Table 2-2: Effluent discharge volumes (total annual and mean rate) siphoned from Garrow Lake since dam installation, 1994 - 2003.

Year	Discharge Duration	# Days	Total Annual Discharge (m^3)	Mean Discharge Rate (m^3/s)
1994	July 12 - Sept 13	63	1,034,136	0.19
1995	July 12 - Sept 12	60	2,862,470	0.55
1996	July 22 - Oct 7	78	2,652,081	0.39
1997	July 21 - Oct 7	79	3,256,677	0.48
1998	July 2 - Aug 25	55	2,165,671	0.46
1999	July 13 - Sept 30	80	2,446,242	0.35
2000	July 20 - Sept 30	72	4,262,427	0.68
2001	July 24 - Sept 25	63	2,955,954	0.54
2002	July 26 - Oct 3	69	5,048,667	0.85
2003*	Late July - Late Sept	60	6,500,000	1.25

* Projected flow from predication based on drawdown of lake volume

Table 2-3: Comparison of metals concentrations in water (a), sediment (b) and clam tissue (c) from Garrow Bay, pre- and post-mining.

a) Historic metals concentrations (ug/L) in surface waters from Garrow Bay and nearby waters.

		AXYS (1991)				Gartner Lee (2001)		
	Ambient Water	Garrow Bay		Reference		Garrow	Polaris	Crozier Strait
Metal	Guideline	May	Sept	May	Sept	May	May	April
Cadmium	0.12*	0.043	0.016	0.043	0.021	<0.1	<0.1	0.07
Copper	3**	0.245	0.205	0.195	0.234	<1	<1	0.26
Lead	2**	<0.015	<0.02	<0.015	<0.02	0.53	0.24	0.83
Zinc	86**	0.185	0.071	0.164	0.100	<1	<1	6

* CCME (1999) guideline
** BCE (1998) guideline
Nearly all metals are in dissolved fraction

Table 2-3. Continued.

b) Historic metals concentrations (ug/g dw) in surface sediment from Garrow Bay.

			Pre - Mine Development			Post - Mine Development			
	CCME (1999)		Fallis (1984)*	Thomas & Erickson (1983)	BC Research (1978, 1981)	BC Research (1988)	AXYS (1991)		Gartner Lee (2001)
Metal	**ISQG**	**PEL**	**Garrow Bay**			**Garrow**	**Garrow**	**Reference**	**Garrow**
Cadmium	0.7	4.2	0.10 - 0.20	0.22 - 0.27	0.20 - 0.35	<2	0.19 - 0.30	0.15	0.15
Copper	18.7	108	8.9 - 12.3	-	7.0 - 14.2		10.8 - 16.0	9	9
Lead	30.2	112	7.0 - 11.6	6.2 - 7.2	6.0 - 6.7	4.6 - 7.6	3.8 - 4.5	2.9	7.5
Zinc	124	271	29 - 38	42 - 45	21 - 45	32 - 41	30 - 37	25 - 29	38

* 1981 Data

Table 2-3. Continued.

c) Historic metals concentrations (ug/g ww) in clams (*Mya* sp.) from Garrow Bay.

	Pre - Mine Development		Post - Mine Development		
	Fallis (1984)*	BC Research (1978)^	AXYS (1991)^		Gartner Lee (2001)^
Metal	**Garrow Bay**	**Garrow Bay**	**Garrow Bay**	**Reference**	**Garrow Bay**
Cadmium	0.25	0.49	1	0.75	0.75
Copper	-	-	1.67	1.17	0.93
Lead	0.14	0.19	0.05	0.14	<0.1
Zinc	9	16.6	14.8	24.2	21

* 1981 Data; converted to wet wt using 85% moisture; depurated clams

^ Non-depurated clams

3. FISH SURVEY AND TISSUE ANALYSIS

This section outlines our strategy for conducting a fish survey and fish tissue analyses at the Polaris Mine.

