 10 stations including four historic stations and six new stations
- Mary Lake - 15 stations including five historic stations and 10 new stations

Lake sediment samples will be collected along transects positioned along the anticipated path of effluent (i.e., direction of inflow stream). At each station, field technicians will establish final locations for the sediment stations that are within depositional areas of the lake. This field fit of the sampling stations will likely result in some modifications to the gradient study design.

Limited stream sediment sampling is proposed for the reasons described in Section 3.5. Select existing stream sediment sampling stations will continue to be monitored as described below (see Figures 3.9, 3.10 and 3.11):

- Four sediment stations within Sheardown Tributary 1 (SDLT-1), a portion of which meet the TOC and % sand cut-offs (SDLT1-R1, D1-01, D1-05, and SDLT1-R4)
- One sediment station in each of Sheardown Tributaries 9, 12 and 13 (SDLT-9-US, SDLT-12-US, SDLT-12-DS), none of which meet the TOC and % sand cut-offs

- Three sediment stations within Camp Lake Tributaries 1 and 2 (CLT-1 and CLT-2) which do not meet the TOC and % sand cut-offs but are the lowest energy stations available (CLT-1 US, CLT-1-DS, CLT-2-DS)
- Two sediment stations on the Mary River, downstream of effluent discharges where sediment collection is possible (E0-20 and C0-05)

At least two sediment quality stations on SDLT-1 are located in depositional environments and the review has identified metals accumulation exceeding generic sediment quality guidelines. It is expected that the AEMP assessment and response framework (Section 3.6.8) can be applied to monitoring data from these stations to identify statistical change. All other retained stream sediment stations will be monitored for comparison against previous results. Stream sediment stations will be evaluated and compared to benchmarks, but statistical comparison to baseline will not be possible. The stream sediment sampling results may support conclusions of lake samples or may trigger action based on a qualitative review of the monitoring data.

3.6.5 Sampling Frequency and Schedule

Sediment quality monitoring will be conducted once each monitoring year in the fall to coincide with benthic invertebrate sampling to be conducted as part of the freshwater biota CREMP (AEMP Appendix C).

As outlined in Schedule 5, Part 2 of the MMER, biological monitoring studies are to be conducted on a three year cycle until two consecutive biological monitoring studies indicate no effect on fish populations, on fish tissue and on the benthic invertebrate community. In the long-term, sediment sampling under the CREMP will be conducted every three years, coinciding with biological monitoring studies. However, to be cautious initially, Baffinland will conduct sediment sampling in 2014 to collect additional pre-mining baseline data, and then annually for the first three years of mining. After monitoring three operating (mining) years, the sampling frequency will be re-assessed with the expectation of conducting the monitoring program on a three year cycle provided annual sampling up to that time supports this change.

