Interpretative Report

Environmental Effects Monitoring (EEM)
Teck Cominco Polaris Mine, Nunavut

Prepared for

Environment Canada
Prairie and Northern Region
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December 2005

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Project No. TC-03-03

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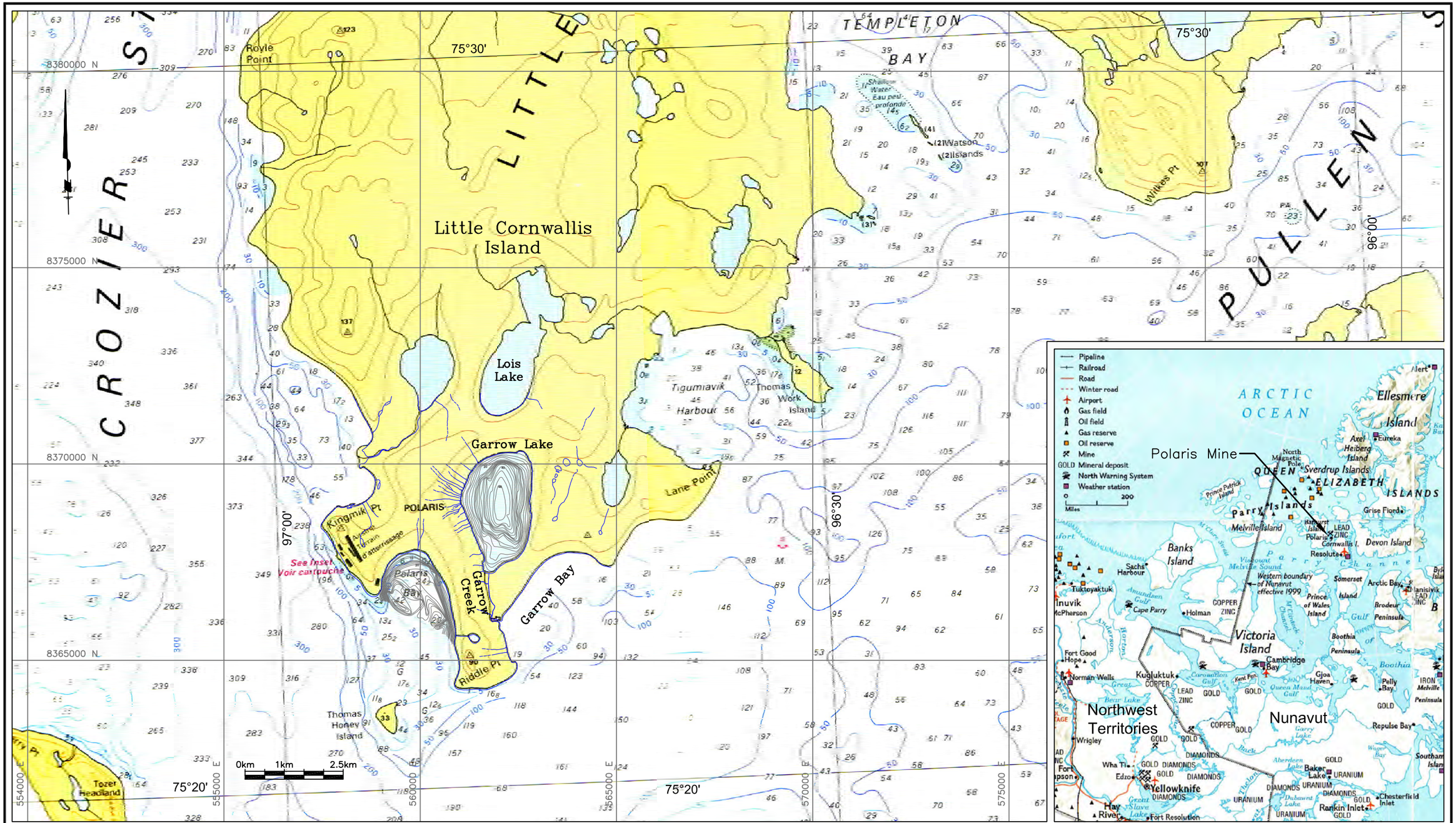

Carrow Lake, Polaris Bay contour data and surrounding creeks digitized from Map 1 Sampling Sites 1980 *prepared by B.C. Research January 1978*

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Insert Location Map from The Modern North: Roads, Radar Stations, and the End of Isolation, *Produced by National Geographic Maps for National Geographic Magazine, Sept. 1997*