3.1. Overview and Site-Specific Considerations

As discussed in Section 2, there are a number of logistical challenges posed by this site by virtue of its remote location, harsh climate, and unpredictable ice conditions that will influence the study design. In addition, there are some ecological factors that require consideration:

- Based on historic information, it may be exceedingly difficult to collect the required number of fish (20 males and females) from Garrow Bay. Nevertheless, every reasonable attempt will be made to acquire as many sculpins as possible to satisfy the study design. Note that the final DFO Habitat Authorization now stipulates that "fish" should be collected from Garrow Bay and no longer specifically refers to "sculpin", in recognition of the absence or low abundance of this species.
- According to site-specific data, we believe that sampling of *Mya* clams will yield the most relevant information to determine if there are any effects to fish in Garrow Bay. Furthermore, there is a history of tissue data (Table 2-3) as recently as 1999. Note, however, that metal concentrations in clams in 1999 are the same as from pre-mining 1981 data (Gartner Lee, 2001).
- Sampling of fish is targeted for early to mid-August, to correspond with the greatest likelihood of encountering favorable oceanographic conditions for marine sampling. However, this time may not correspond with sexual maturity of target species. For instance, fourhorn sculpins probably spawn during winter, so timing of sampling of sculpins may be premature as they will not be in optimal spawning condition for EEM purposes. However, Environment Canada (2002) states "sampling when effluent is not being discharged for long periods of time should be avoided". This implies that diver-assisted sampling through the ice during spring should not be undertaken (i.e., since there has been no discharge for a period of at least eight months).
- It is not known when spawning by clams takes place in Garrow Bay. According to literature sources, spawning by *Mya* takes place in temperate waters once or twice per year between March and November. In Arctic waters, where resources are more limited, spawning probably only takes place once per year, most likely in summer and fall. Therefore, clam collection should be targeted during effluent discharge in August.

With respect to fish tissue analysis for mercury, this is only required if effluent concentrations of mercury exceed 0.10 µg/L. During routine (thrice annual) monitoring of Garrow Lake surface water metal concentrations between 1997 and 2003, mercury concentrations were below (<0.05 µg/L) the guideline concentration, except for winter sampling in 2001 (0.12 to 0.14 µg/L), which slightly exceeded the guideline. As part of routine effluent characterization that will be conducted as part of the EEM program for Polaris, mercury concentration in the discharge will be confirmed using a dedicated mercury laboratory (Flett Research, Winnipeg). Notwithstanding this, we propose to measure total metals in fish and clams as a tool to further characterize exposure in receiving environment biota.

3.2. Fish Species Selection

According to Environment Canada (2002), selection of fish species for monitoring purposes must be based on a number of criteria including exposure to effluent, relevance to the study area and sensitivity to effluent, with the objective of determining population level effects and usability of fish. Note that because of the remote location, fish or clam species are not known to have been used by humans as a food source, either domestically or otherwise.

As mentioned previously, we have chosen fourhorn sculpin and *Mya* clams as the candidate species for monitoring for the following reasons:

Fourhorn Sculpin	*Mya* Clams
Benthic dwelling, resident species in the bay	Benthic sessile species
Only recognized species from biological surveys of the bay	Filter feeding (overlying water and sediment) and exposed to effluent (if present)
The same species is found in Garrow Lake	Abundant and has widespread distribution throughout Garrow Bay
Historic metals data for sculpins in Garrow Bay	Relatively good historic data over an extended time period (1974 – 1999)
May be approaching sexual maturity at time of sampling	Important food chain component for walrus (*Odobedon rosmarus*)
Present in Tigumiavik Harbour	Present in Tigumiavik Harbour

There are no other species present that we are aware of that would make better candidate species for evaluation than fourhorn sculpins and *Mya* clams. As stated above, the only other species observed from diver surveys were snail fish and prickleback. Although these fish are fairly sessile, there is no precedent for their use, there is no reference or historic metals data and they have no ecological relevance. Fourhorn sculpin also have very little or no ecological relevance, because they are not abundant and are not an important component of the Arctic food web. On the other hand, *Mya* clams are very abundant and are important from a food chain perspective, especially to walrus.

3.3. Sampling Areas and Sample Size

The Polaris EEM program will follow a control/impact (C/I) study design. Accordingly, Fourhorn sculpins and *Mya* clams will be collected in the Garrow Bay exposure area as well as in the reference area, Tigumiavik Harbour (Figure 3-1). Because very few historic data exist for sculpins, we propose to collect the minimum sample size of 20 male and 20 female fish from each area. All fish will be measured for the following parameters:

- Fork length (mm).
- Total weight (g).
- Age (yr).
- Gonad weight (g) and appearance.
- Egg weight (100 egg sub-sample).
- Fecundity (# of eggs).
- Liver weight (g) and appearance.
- External and internal condition, appearance, parasites, tumours.