3.6.6 Quality Assurance/Quality Control

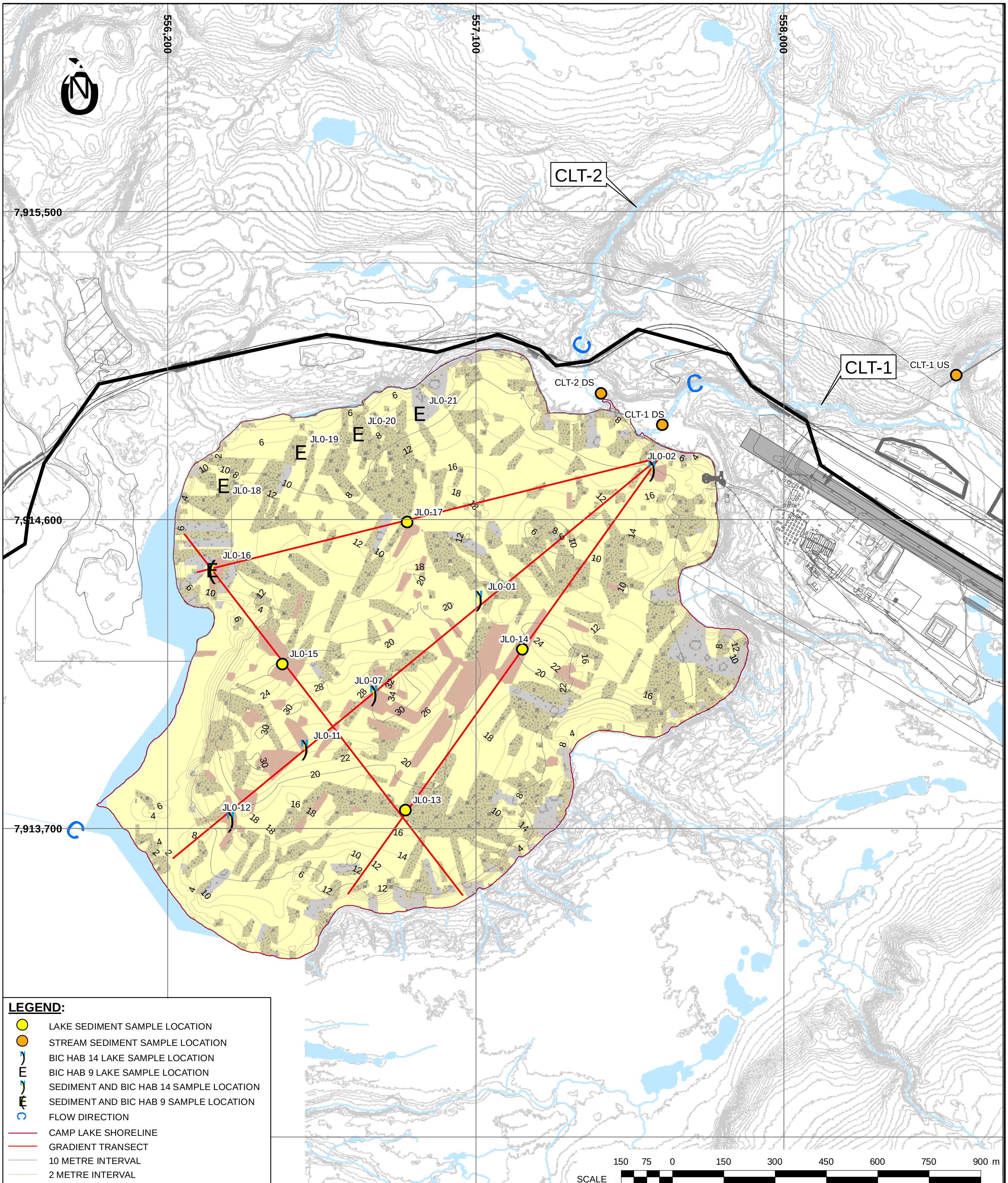
The same QA/QC program described in Section 2.6.6 will be applied to sediment quality monitoring. The field sampling protocols being applied to the sediment (and water) quality programs are presented in Appendix A.

Table 3.6 Selected Benchmark Approach and Interim Area-Wide Sediment Quality Benchmarks

Jurisdiction, Type of Guideline and Statistical Metric		Hg	As	Cd	Cr	Cu	Fe	Mn	Ni	P	Pb	Zn
CCME CSQG	**ISQG**	0.17	5.9	0.6	37.3	35.7	NGA	NGA	NGA	NGA	35	123
	PEL	0.486	17	3.5	90	197	NGA	NGA	NGA	NGA	91.3	315
Ontario PSQG	**LEL**	0.2	6	0.6	26	16	20,000	460	16	600	31	120
	SEL	2	33	10	110	110	40,000	1100	75	2,000	250	820
US EPA Sediment Quality Guidelines	**Screening**	0.18	9.8	0.99	43.4	31.6	20,000	460	22	NGA	35.8	121
97.5th Percentiles of Each Lake Area (sample size)												
Tributaries of Sheardown Lake (5)		0.1	2.95	1.9	118	106	28,370	809	115	295	52	171
Mary Lake (6)		0.1	4.95	0.5	97	38	51,463	4,305	61	1,580	28	103
Camp Lake (9)		0.1	4	0.5	83	50	40,920	1,057	74	1,480	23	69
Sheardown Lake NW (25)		0.1	7.95	0.5	96	60	56,240	5,612	81	2,310	24	92
Sheardown Lake SE (6)		0.1	2.0	0.9	80	32	32,988	547	66	1,278	18	57
95th %ile of Area-Wide Data (47)[2]		NC	5.2	0.5	93	56	50,430	3,874	76	1,565	24	91
97.5th %ile of Area-Wide Data (47)[2]		NC	6.2	0.5	97	58	52,200	4,530	77	1,958	24	94
Proposed Interim Area-Wide Benchmark		**0.17**	**6.2**	**1.5**	**97**	**58**	**52,200**	**4,530**	**77**	**1,958**	**35**	**123**
Benchmark Method		A	B	C	B	B	B	B	B	B	A	A