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PROJECT: Polaris

TITLE: **Polaris Mine Study Area**

CLIENT: Teck Cominco

Figure 1-1

1 INTRODUCTION

1.1 Background

Teck Cominco Metal Ltd.'s Polaris Mine is located on Little Cornwallis Island in the Canadian high Arctic, Nunavut. Situated at about latitude 75°N and longitude 97°W, Polaris is approximately 100 km northwest of Resolute Bay and is the world's most northerly metal mine (**Figure 1-1**). Underground zinc-lead mining operations, which initially began in the early 1980s, permanently ceased on September 3, 2002 with the final shipment of concentrate, via an ocean going bulk carrier, taking place later that same month. The Polaris Mine concluded a two-year reclamation and decommissioning phase in September 2004.

Tailings from the Polaris Mine have historically been deposited into nearby Garrow Lake, which is recognized under the Metal Mining Regulations (MMER) as a Tailings Impoundment Area. Garrow Lake is permanently thermally and chemically stratified (i.e., meromictic) and, in the nearly 3,000 years since its separation from adjacent marine waters, the annual freeze-thaw cycle at the lake's surface has transferred and concentrated salt in the deeper parts of the lake. The strong density difference between the bottom and surface layers has generally prevented the upward movement of metals associated with the tailings deposited on the bottom. Discharge from Garrow Lake occurs only during summer/fall (i.e., approximately last week of June to early September; 1994 - present) when brackish water from the surface layer of the lake flows into Garrow Creek and, approximately 1.4 km downstream, drains into the marine foreshore of Garrow Bay (**Figure 1-1**). During the remainder of the year, the lake is frozen so no discharge occurs.

Pursuant to Section 32 of the MMER, Teck Cominco provided written notification of closure on December 16, 2002 and undertook to complete a series of environmental investigations over a three-year period. These investigations were aimed at characterizing and monitoring effluent discharge from the Polaris Mine as well as evaluating the spatial extent and magnitude of any effects to fish, fish habitat, and fisheries resources. Under Section 32 of the MMER, the Polaris Mine will become a recognized closed mine after the expiry of the three-year period on December 16, 2005. Any effluents will thereafter be subject to the prohibitions presented in Section 36(3) of the *Fisheries Act*.

Azimuth Consulting Group Inc. (Azimuth) was retained by Teck Cominco to assist in implementation of MMER-related investigations at Polaris. Azimuth also conducted concurrent studies at the site, in Garrow Lake and Garrow Bay, to fulfill obligations under a Fisheries and Oceans Canada (DFO) habitat authorization permit as part of decommissioning activities on-site.

1.2 Objectives

In addition to routine chemical analyses and acute toxicity testing of the mine effluent (i.e., Garrow Lake discharge), a key requirement of the MMER was to undertake an environmental effects monitoring (EEM) program comprised of the following two components:

- Biological monitoring studies, including a fish survey (using indicators of fish population health and fish tissue analysis) and a benthic invertebrate community survey.
- Effluent and water quality monitoring studies during discharge intended to provide background, supporting information for the assessment and interpretation of biological monitoring. These studies included effluent characterization, water quality monitoring, and sublethal effluent testing.

The purpose of the Polaris Mine EEM interpretative report is to document results of the above requirements based on historical information and data collected between 2003 and 2005. Note that, with one exception (see below), most of the information presented in this report was previously submitted and discussed with members of the mine's Technical Advisory Panel (TAP). It is provided as part of this document for ease of reference.

To supplement the interpretative report, we included a discussion of anticipated future trends in effluent characteristics. Its purpose is to provide some context for understanding potential implications for receiving environment water quality in the long-term.

1.3 Approach and Report Organization

The Polaris Mine is located in the high Arctic, where climate is severe, with short cold summers and long (colder…) dark winters. During summer, there is limited opportunity for sampling because of the relative lack of ice-free, open water conditions. Ice movements in Crozier Strait and Garrow Bay are unpredictable and in some years, the bay remains ice-covered. Over the course of the 2003-2005 EEM program, access to Garrow Bay was only possible in 2003 at which time reconnaissance studies in Garrow Bay and comprehensive studies in Garrow Lake were conducted. In 2004, when the main biological monitoring program was planned, Garrow Bay (and Garrow Lake) was completely ice-covered during the entire summer and was inaccessible. Field staff were on site and mobilized to carry out the investigations documented these conditions and communicated regularly with Environment Canada.