Although the MMER do not require that tissue samples be analysed for metals other than mercury, we propose to composite eight samples of up to five whole fish each for analysis of moisture content, lipid content, and total metals. Because sculpins are small and not normally consumed by humans, compositing of samples for analysis is justified. This will address this issue of exposure by receiving environment biota and will satisfy a requirement of the DFO Habitat Authorization (Appendix D). Teck Cominco is required to provide sculpin and fish samples from Garrow Lake and Garrow Bay respectively, to the Department of Fisheries and Oceans Winnipeg for analysis by their laboratories. Sculpins in Garrow Bay will be collected nearshore, as near to the creek mouth as possible, depending on weather and ice conditions. Sampling of Tigumiavik Harbour will take place in a similar habitat and time frame as the exposure area.

Since *Mya* clams are sessile organisms that may reflect more localized patterns of exposure, the general C/I design employed for the fish survey will incorporate both near-field and near-field areas within Garrow Bay (Figure 3-1). It may be very difficult to find or collect clams within 300 m of the effluent (up to 5 m depth) because of the hard, ice-scoured substrate, which is not ideal for burrowing clams. Therefore, we propose to collect the nearest available clams to the effluent plume, which will be designated as the near-field area. The location of the near-field collection area may be modified pending results of the theoretical plume modeling (e.g., if the plume is dispersed westwards along shore by currents, the sampling area will be shifted).

The far-field area will be established at least 500 to 800 m offshore of the creek in approximately 8 m of water; the exact location will be fixed pending results of the theoretical plume modeling. The location and timing of sampling is dependent upon ice and weather conditions.

In both Garrow Bay (i.e., near-field and far-field areas) and Tigumiavik Harbour, three composites of five to seven clams will be collected per area. Individual clams will be measured for shell length, width, girth, total weight, sex, gonad and liver weight. Undepurated composites will be analyzed for moisture content, lipid content, and total metals, including mercury, pending the outcome of effluent mercury concentration. Again, because walrus harvest clams from this area, it makes ecological sense to composite samples for metals analysis as walrus can consume several hundred clams per meal.

Note that supporting water and sediment chemistry analyses will be conducted to assist in the interpretation of tissue data, particularly for *Mya* clams; these analyses are detailed in Section 5.

Standard methods and QA/QC procedures (Environment Canada, 2002) will be implemented in all phases of the study including collection and processing of fish and clams.

3.4. Proposed Methods

As indicated previously, all sampling and analysis procedures will follow, as much as possible, guidance outlined in Environment Canada (2002).

3.4.1. Sample Collection

Fine mesh gill nets and beach seines will be used to attempt to capture fish from exposure and reference areas. Seining will be conducted along shore, ice conditions permitting, in

the vicinity of the creek mouth in Garrow Bay. This will be augmented with gill netting in the nearshore (<5 m) area of the bay near the creek. All fish species captured will be enumerated and identified. Only sculpins will be retained.

In the event that sculpins cannot be captured, or can only be captured in very small numbers, greater effort will be placed on collecting *Mya* clams because of their abundance and their much greater ecological relevance.

Clams will be collected in the exposure and reference areas using SCUBA. Because of the coarse, ice scoured bottom to a depth of 5 m within Garrow Bay, it is very unlikely that there is an intertidal population of clams present. All other historic collections of clams have been conducted under the ice in late winter or spring from depths of at least 5 m. Divers will enter at the beach and swim along the bottom searching for clam populations. It is expected, based on previous studies, that few clams will be encountered until 5 m depth and about 200 to 300 m offshore. Note that dive surveys can be constrained by a number of factors including limited bottom time, visibility, weather, ice conditions and walrus! Note that safety factors will not be compromised to acquire biological samples.

Details of field sampling activities will be recorded in a field log book containing the following information:

- Area identification and location (UTM coordinates).
- Species sampled.
- Individual and composite identification.
- Date and time of sampling.
- Level of effort.
- Life history parameters (see Section 3.3).
- Details of paired water quality measurements .
- Photographs.
- General observations (depth, biota, other relevant information).
- Information noted during diver surveys.

All tissue samples requiring chemical analyses will be shipped on ice to DFO, Winnipeg or to ALS Environmental in Vancouver, BC as required. Appendix E provides a quality management program for ALS.