NOTES:

1. SHADED CELLS HAVE CONCENTRATIONS HIGHER THAN THE ISQG OR LEL; NC = NOT CALCULATED AS ALL VALUES < MDL.
2. TRIBUTARIES OF SHEARDOWN LAKE DATA ARE NOT INCLUDED DUE TO ELEVATED RESULTS IN THIS AREA.
3. GUIDELINE IS BASED ON SEDIMENT QUALITY GUIDELINE.
4. GUIDELINE IS BASED ON 97.5TH %ILE OF BASELINE DATA.
5. GUIDELINE IS BASED ON 3 TIMES MDL, THE 97.5TH %ILE IS EQUAL TO THE MDL.
6. MERCURY WAS NOT DETECTED IN ANY SAMPLES; MERCURY DETECTION LIMIT IS USED TO REPRESENT THE 95TH AND 97.5TH PERCENTILES.



LEGEND:

- LAKE SEDIMENT SAMPLE LOCATION
- STREAM SEDIMENT SAMPLE LOCATION
- BIC HAB 14 LAKE SAMPLE LOCATION
- BIC HAB 9 LAKE SAMPLE LOCATION
- SEDIMENT AND BIC HAB 14 SAMPLE LOCATION
- SEDIMENT AND BIC HAB 9 SAMPLE LOCATION
- FLOW DIRECTION
- CAMP LAKE SHORELINE
- GRADIENT TRANSECT
- 10 METRE INTERVAL
- 2 METRE INTERVAL
- EXISTING TOTE ROAD
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

CAMP LAKE PROPOSED SEDIMENT LOCATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 3.9 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
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0	DDMMM'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM

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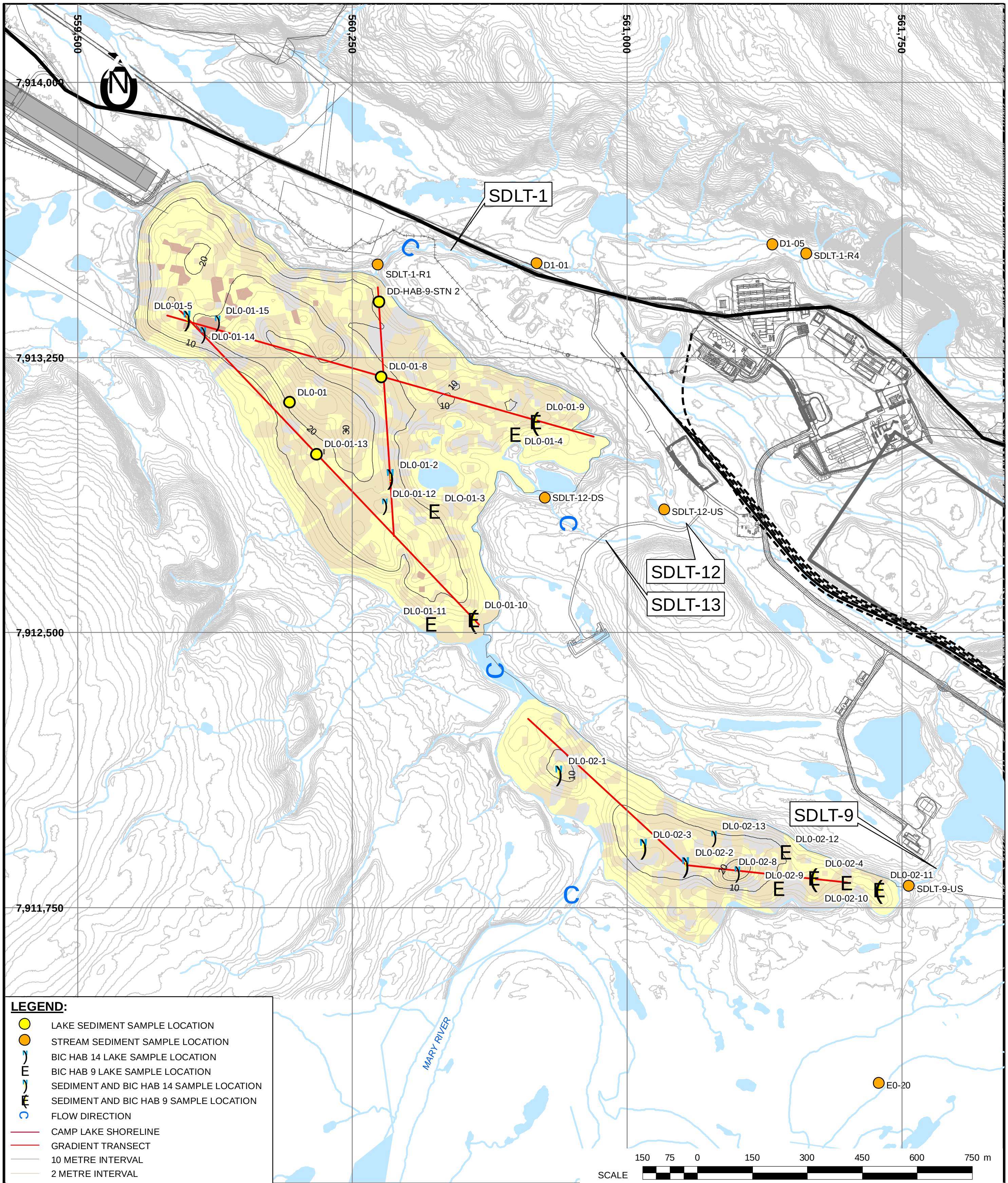