Given these harsh field conditions, biological monitoring studies (i.e., the fish and benthic invertebrate community surveys) could not be completed in Garrow Bay as part of the Polaris Mine EEM program. However, access to receiving waters immediately adjacent to the shoreline was possible every year during the summer (i.e., where some ice melt had occurred). Access to Garrow Creek at the discharge location from Garrow Lake

was also possible during each summer. Accordingly, effluent and receiving water quality were monitored as per MMER requirements between 2003 and 2005.

To document our efforts and present available information and data, the interpretative report was organized as follows:

Section 1 – Introduction

Section 2 – Summary of available information and data

- Study design, including historical synopsis (**Appendix A**)
- Addendum to the study design (**Appendix B**), including
  - Results of 2003 field reconnaissance studies conducted in Garrow Bay documenting field effluent plume delineation, underwater video survey, fish survey, intertidal and subtidal sediment survey.
  - Results of theoretical effluent plume modeling.
- Overview of 2004 EEM field program (**Appendix C**)
- Effluent and water quality data from 2003 to 2005 (**Appendix D**)

Section 3 – Discussion of future trends in effluent characteristics, including:

- Summary of 2003 Garrow Lake limnological and ecological investigations conducted to fulfill obligations under a DFO habitat authorization permit (**Appendix E**)
- Discussion of likely future effluent characteristics and potential effects

Section 4 – References

Note that the "compilation report" format used for the Polaris Mine EEM interpretive report is consistent with discussions and feedback received *a priori* from members of the TAP (J. Ferone, pers. comm.. email to P. Allard, May 9, 2005).