3.4.2. Laboratory Analysis

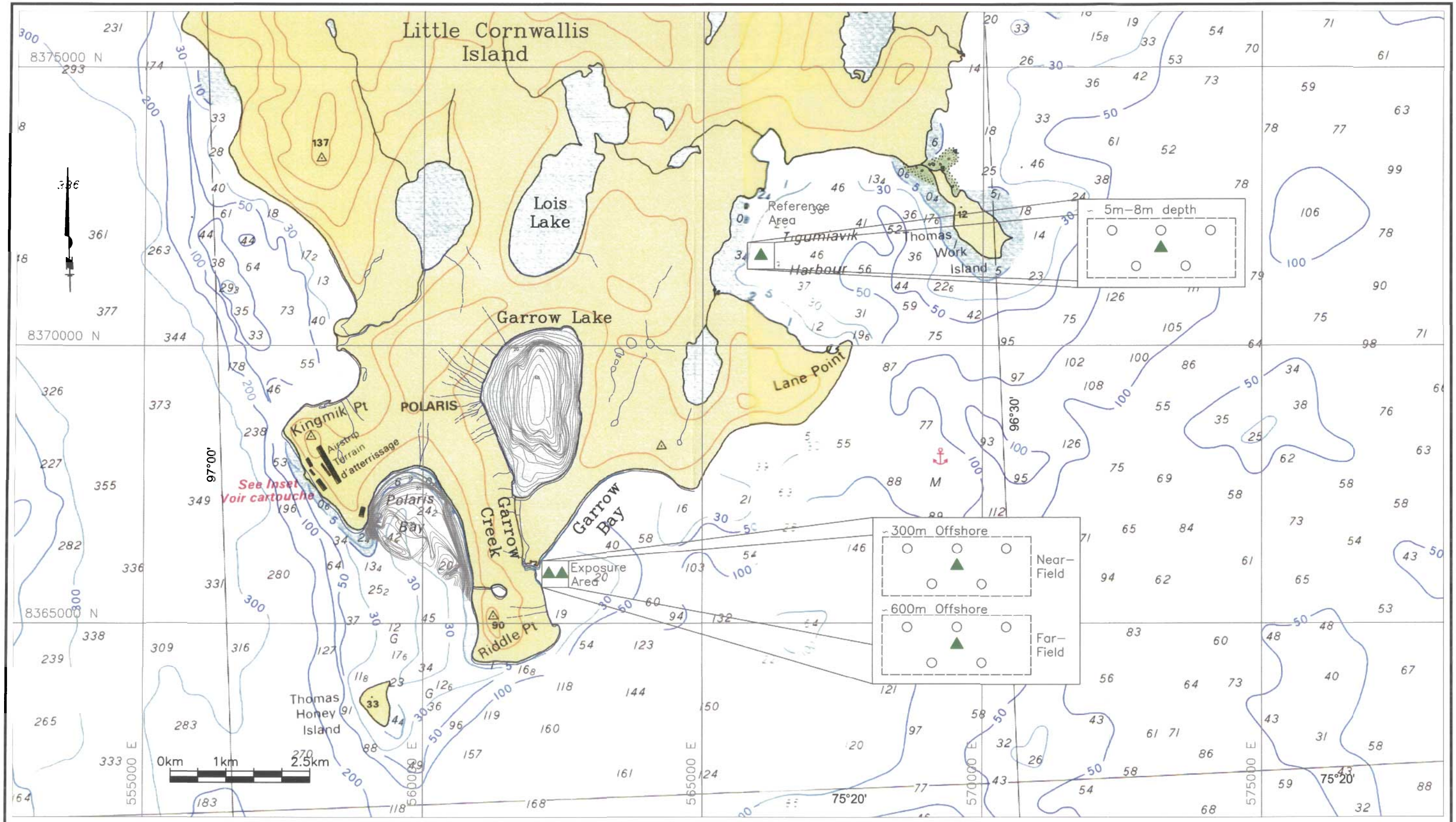
Methods for tissue analysis will follow guidance provided in Environment Canada (2002). In the field, subsamples of fish muscle and liver tissue will be composited, such that six subsamples of tissue (three male composites and three female composites) will be analysed from each area. None of the target species are normally consumed by humans, therefore it is reasonable to composite tissue to determine possible exposure to wildlife (e.g., walrus).

Fish tissue delivered to DFO and ALS will be analysed using standard analytical procedures and detection limits for metals analysis and lipid content. All data will be reported in terms of mg per wet weight kilogram (mg/km or ppm). Moisture content will also be determined to estimate dry weight concentrations if necessary. Note that nearly all metals, except mercury are not positively correlated with increasing fish size. Therefore, it is not necessary to stratify by size if mercury is not being sampled. However, mercury will also be measured in muscle tissue (ppm ww) if necessary and if this is the case, composites of fish will be stratified by size within sexes.