LEGEND:

- LAKE SEDIMENT SAMPLE LOCATION
- STREAM SEDIMENT SAMPLE LOCATION
- BIC HAB 14 LAKE SAMPLE LOCATION
- BIC HAB 9 LAKE SAMPLE LOCATION
- SEDIMENT AND BIC HAB 14 SAMPLE LOCATION
- SEDIMENT AND BIC HAB 9 SAMPLE LOCATION
- FLOW DIRECTION
- CAMP LAKE SHORELINE
- GRADIENT TRANSECT
- 10 METRE INTERVAL
- 2 METRE INTERVAL
- EXISTING TOTE ROAD
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

SHEARDOWN LAKE SEDIMENT LOCATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE 3.10 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
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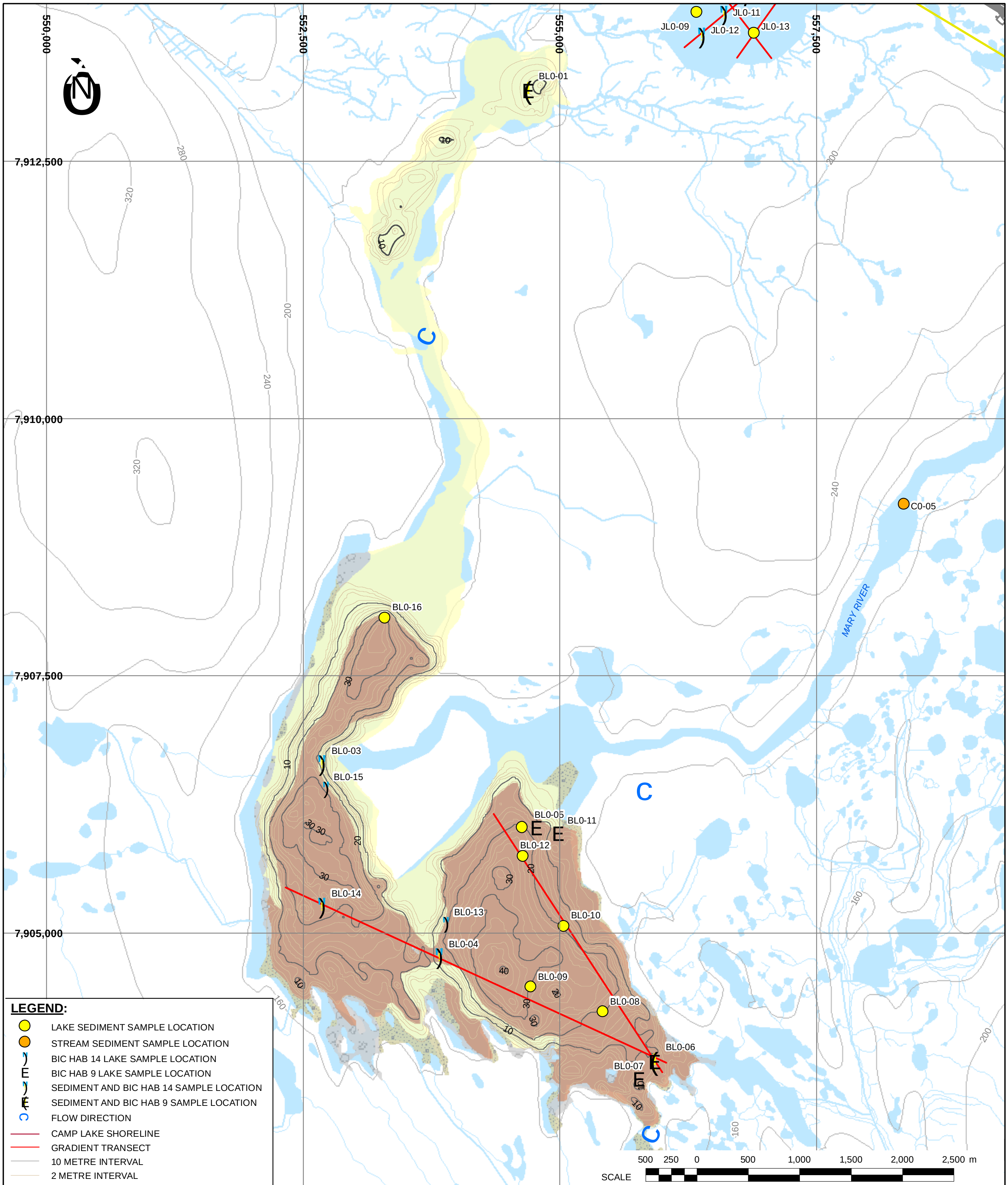