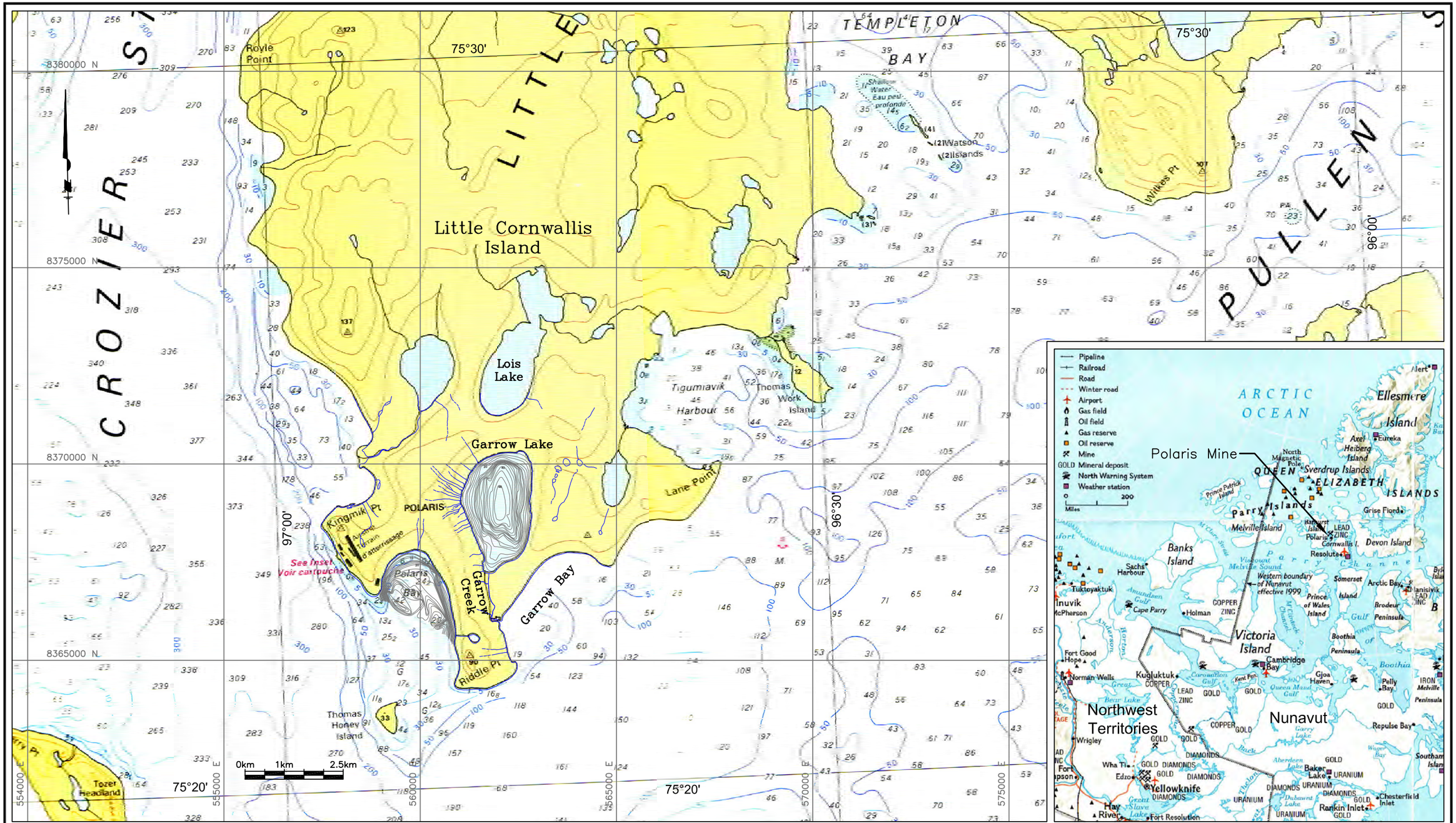

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Figure 1-1

2 SUMMARY OF AVAILABLE INFORMATION AND DATA

2.1 Study Design (Appendix A)

A draft study design for the Polaris Mine EEM program was submitted to Environment Canada (S. Blenkinsopp, Edmonton) in June 2003 and approved with minor clarifications. The entire report is appended (**Appendix A**) to facilitate reference to our review of historical data and our proposed design for conducting biological monitoring studies. Specific components of the draft study design were:

- Introduction (**Section 1**)
- Site characterization (**Section 2**)
- Fish survey and tissue analysis (**Section 3**)
- Benthic invertebrate community survey (**Section 4**)
- Supporting environmental variables (**Section 5**)
- General quality assurance/quality control (QA/QC) program (**Section 6**)

Our intent was to finalize the study design following the completion of field reconnaissance work conducted in Garrow Lake and Garrow Bay in summer 2003 (see below).

2.2 Addendum to Study Design (Appendix B)

The purpose of the Addendum report (**Appendix B**) was to finalize the study design for the Polaris Mine EEM program. Specifically, the Addendum supplemented the draft study design report (see **Appendix A**) by outlining final study components and methods that were adopted for biological monitoring to be implemented during summer 2004.

Development of a final EEM strategy for the Polaris Mine incorporated the following information:

- Results of 2003 field reconnaissance studies conducted in Garrow Bay, including:
  - Field effluent plume delineation
  - Underwater video survey
  - Fish survey
  - Sediment survey
- Results of theoretical effluent plume modeling.

- Feedback obtained from members of the TAP during a workshop held in Edmonton in December 2003 as well as written comments received subsequently. Letters received from the TAP are included in **Appendix B**.

The Addendum report followed a letter report format consisting of five sections organized as follows:

- Introduction (**Section 1**)
- Overview and key considerations (**Section 2**)
- Fish survey and tissue analysis (**Section 3**)
- Benthic invertebrate community survey (**Section 4**)
- Supporting environmental variables (**Section 5**)

2.3 Overview of 2004 Field Program (Appendix C)

Implementation of biological monitoring studies in support of the Polaris Mine EEM program was scheduled for August 14 – 28, 2004, when the likelihood of safe access to Garrow Bay for sampling would be optimal. It was agreed *a priori* with members of the TAP that a two-week level of effort would be sufficient for attempting to complete the field studies in the mine's harsh receiving environment (see Minutes of December 2003 Workshop included in **Appendix B**).

As shown in **Appendix C**, highlights of the 2004 field program can be summarized as follows:

- Six field crew members and all equipment arrived at mine site on August 14th.
- Garrow Bay sampling areas were inaccessible from shore or by boat due to large ice floes covering the entire bay and most of offshore Pullen Strait.
- Diving equipment, compressor, two boats, and a beach camp were operational within two days of arrival to ensure readiness in the event that ice conditions changed.
- While Garrow Bay was ice-covered, we conducted a survey of fish habitat near the former dock area using seabed imaging and mapping system (SIMS) on August 16th and 19th. This work fulfilled mine closure requirements by DFO.
- We also conducted an additional underwater survey of the former dock area using divers on August 20th.
- Throughout the duration of the two-week field program, we documented ice conditions on Garrow Bay and provided weekly verbal updates to Sandra Blenkinsopp (Environment Canada).

- Overall, Garrow Bay remained completely inaccessible throughout the summer of 2004 due to ice conditions. Garrow Lake also remained completely ice covered during that summer.