3.5. Possible Alternatives

In the event that fish or clams cannot be collected for whatever reason, there are few other alternatives. In the past, clams have been collected using divers, under ice in May. This was conducted by Garner Lee (2001) as recently as 1999. Very few if any, sculpins have been observed by divers in Garrow Bay. Furthermore, given the extended time period between the end of effluent discharge in early September and sampling in May (eight months), this is not ideal from an exposure perspective and is contrary to the intent of the guidelines, in that sampling should not be undertaken in the absence of effluent over an extended period. This presents a conundrum. If biota cannot be acquired for whatever reason in summer 2004, there seems little justification for under ice sampling in May 2005 when weather conditions are appropriate (warming, reasonable light) and ice conditions are stable. Sampling is not possible in late fall or early winter because of severe cold, storms, utter darkness and unstable ice conditions.

Section 4.3.3 of Environment Canada (2002) provides some suggestions for sampling in marine environments that may be difficult to sample because of tides, currents, unsuitable habitats, etc., all of which are encountered at Polaris. Considering site-specific conditions at Polaris and based on our understanding of the local environment, we believe that the proposed study design takes into consideration the above factors and presents the most reasonable approach to collecting ecological receptor organisms that have any chance of being exposed to the effluent stream from Garrow Creek.



Sampling Area* - fish (sculpin, clam), benthos, water, sediment

Replicate Station - benthos, sediment

Sampling Station - water

* For the fish survey, sculpins will be collected throughout the exposure area

Carrow Lake, Polaris Bay contour data and surrounding creeks digitized from Map 1 Sampling Sites 1980 *prepared by B.C. Research January 1978*

Other data from Crozier Strait And/Et Pullen Strait 7935 *corrected 2003–03–28 published by the Canadian Hydrographic Service*

AZIMUTH

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DRAWN BY:	CHK. BY:	PROJECT No:
BT	RB	TC-03-03
	DATE: 6/10/2003 3:43 PM	

PROJECT: Polaris

TITLE: **Approximate Location of Exposure and Reference Sampling Areas**

CLIENT: Teck Cominco

Figure 3-1

4. BENTHIC INVERTEBRATE COMMUNITY SURVEY

The following section outlines our strategy for conducting a benthic invertebrate community survey at the Polaris Mine.

4.1. Overview and Site-specific Considerations

Two key aspects of the mine discharge and receiving environment were specifically considered in developing a study design to evaluate potential effects on benthic invertebrate communities. These were:

- The short discharge period, combined with the influence of ocean currents, tidal movements and winds in Garrow Bay, is anticipated to result in relatively limited effluent exposure in the marine environment. Furthermore, undiluted Garrow Lake surface waters were shown not to be acutely toxic to resident arctic marine fauna (see Section 2.3.3). Therefore, gross impacts are not expected and the resolution of benthic studies needs to be sufficiently powerful to detect more subtle effects, if any.
- Nearshore portions of Garrow Bay are substantially affected by ice scour to depths of approximately 5 m and up to at least 300 m offshore. This results in coarse substrates with little accumulation of fine sediments. While deeper portions of the bay tend to be more depositional (i.e., characterized by higher clay and silt content), numerous pebbles and large stones have limited the efficiency of historical investigations relying on grab samplers (i.e., standard Ponar grab required up to ten attempts to obtain sufficient sediment volume for sediment chemistry analyses alone; Axys, 1991). No quantitative benthos sampling has ever been attempted.

Given the need for investigative tools with relatively high resolution, we intend to give a higher priority to the use of standard, proven sample collection and handling techniques (Environment Canada, 2002) that can support the assessment of subtle changes in benthic communities. Consequently, as part of the 2003 EEM reconnaissance studies, we will further explore the possibility of using boat-mounted grab sampling techniques. This will involve broad characterization of bottom substrate across near-field and far-field areas of Garrow Bay as well as in the Tigumiavik Harbour reference area. The remainder of Section 4 was prepared under the assumption that seabed characteristics in these areas will support the use of standard methods; however, in the event that this is not the case, alternative tools are also briefly outlined.