LEGEND:

- LAKE SEDIMENT SAMPLE LOCATION
- STREAM SEDIMENT SAMPLE LOCATION
- BIC HAB 14 LAKE SAMPLE LOCATION
- BIC HAB 9 LAKE SAMPLE LOCATION
- SEDIMENT AND BIC HAB 14 SAMPLE LOCATION
- SEDIMENT AND BIC HAB 9 SAMPLE LOCATION
- FLOW DIRECTION
- CAMP LAKE SHORELINE
- GRADIENT TRANSECT
- 10 METRE INTERVAL
- 2 METRE INTERVAL
- EXISTING TOTE ROAD
- PROPOSED INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- WATER
- COBBLE/BOULDER
- FINE SAND/SILT/CLAY
- GRAVEL/PEBBLE
- SAND
- PROPOSED INFRASTRUCTURE

NOTES:

1. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
2. CONTOUR INTERVAL IS 30 CENTIMETRES.
3. SUBSTRATE AND BATHYMETRY DATA PROVIDED BY NORTH/SOUTH CONSULTANTS INC., NOVEMBER 28, 2013.
4. DEPTHS OF BATHYMETRIC CONTOURS ARE IN METRES AND ARE RELATIVE TO SHORELINE AT TIME OF SURVEY.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

MARY LAKE SEDIMENT LOCATIONS

Knight Piésold CONSULTING

P/A NO. NB102-181/33 | REF NO. 1

FIGURE 3.11 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
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0	27MAR'14	ISSUED WITH REPORT	DKK	SWK	RAC	RAM

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Table 3.7 Sediment Quality CREMP Stations Details