2.4 Effluent and Water Quality: 2003 to 2005 (Appendix D)

As indicated in **Section 2.3**, biological monitoring studies (i.e., fish and benthic invertebrate community surveys) could not be completed in Garrow Bay as part of the Polaris Mine EEM program. However, access to receiving waters immediately adjacent to the shoreline (i.e., corresponding to the exposure and reference stations for water quality monitoring) was possible every year during the summer (i.e., where some ice melt had occurred). Garrow Creek was also accessible at the final discharge point, near Garrow Lake. Accordingly, effluent and water quality were monitored between 2003 and 2005.

Consistent with MMER requirements for annual Effluent and Water Quality Reports, methods and results of the 2003-2005 investigations have been submitted to the Authorization Officer[1]. **Appendix D** provides a compilation of the annual reports and the following sections summarize the findings, particularly for lead and zinc, which are considered the two most relevant metals present in the mine's effluent.

2.4.1 Effluent Characterization

Due to its high Arctic location, Polaris Mine effluent samples could only be collected during the ice-free summer period in 2003 (late July to mid September), 2004 (early July to early September), and 2005 (late June to late August). Effluent samples were analyzed for all MMER water quality parameters. Throughout the remainder of the year there was no discharge from Garrow Lake, as Garrow Creek was frozen.

During the 2003-2005 period, ten EEM effluent characterization events were sampled at the final discharge point in Garrow Creek (about 20 m downstream of the historic dam and siphon location on Garrow Lake) (**Table 2-1**). Over the last three years there was only a single non-compliant concentration for total suspended solids (TSS) on July 7, 2004. Laboratory results indicated a TSS concentration of 117 mg/L compared to the MMER Schedule 4 limit of 30 mg/L for a single grab sample. This was due to entrainment of creek sediment during the "first flush" of the creek during spring break-up. Concurrent with the July 7th, 2004 sample, a set of acute lethality samples were also taken, which were compliant with the MMER and showed no acute toxicity to either rainbow trout or *Daphnia magna* (i.e. LC50s in both cases were >100% effluent). There

[1] Note that for 2005, only the Third Quarter report has been submitted, with the annual report being due by March 31, 2006. Notwithstanding this, the Third Quarter results effectively represent final data given the short discharge period of effluent at the Polaris Mine.

were no other non-compliant results between 2003 and 2005. No holding times were missed for any of the water chemistry or toxicity testing samples with the exception of mercury (June 29, 2005) and nitrate and alkalinity (June 29 and July 6, 2005) due to an oversight by the laboratory. The missed holding times are unlikely to affect results and additional measurements were taken on July 16, 2005, corresponding to acute and sublethal toxicity testing.

2.4.2 Receiving Environment Chemistry

During the same period, water quality characterization was conducted at the exposure (*n* = 8) and reference[2] (*n* = 7) stations in Garrow Bay. Fewer samples were collected at these stations than in Garrow Creek due to ice cover in Garrow Bay, preventing sample collection. This occurred on July 7, 2004, July 27, 2004 (reference only), and July 6, 2005.

The exposure station is within the shallow mixing zone where the creek discharges to the intertidal marine environment of Garrow Bay. The reference station is in Garrow Bay approximately 1 km northeast of the exposure station. Both stations were accessed from shore using chest waders, in water no more than 0.8 m depth and 20 m from shore.

Concentrations of all parameters measured at the exposure and reference stations are presented in **Table 2-2**. Polaris was a lead/zinc mine. Concentrations of these metals were plotted during EEM sampling episodes in (1) Garrow Creek, (2) Garrow Bay exposure (i.e., at the creek mouth), and (3) Garrow Bay reference stations for zinc (**Figure 2-1**) and lead (**Figure 2-2**). Concentrations of both metals were consistently well below their respective MMER limits.

Zinc – Concentrations of zinc in Garrow Creek have decreased over time, and, since late July, 2004, are not significantly different from the Canadian Council of Ministers of the Environment (CCME) ambient freshwater guideline of 30 µg/L (0.030 mg/L) (CCME, 2002). As discussed in **Section 3.1** (below), since mining has ceased, dissolved metals concentrations, especially zinc, in the water column of Garrow Lake have diminished. The reduction in zinc concentration in Garrow Creek mirrors what is being observed in surface waters of Garrow Lake.

[2] Initially Tigumiavik Bay was designated as the reference station, and was sampled only on the July 29, 2003 event. However, access to this location via both land and sea was difficult due to terrain, polar bears, shifting ice flows and wind conditions. Therefore, based on the plume delineation study, the reference station was shifted to Garrow Bay, approximately 1km from the mouth of Garrow Creek. See further information provided in the Addendum to the Study Design (**Appendix B**).