4.2. Sampling Areas and Sample Size

The benthic survey will follow a C/I design consistent with the one proposed for the fish survey (Section 3). Specific sampling areas and sample allocations are shown in Figure 3-1 and can be summarized as follows:

- Garrow Bay near-field area: five replication stations located at approximately 300 m offshore from the mouth of Garrow Creek; the exact location will be fixed pending results of the theoretical plume modeling to be conducted in 2003.
- Garrow bay far-field area: five replication stations located at least 500 m offshore from the mouth of Garrow Creek; the exact location will be fixed pending results of the theoretical plume modeling to be conducted in 2003.
- Tigumiavik Harbour reference area: five replication stations located at a depth of approximately 5 to 8 m; the exact location will be fixed after completion of the reconnaissance survey.

The selected sample size (i.e., five replicate stations per area) follows Environment Canada (2002) guidance, which recommends setting α and β equal at 0.1, and assumes that variance will be reasonably similar between Garrow Bay and Tigumiavik Harbour. Each of the replicate station will be approximately 10 m x 10 m in size and will be separated by a distance of approximately 50 m. A total of three field subsamples will also be collected semi-randomly within each replicate station and pooled in the field to provide one data point per station.

To improve our ability to detect changes related to effluent exposure and/or physical substrate characteristics, additional sediment will be collected at each replicate station and analyzed for grain size, total organic carbon (TOC), and metals. Details of this study component are provided in Section 5.

As mentioned for the fish survey, sampling of benthos will be targeted for early to mid-August 2003, to correspond with the greatest likelihood of encountering favorable oceanographic conditions for marine sampling.

4.3. Proposed Methods

All sampling and analysis procedures will follow, as much as possible, guidance outlined in Environment Canada (2002).

4.3.1. Sample Collection

To assist in station positioning (see design in Figure 4-1), a global positioning system (GPS) will be used to acquire Universal Transverse Mercator (UTM) coordinates (NAD 83) at each replicate station. However, given the extreme northerly latitude, GPS is not necessarily reliable and shore-based reference areas and maps will be used to triangulate and site stations on marine charts.

Benthos field subsamples will be collected within the 10 m x 10 m footprint of each replicate station using a 0.05 m^2 standard Ponar grab. After examination of grab quality to ensure that it meets collection criteria (e.g., no large foreign objects; adequate penetration; not overfilled; not leaking water; no obvious disturbance or winnowing), it will be carefully opened in a plastic basin. The grab contents will be gently rinsed through a 0.5 mm screens using site water strained for zooplankton. In the laboratory the 1.0 mm fraction will be separated from the 0.5 mm fraction, which will be archived and processed only if appropriate. Sieved biota will be transferred into a 1 L plastic container and preserved in a 10% solution of buffered formalin. Grab failures may occur due to hard bottom conditions or large debris. In these situations, the grab will be re-deployed until one adequate grab sample is obtained.

This procedure will be repeated until three field subsamples are collected and pooled for each of the replicate stations. Prior to starting a new station, the grab and other stainless steel equipment will be cleaned by scrubbing and rinsing with seawater.

Sample jars will be appropriately labeled and recorded in a field log book that will include, but not be limited to, the following information:

- Station identification.
- Station location (UTM coordinates).
- Date and time of sampling.
- Field crew members.
- Level of effort.
- Substrate characteristics and details of paired water quality measurements and/or sediment quality samples.
- Photographs.
- General observations.

Benthos samples will be shipped to Ms. Val Macdonald of Biologica Environmental Services, Victoria, BC.

4.3.2. Sample Analysis

Methods for sample sorting and taxonomy will follow detailed guidance provided in Environment Canada (2002). Note that benthos identification will be performed at the lowest practicable taxonomic level.

At a minimum, the following endpoints will be used for assessing benthic invertebrate community structure:

- Total invertebrate density.
- Taxon richness.
- Simpson's diversity index.
- Bray-curtis index.
- Abundance and richness of all major taxa (e.g., polychaetes, arthropods, molluscs).
- Indicator species abundance.

Appropriate statistical analyses (e.g., analysis of variance and analysis of contrasts for C/I design; multidimensional scaling) will be used in conjunction with tabular and graphical presentations of the data.

4.4. Possible Alternatives

Environment Canada (2002) recognizes that it may not be feasible to collect benthos samples in some particularly erosional marine habitats. If this is found to be the case in Garrow Bay and in Tigumiavik Harbour during the 2003 reconnaissance studies, other assessment tools will need to be considered. The most likely alternative, if approved by the TAP, would involve a visual survey intended to record and map the major biological features for assessment of gross changes in the biological community (Environment Canada, 2002).