Station ID	Easting	Northing	Sediment	BIC Habitat 9	BIC Habitat 14	Description/Rationale
	NAD 83, Zone 17N					
Mary Lake (North Basin)						
BL0-01	554690	7913194	X	X		North basin receiving water from Camp Lake
Mary Lake (South Basin)						
BL0-03	552680	7906651	X		X	Main basin receiving water from north basin
BL0-04	553817	7904886	X		X	Main basin receiving water from north basin
BL0-05	554632	7906031		X		Main basin near outlet of Mary River
BL0-06	555924	7903760	X	X		Main basin near outlet of Mary River
BL0-07	555774	7903588		X		Main basin near outlet of Mary River
BL0-08	555420	7904237	X			Main basin between BL0-05 and BL0-06
BL0-09	554715	7904479	X			Main basin between BL0-05 and BL0-06
BL0-10	555038	7905069	X			Main basin between BL0-05 and BL0-06
BL0-11	554987	7905976		X		Main basin near outlet of Mary River
BL0-12	554641	7905752	X			Main basin near outlet of Mary River
BL0-13	553887	7905092			X	Main basin receiving water from north basin
BL0-14	552679	7905263	X		X	Main basin receiving water from north basin
BL0-15	552716	7906412			X	Main basin receiving water from north basin
BL0-16	553295	7908068	X			Main basin receiving water from north basin
Mary River (D/S of SDL)						
C0-01	556305	7906894	X			Mainstem, before outflow into Mary Lake
C0-05	558352	7909170	X			Mainstem, d/s of mine
SDL-Tributaries						
D1-01	560753	7913507	X			Tributary SDLT-1
D1-05	561397	7913558	X			
SDLT-1-R1	560320	7913504	X			
SDLT-1-R4	561490	7913533	X			
SDLT-9-US	561770	7911810	X			Tributary SDLT-9
SDLT-12-DS	560776	7912867	X			Tributary SDLT-12
Sheardown Lake NW						
DD-Hab 9-Stn 2	560323	7913402	X			Nearshore station
DL0-01	560079	7913128	X			Mid-lake position
DL0-01-2	560353	7912924	X		X	Mid-lake position
DL0-01-3	560474	7912833		X		Southeastern region
DL0-01-4	560695	7913043		X		Eastern region, near SDLT-9 inflow stream
DL0-01-5	559798	7913356	X		X	Near treated wastewater discharge location
DL0-01-8	560329	7913197	X			Mid-lake position
DL0-01-9	560750	7913077	X	X		Eastern region, near SDLT-9 inflow stream
DL0-01-10	560580	7912537	X	X		Near outlet channel to Southeast Basin
DL0-01-11	560464	7912525		X		Near outlet channel to Southeast Basin
DL0-01-12	560337	7912848			X	Mid-lake position
DL0-01-13	560152	7912986	X			Mid-lake position
DL0-01-14	559842	7913316			X	Near treated wastewater discharge location
DL0-01-15	559881	7913347			X	Near treated wastewater discharge location

Station ID	Easting	Northing	Sediment	BIC Habitat 9	BIC Habitat 14	Description/Rationale
	NAD 83, Zone 17N					
Sheardown Lake SE						
DL0-02-1	560813	7912116	X		X	Near inlet channel from Northwest Basin
DL0-02-2	561160	7911866	X		X	Mid-lake position
DL0-02-3	561046	7911915	X		X	Mid-lake position
DL0-02-4	561511	7911832	X	X		Eastern region
DL0-02-8	561301	7911846			X	Mid-lake position
DL0-02-9	561414	7911804		X		Eastern region
DL0-02-10	561600	7911819		X		Eastern region near SDLT-9 stream inflow
DL0-02-11	561688	7911801	X	X		Eastern region near SDLT-9 stream inflow
DL0-02-12	561434	7911904		X		Eastern region
DL0-02-13	561237	7911943			X	Mid-lake position
Mary River (US of SDL)						
E0-20	561688	7911272	X			Near EEM near field exposure area
Camp Lake						
JL0-01	557107	7914369	X		X	On gradient transect between CLT-1 and lake outlet
JL0-02	557614	7914750	X		X	
JL0-07	556800	7914094	X		X	
JL0-11	556598	7913935	X		X	
JL0-12	556382	7913724	X		X	
JL0-13	556894	7913752	X			Southern region
JL0-14	557235	7914222	X			Mid-lake position
JL0-15	556534	7914179	X			Eastern region
JL0-16	556329	7914456	X	X		Near northwest shoreline
JL0-17	556899	7914593	X			Northern region
JL0-18	556361	7914702		X		Along the northwest shoreline
JL0-19	556588	7914800		X		Along the northwest shoreline
JL0-20	556755	7914854		X		Along the northwest shoreline
JL0-21	556935	7914913		X		Along the northwest shoreline
Camp Lake Tributaries						
CLT-1 DS	557645	7914878	X			Lower reach of CLT-1 near lake outlet
CLT-1-US	558504	7915022	X			Upstream of CLT-1 near natural fish barrier
CLT-2 DS	557466	7914969	X			Lower reach of CLT-2 near lake outlet
Reference Lakes						
TBD						
Duplicates			**5**	**-**	**-**	
TOTAL			**50**	**20**	**20**	

NOTES:

1. STATION LOCATIONS PROPOSED BASED ON AVAILABLE SUBSTRATE AND WATER DEPTH DATA, SUBJECT TO CHANGE FOLLOWING IN-SITU FIELD CONFIRMATION OF CONDITIONS.