Year	Average Zinc Concentration at Final Discharge Point in Garrow Creek[3] (mg/L, range in brackets)	Average Lead Concentration at Final Discharge point in Garrow Creek[2] (mg/L, range in brackets)
2003	0.128 (0.048 – 0.186)	0.0219 (0.00046 – 0.0079)
2004	0.072 (0.035 – 0.198)	0.0167 (0.00032 – 0.0028)
2005	0.039 (0.013 – 0.091)	0.0073 (0.00017 – 0.0023)

Zinc concentrations in the Garrow Bay exposure station show a similar trend of reduction since 2003. It is noteworthy that the receiving environment "exposure" station is very near to the creek mouth where the creek enters the bay. There is no CCME marine guideline for zinc. The BC Approved Water Quality Guideline (BC AWQG) for zinc is 0.010 mg/L (10 µg/L) for the protection of marine life (BC AWQG, 2001). This value is three times lower than the CCME freshwater guideline concentration.
Concentrations in the mixing zone were only slightly higher than the guideline concentration for a small zone surrounding the creek mouth. See also results of the plume delineation study presented in **Appendix B**.

Zinc concentrations at the reference station were very low during all events measured (**Figure 2-1**) and well below the BC AWQG marine guideline concentration, as was expected.

Lead – Concentrations of lead in the creek have also decreased over time (**Figure 2-2**; also see above table), and only exceeded the CCME ambient freshwater water quality guideline of 2 µg/L on two occasions. These data again reflect trends in water chemistry observed in Garrow Lake. Lead concentration also declined at the Garrow Bay/Creek exposure station since 2003. Variation in lead concentration in the receiving environment over time may be due to variability in sampling location (e.g., proximity to shore, tide, degree of influence of the creek). Lead exceeded the BC AWQG for marine waters (2 ug/L) only during the July 29, 2003 sampling event at the exposure station, just after mining ceased. Since then, lead concentration at the exposure station has been consistently low.

Lead concentration at the reference station in Garrow Bay was consistently low and well below the BC AWQG concentration (**Figure 2-2**).

2.4.3 Quality Assurance/Quality Control (QA/QC) Data

QA/QC data are presented in **Tables 2-3, 2-4 and 2-5** for 2003, 2004, and 2005, respectively. Relative percent differences (RPDs) were typically less than 50% and showed good reproducibility between co-located field duplicates. The one possible

[3] The average and range includes MMER weekly sampling events in addition to the EEM monitoring events.

exception was the cyanide measurement on July 16, 2005, which was higher than detection limit in the reported sample, but 87% lower in the duplicate. Very small amounts of cyanide were used during processing. Cyanide concentration has always been below detection in all other samples since mining ceased. The reason for higher than detection cyanide is not known, but is probably due to sample contamination. Metal concentrations in blank samples comprised of on-site distilled water were higher than expected for zinc, copper, and lead. Distilled water was prepared on-site and was stored in metal containers. When the mine was operating, distilled water was used frequently and did not sit in the container for long. Since the mine has been closed, this water has not been replaced and we suspect that metal leached from the metal container cans during storage over the 2004-2005 period, resulting in minor contamination of the distilled water source used for QA/QC purposes. Blanks comprised of commercial distilled water shipped with and analysed with field samples indicated low concentrations of all parameters (i.e., typically less than, or slightly higher than detection limits) and confirmed there has been no background contamination issues by the laboratory.

2.4.4 Effluent Toxicity

2.4.4.1 Lethal Toxicity

Eight rainbow trout (*Oncorhynchus mykiss*) and water flea (*Daphnia magna*) acute lethality tests were conducted using effluent collected from the final discharge point (Garrow Creek) during the open water seasons of 2003, 2004, and 2005. Also, toxicity samples were collected during all 10 EEM effluent characterization events. However, due to weather conditions, sample delivery out of the mine site was prevented on August 17, 2004, and July 6, 2005, compromising holding times. Environment Canada was advised during each of these events. There were no adverse effects observed for any of the 96-hr rainbow trout toxicity tests, or the 48-hr *Daphnia magna* toxicity tests. LC50 results were >100% effluent for both species in all testing events (**Table 2-6**). All MMER required reporting information on test conditions, methods, and results have been detailed in the Polaris Mine Effluent and Water Quality annual reports for 2003, 2004, and 2005[4] (**Appendix D**).