A video imaging technique using a towed underwater camera system (Seabed Imaging and Mapping System [SIMS]) has been used successfully throughout the BC coastline for completing qualitative and semi-quantitative evaluations of subtidal habitats and macro-benthic invertebrate communities. Specifically, SIMS is comprised of a tethered, lightweight V-fin towbody instrumented with a high-resolution color underwater video camera. An electric winch attached to a vessel-mounted davit controls tow depth of the camera. This permits the camera to maintain a steady height (about 0.5 – 1.0 m) above the seabed to deliver the best field of view in the available ambient light and water clarity conditions. Video imagery of the seabed is viewed in real time aboard the vessel and

recorded on super 8 tape and later transferred to VHS tape. SIMS operational depth is 1 to 30 m.

A differential GPS is built into SIMS to provide navigational data to the vessel operator, survey data to the digital video caption device, and to GPS memory for use in post-survey mapping. Survey data and the vessel track are displayed on a laptop computer trackplotter as an aid to navigation for the boat operator. Time, position (UTM in NAD83) and depth (m) are overlain on the video imagery to allow precise orientation.

Maps depicting the spatial distribution of major substrate and habitat types, as well as macro-benthic communities can be compiled during post-processing of the videos. Selections of still photographs can also be reproduced from the SIMS video imagery. Data generated by SIMS can be used for statistical analysis of spatial patterns in community structure (i.e., comparisons of observational units that reflect variations in distance, orientation, depth and substrate in benthic communities) (GVRD, 2002).

Overall, a SIMS survey would likely represent the most effective tool for gathering a substantial amount of information regarding potential impacts to benthos in a relatively short amount of time, which is critical in Polaris' unique receiving environment.

5. SUPPORTING ENVIRONMENTAL VARIABLES

The following section summarizes our approach for conducting water and sediment quality monitoring that will specifically support the biological monitoring studies; details of routine effluent characterization and routine water quality monitoring studies were not included as part of the study design (see Section 1.2; Environment Canada, 2002).

5.1. Water Quality Monitoring

5.1.1. Sampling Areas and Frequency

To ensure consistency with the fish and benthic invertebrate community surveys, water quality monitoring will be based on a C/I design as follows (Figure 3-1):

- Garrow Bay near-field area: one water quality station at the center of this study area, which is located approximately 300 m offshore from the mouth of Garrow Creek. For 2003 sampling, this location will be approximated until results of the theoretical plume modeling are available.
- Garrow Bay far-field area: one water quality station at the center of this study area, which is located at least 500 m offshore from the mouth of Garrow Creek. For 2003 sampling, this location will be approximated until results of the theoretical plume modeling are available.
- Tigumiavik Harbour reference area: one water quality station at the center of this study area, which is located at a depth of approximately 5 to 8 m. For 2003 sampling, this location will be approximated until the reconnaissance studies are completed.

Sampling of the above water quality stations is only required once, at the same time that biological monitoring studies are carried out (i.e., in summer 2004). Note that, as recommended by Environment Canada (2002), water quality monitoring will also be conducted concurrently with routine effluent characterization and routine water quality monitoring to help interpret the findings obtained in the receiving environment.

5.1.2. Water Chemistry Parameters and Proposed Methods

Station positioning will be conducted in the same manner as described for the benthic survey (Section 4.3.1). Once located, each water quality monitoring station will be sampled for the following parameters:

- Field parameters (water column at 1 m intervals): dissolved oxygen (DO), pH, conductivity, water temperature, and salinity. Total water depth and transparency will also be recorded.
- Laboratory parameters (two depths - subsurface and near the bottom): pH, temperature, DO, hardness, alkalinity, Al, As, Cd, Cu, cyanide, Fe, Hg, Pb, Mo, Ni, Zn, TSS, ammonia, nitrate, radium 226.

Sampling and analysis methods as well as sample containers, preservatives required and holding times will follow Environment Canada (2002) guidance. Briefly, this will involve using a conductivity temperature oxygen meter and a portable pH meter. To collect water samples we will employ a direct pumping system whereby water is pumped from depth with a diaphragm pump and ultra-clean Teflon tubing. Water is discharged directly into sample collection bottles and held on ice. All instruments will be calibrated prior to use according the manufacturer's specifications. For water collection, the following general procedures will be followed:

- Sampling will proceed from the least contaminated to the more contaminated stations.
- Sample bottles and caps will be rinsed three times prior to water collection.
- No preservatives will be placed in the sample bottles prior to sample collection.
- Sample collectors will wear nitryl gloves to avoid contamination of the sample.
- Caps of water containers will be held lid-down during sample collection.