3.6.7 Study Design and Data Analysis

The purpose of sediment quality monitoring is to answer the same question posed in regard to water quality:

"What is the estimated mine-related change in contaminant concentrations in the exposed area?"

To answer this question, the study has been designed to test the following three hypotheses:

Null hypothesis: Change over time is the same for exposure and reference stations. Alternate hypothesis: Data from exposure stations is statistically different from data measured at reference stations.

Null hypothesis: Difference between exposure and reference stations is due to natural environmental variation. Alternate hypothesis: Difference in exposure and reference station is due to mine effects.

Null hypothesis: Magnitude of concentrations at the exposure station does not exceed the benchmark. Alternate hypothesis: Magnitude of concentrations at the exposure station exceeds the benchmark.

The sediment quality CREMP monitoring program will focus on sediment in lakes, since the depositional characteristics found within the lakes is the final sink for natural and project-related contributions to sediment load.

Environment Canada (2012) recommends a Control-Impact (CI) or Gradient Sample design for detection of effects in the lake environment benthic invertebrate community (Figure 3.8). A gradient sample design has been defined for the CREMP lake sediment stations that is integrated with benthic invertebrate sampling and utilizes existing sediment sampling locations that meet the cut-off criteria (Section 3.5.2). Sediment samples will be collected mainly along lake transects. Transects have been positioned along the anticipated path of effluent (i.e., direction of inflow stream). Preliminary sediment sample locations are presented on Figures 3.9, 3.10 and 3.11, and are discussed in Section 3.6.4.

Candidate reference lakes have been identified for application to the AEMP. Being located outside of the mine area, the reference lakes are expected to be unaffected by local mineralization to the extent that the mine site lakes are. Therefore, a control-impact approach to monitoring change in the mine site lakes may have limited utility in detecting Project-related changes to sediment quality.

With the exception of Sheardown Lake NW, the baseline dataset for sediment quality at the mine area is relatively limited. Additional baseline (pre-mining) sediment quality data will be collected in 2014 to supplement the baseline dataset. Nonetheless, a before-after comparison of monitoring data to baseline data will be carried out to the extent that the dataset allows.

In addition, the gradient design selected for lake sediment quality will allow for an assessment of the spatial extent of mine impacts. Since effluent discharges are fixed and dust deposition can be expected to occur in a gradient, it is expected that concentrations will decrease as the distance from the mine increases In the absence of appropriate control data, it may be necessary to use the exposure data alone to assess mine effects. Mining effects could be observed in several ways:

Before-After: concentrations increase over time at a given station

Gradient effect: concentrations increase with increasing proximity to the mine

Gradient effect changes over time: concentrations are stable across the gradient during baseline but increase with increasing proximity to the mine after mining commences. That is, concentrations increase over time at stations close to the mine but remain relatively stable at far field stations (i.e., the slope of the gradient effect increases over time).

In addition, because there is a relationship between sediment SOPCs, increases in multiple parameters can be used in a weight of evidence to identify project-related changes.

3.6.8 Assessment Framework

Monitoring data will be assessed during each year of monitoring and would follow the assessment framework as outlined in Figure 2.12 and described below. The assessment framework for sediment quality monitoring closely mirrors that described for water quality in Section 2.6.8, with minor differences.

3.6.8.1 Step 1: Initial Data Analysis

Initial data analysis will involve following specific data management and monitoring protocols in the handling and initial comparison of data.

Data Input and Storage

Following data collection, and upon receipt of the laboratory reports, data will be entered into the Project EQWin® database.

Initial Data Analysis including Outlier Assessment

The initial data analysis will include a number of possible steps, such as the following:

- Completion of summary statistics (average, median, maximum, minimum, quartiles)
- Flagging of lake and stream sediment samples that do not meet the TOC and % sand cut-off values
- Flagging of values greater than the defined benchmark values
- Flagging of values at or exceeding the mid-point between the baseline mean and the benchmark
- Evaluating temporal changes in the data by season

The initial data analysis will include an outlier assessment after data entry and the completion of quality assurance and quality control steps. An outlier assessment is completed after each round of sampling to ensure data anomalies are identified early. If necessary, the laboratory can be contacted to re-analyze samples. Any identified outliers will be investigated to ensure no data integrity issue exists. For example, duplicate samples will be assessed along with any holding time exceedances. If no evidence exists to discard data, then the data will remain in the dataset but be flagged for future consideration.