2.4.4.2 Semi-annual Sublethal Testing

Sublethal toxicity tests utilized in this EEM program include the estuarine species topsmelt (*Atherinops affinis*) 7-d growth and survival test, the 92-h echinoderm (sandollar *Dendraster excentricus*) fertilization test, and the red algae (*Champia parvula*) 7-d

[4] As mentioned earlier, only the Third Quarter report has been submitted for 2005, with the annual report being due by March 31, 2006. Notwithstanding this, the Third Quarter results effectively represent final data given the short discharge period of effluent at the Polaris Mine.

sublethal toxicity test (**Table 2-7**). Five sublethal toxicity testing events were conducted between 2003 and 2005. A sixth test was conducted on topsmelt only, due to laboratory issues with initiating the Echinoderm and *Champia* tests. There were no effects observed at any concentration for all topsmelt tests for both survival and growth endpoints (the highest concentrations ranged between 67.4 and 72.6% effluent v/v, due to salinity adjustment). IC25s for the Echinoderm test ranged between 3.8 and 17.5 % effluent v/v. IC25s for the *Champia* test ranged between 13.6 and 45.3 % effluent v/v.

Zinc was considered the primary contaminant of potential concern (COPC) in mine effluent. As a result, IC25 and IC50 concentrations (% effluent v/v) were converted to zinc concentrations to assess correlation between zinc in the effluent and reference toxicity tests for zinc performed on *Dendraster* (echinoderm) and *Champia*:

Date	CCME Freshwater Zn Guideline (µg/L)	Calculated Zinc Concentration for Echinoderm Test (µg/L)		Calculated Zinc Concentration for *Champia* Test (µg/L)	
		IC25	IC50	IC25	IC50
19-Aug-03	30	5.5	19.0	19.9	27.4
27-Jul-04	30	3.7	16.0	11.4	18.6
24-Aug-04	30	8.8	25.4	22.6	33.4
16-Jul-05	30	0.93	2.4	4.4	NR
6-Aug-05	30	5.5	19.6	16.1	21.9
Reference	30	8.5-60 (Mean EC50s for *Dendraster* fertilization tests, Dinnel et al. 1983)		27 (16-42) SRC in-house *Champia* IC25 for Zn (95% confidence limits)	

NR = IC50 not reported

Given the similarity between calculated zinc inhibition concentrations (IC) in the effluent samples and the effects concentrations of zinc in reference tests, with the possible exception of the July 16, 2005 sample, it is likely that zinc is responsible for the sublethal effects observed in both the *Dendraster* and *Champia* laboratory tests. Both the echinoderm and *Champia* tests are quite sensitive to zinc, with IC25s and IC50s, and reference test concentrations, being less than the CCME freshwater guideline (30 µg/L), which is unusual. All MMER required reporting information on test conditions, methods, and results have been detailed in the Polaris Mine Effluent and Water Quality annual reports for 2003, 2004, and 2005[5] (**Appendix D**).

[5] As mentioned earlier, only the Third Quarter report has been submitted for 2005, with the annual report being due by March 31, 2006. Notwithstanding this, the Third Quarter results effectively represent final data given the short discharge period of effluent at the Polaris Mine.

Table 2-1. Polaris Mine Effluent Characterization Results, 2003-2005.

Effluent Characterization from Final Discharge Point - Garrow Lake Former Dam / Syphons
Northing: 75°22'32"
Easting: 96°48'37"