Detailed notes for field measurements and water samples will be recorded in a field log book that will include, but not be limited to, the following information:

- Station identification and location (UTM coordinates).
- Date and time of sampling.
- Field crew members.
- Sampling methods.
- Field measurements, number and volume of water samples collected.
- Handling techniques, preservation methods, and sampling containers used.
- Documentation of paired biological monitoring studies.
- Photographs.
- General observations.

Water sample collection will be timed to coordinate with outgoing flights from Resolute Bay to minimize shipping and holding times prior to analysis.

Water samples will be kept refrigerated at 4°C and shipped in coolers with ice packs via express courier service to ALS Environmental, Vancouver BC. Appendix E provides a quality management program for ALS. Note that all efforts will be made to ensure that water samples are analyzed within appropriate holding times.

5.2. Sediment Quality Monitoring

5.2.1. Sampling Areas

To ensure consistency with the fish and benthic invertebrate community surveys, sediment quality monitoring will be based on a C/I design as follows (Figure 3-1):

- Garrow Bay near-field area: a total of five composite sediment samples will be collected within this study area, approximately 300 m offshore from the mouth of Garrow Creek; the exact location of the study area will be fixed pending results of the theoretical plume modeling to be conducted in 2003. The five composite sediment samples will match benthos replicate stations (see Section 4.2).
- Garrow Bay far-field area: a total of five composite sediment samples will be collected within this study area, approximately 500 m offshore from the mouth of Garrow Creek; the exact location of the study area will be fixed pending results of the theoretical plume modeling to be conducted in 2003. The five composite sediment samples will match benthos replicate stations (see Section 4.2).
- Tigumiavik Harbour reference area: a total of five composite sediment samples will be collected within this study area, which is located at a depth of approximately 5 to 8 m; the exact location of the study area will be fixed pending results of the theoretical plume modeling to be conducted in 2003. The five composite sediment samples will match benthos replicate stations (see Section 4.2).

Sediment sample collection is targeted for summer 2004. Note that sediment sampling will also be conducted in Garrow Bay in 2003 from the exposure areas as part of the habitat authorization for DFO.

5.2.2. Sediment Chemistry Parameters and Proposed Methods

As is the case for all EEM study components, sampling and analysis methods will follow Environment Canada (2002) guidance.

Station positioning will be conducted in the same manner as described for the benthic survey (Section 4.3.1). At each of the benthos replicate station, a composite sediment sample will be prepared from sediments collected from a minimum of three individual grabs. Sediments will be collected using a standard Ponar grab (0.053 m^2). Each retrieved grab sample will be examined to ensure acceptable sample quality (i.e., no large foreign objects; adequate penetration; not overfilled; no leaking water; no disturbance or winnowing). Once the grab sample quality is determined to be acceptable, overlying water will be siphoned off. The top 2 – 3 cm will be removed using a pre-cleaned stainless steel spoon and placed in a pre-cleaned stainless steel mixing bowl. Sediment will be mixed using the spoon until it is homogenous in texture and color. The process will be repeated for each of the three individual grabs that comprise a composite sample. Care will be taken to ensure that sediment at each benthos replicate station is collected and processed in the same manner to minimize inconsistencies.

To avoid cross-contamination between replicate stations, the Ponar grab, stainless steel compositing bowls and spoons will be decontaminated. This will entail rinsing the grab with site water to remove sediment and organic material, scrubbing with phosphate-free (Liquinox™) critical cleaning detergent, and again rinsing with site water. Field cross-contamination swipes will be taken and analyzed for metals to assess the degree to which contaminants may be exchanged from one sample to the next during sample collection and processing. Filter blanks (i.e., filters that are not swiped on equipment) will be archived pending results of the cross-contamination swipes. To evaluate variability within sediment composites, homogenization duplicate samples will also be collected and analyzed (see below).

Detailed notes for sediment samples will be recorded in a field log book that will include, but not be limited to, the following information:

- Station identification and location (UTM coordinates) .
- Date and time of sampling.
- Field crew members.
- Sampling methods.
- Volume of sediment samples collected and analyses required.
- Sediment characteristics; documentation of paired biological monitoring studies.
- Photographs.
- General observations.

Sediment samples, placed in their appropriate containers will be shipped by courier to ALS Environmental, Vancouver BC. Samples will be stored in a covered ice chest with frozen gel packs or ice and transferred to 4°C storage until analysis by the laboratory. These will include grain size, total organic carbon (TOC), and metals. Appendix E provides a quality management program for ALS.