3.6.8.2 Step 2: Determine if Change is Mine Related

Step 2 involves determining if the changes in sediment quality parameters of concern are due to the Project or due to natural variability or other causes. This question will be addressed using exploratory data analysis (EDA) and subsequently using statistical data analysis (SDA), as described below.

Prior to conducting EDA and SDA, Project activities with the potential to alter sediment quality will be reviewed to identify potential Project-related causes or sources. This could include evaluating effluent quality, discharge regime/rates, and loading, dust deposition, and other point/non-point sources as required. Also, any evidence of potential natural causes (i.e., a major erosional event such as a slumping riverbank) will be investigated. Sampling data sheets and site personnel will be a source of this information.

Exploratory Data Analysis

Exploratory data analysis (EDA) will be completed to visualize overall data trends. This could include evaluating spatial patterns in sediment quality results for the mine area as a whole, including mine area lakes and streams, to evaluate if changes are widespread or specific to certain waterbodies, or proximate to mine-related sources, and to identify the spatial extent and pattern of observed changes.

Data from Mine Area lakes will be compared to data from Mine Area streams to reference streams and potentially to reference lake(s) and stream(s). This will further assist with determining whether the observed changes were due to natural variability or the Project.

These graphical analyses will also confirm assumptions required for statistical testing (normality, sample size, independence). Results of the EDA will be used in tandem with the SDA to confirm the observed statistical trends and can be used to evaluate the potential for biologically relevant change.

Statistical Data Analysis

Primary SDA will be completed using methodology consistent with the before-after design used for the power analysis. This will be used to assess the potential magnitude of change during post-mining. This step in the analysis tests the primary hypothesis for the effects of mine-related change and can be applied to the parameters of interest.

If the Step 2 analysis concludes that the changes in sediment quality parameters of concern are, or are likely, due to the Project, the assessment will proceed to Step 3. If it is concluded the observed differences relative to baseline conditions are not due to the Project, no management response will be required.

3.6.8.3 Step 3: Determine Action Level

Once EDA and primary SDA has indicated with some certainly that the measured change is project-related, Step 3 involves determination of the action level associated with the observed monitoring results through comparisons to the benchmark.

If the benchmark is not exceeded, a **low action response** would be undertaken and would include:

- Evaluate temporal trends
- Identify likely source(s) and potential for continued contributions
- Confirm the site-specific relevance of benchmark and establish a site-specific benchmark, if necessary
- Based on evaluations, determine next steps

If the benchmark is exceeded and it is concluded to be due to, or likely due to, the Project, a **moderate action level response** would be undertaken and would include, in addition to analyses identified in for a low action response, the following:

- Consider a weight-of-evidence (WOE) evaluation and/or risk assessment, considering other monitoring results collectively with sediment quality to evaluate effects on the ecosystem

- Evaluate the need for and specifics of increased monitoring
- Evaluate the need for additional monitoring (e.g., confirmation monitoring) and/or modifications to the CREMP
- Consider results of the trend analysis (i.e., trend analysis indicates an upward trend) and evaluation of potential pathways of effect (i.e., causes of observed changes) to determine if management/mitigation is required
- Identify next steps based on the above analyses. Next steps may include those identified for the high action level response.

A quantitative trigger for the **high action level response** has not been identified as the need for additional study and/or mitigation will depend on the ultimate effects of the observed increases in sediment quality parameters of concern on the lakes as a whole, as well as the monitoring results from the freshwater biota CREMP. Also, the benchmark may need to be revised in consideration of ongoing monitoring results. The precise relationships between water quality, sediment quality and lower trophic level changes and the collective effects on fish is difficult to predict and therefore actions undertaken under Level 2 will attempt to explore these relationships to advise on overall effects to the ecosystem. Results would be discussed with regulatory agencies and the next steps would be identified. Additional actions that may be implemented in a subsequent phase (i.e., high action level response) include:

- Implementation of increased monitoring to confirm effects and/or define magnitude and spatial extent of effects if warranted
- Implementation of mitigation measures or other management actions that may be identified under the moderate action level response

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5 – CERTIFICATION

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