Year:				2003				2004					2005
Facility Name:				Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)				Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)					
FDP Name:				Garrow Lake Syphons				Garrow Lake Syphons					
Sample ID:				G-Creek-073003	G-Creek-081903	G-Creek		G Creek	G CREEK	G CREEK	G Creek		G Creek
Sampling Date:				29-Jul-03	19-Aug-03	16-Sep-03		7-Jul-04	27-Jul-04	17-Aug-04	24-Aug-04		29-Jun-05
Sample Method:				Grab	Grab	Grab		Grab	Grab	Grab	Grab		Grab
		MMER Schedule 4 Limits											
Parameter	Units	Column 2 - Monthly mean	Column 4 - Max in grab sample				*Detection Limit*					*Detection Limit*	
Hardness	mg/L			459	1130	1540	*6*	1400	483	973	1380	*2.7*	132
Alkalinity	mg/L			46	103	122	*1*	138	62.4	111	128	*1.0*	30.7
Aluminum	mg/L			<0.1	<0.1	<0.1	*0.1*	0.34	0.021	<0.1	<0.1	*0.1*	<0.1
Cadmium	mg/L			0.00016	0.00037	0.00047	*0.00002*	0.000588	0.00014	0.00023	0.000335	*0.0002*	0.000035
Iron	mg/L			0.02	0.03	0.04	*0.01*	0.487	0.084	0.042	0.014	*0.01*	0.024
Mercury	mg/L			<0.00005	<0.00005	<0.00005	*0.00005*	<0.00001	<0.00001	<0.00001	<0.00001	*0.00001*	<0.00001
Molybdenum	mg/L			<0.002	<0.002	<0.005	*0.002 - 0.005*	<0.005	0.0013	<0.005	<0.005	*0.005*	<0.005
Ammonia	mg/L			0.08	0.03	0.04	*0.02*	0.071	<0.02	0.146	0.133	*0.02*	0.089
Nitrate	mg/L			0.102	0.225	0.217	*0.005*	0.277	0.0644	0.525	0.531	*0.01, 0.02*	0.038
Arsenic	mg/L	0.50	1.00	<0.0004	<0.001	<0.001	*0.0004 - 0.001*	<0.001	<0.001	<0.0002	<0.0002	*0.001, 0.0002*	<0.0002
Copper	mg/L	0.30	0.60	0.00057	0.00097	0.00099	*0.00005*	0.00265	0.000518	0.00121	0.00134	*0.00005*	<0.0005
Cyanide	mg/L	1.00	2.00	<0.005	<0.005	NS	*0.005*	<0.005	<0.005	<0.005	<0.005	*0.005*	<0.005
Lead	mg/L	0.20	0.40	0.00319	0.00046	0.00046	*0.00005*	0.00269	0.00157	0.00177	0.00119	*0.00005*	0.00037
Nickel	mg/L	0.50	1.00	0.00115	0.00265	0.00365	*0.00005*	0.00442	0.00207	0.00644	0.00967	*0.00005*	0.00075
Zinc	mg/L	0.50	1.00	0.0625	0.1460	0.1860	*0.0005*	0.198	0.0429	0.0418	0.0498	*0.0005*	0.0137
TSS	mg/L	15.00	30.00	<3	8	5	*3*	117	<3	5.3	4.4	*3.0*	<3
Radium 226	Bq/L	0.37	1.11	<0.005	<0.005	<0.005	*0.005*	0.02	<0.005	0.01	0.008	*0.005*	<0.005
pH	pH units	<6.0 or >9.5		7.84	8.10	7.96	*0.01*	8.05	7.87	7.95	7.84	*0.01*	7.98

Notes:
NS = no sample
< = Less than the detection limit indicated.
(a) Results are expressed as Becquerels per litre (Bq/L). This analysis is subcontracted to SRC, Saskatoon.
[1]Original data reports are available upon request
[2]SPR-IDA = Suspended Particulate Resin consisting of immobilized iminodiacetate on a divinyl benzene polymer is used to chelate and preconcentrate metals in seawater (preparation technique).
[3]Instrumental analysis is by ICPMS = Inductively Coupled Mass Spectrometry.
[4]This analysis is carried out using procedures adapted from "StandardMethods for the Examination of Water and Wastewater" 20th Edition 1998, published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the USEPA. The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emissionspectrophotometry ICPOES (EPA Method 6010B).
[5]All radium isotopes in the sample solution are separated by coprecipitation with lead sulfate. The precipitate is redissolved and the radium isotopes are separated by coprecipitation with barium sulfate. The precipitate is filtered and mounted on a stainless steel disk. It is then counted on an alpha spectrometer. The radium 226 alpha energy is distinct and the peak can be clearly identified.

Table 2-1. Polaris Mine Effluent Characterization Results, 2003-2005.

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Easting: 96°48'37"

Year:				2005 Cont'd				
Facility Name:				Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)				
FDP Name:				Garrow Lake Syphons				
Sample ID:				G Creek	G-Creek	G-Creek		
Sampling Date:				6-Jul-05	16-Jul-05	6-Aug-05		
Sample Method:				Grab	Grab	Grab		
		MMER Schedule 4 Limits						
Parameter	Units	Column 2 - Monthly mean	Column 4 - Max in grab sample				*Detection Limit*	Methods[1]
Hardness	mg/L			149	184	375	*0.54 - 5.4*	Calculation - EPA Method 3005A, ICPOES (EPA Method 6010B)[4]
Alkalinity	mg/L			28.1	29.2	52.5	*2.0*	Colourimetry - APHA Method 2320 (potentiometric titration)
Aluminum	mg/L			<0.20	0.0085	<0.20	*0.001 - 0.2*	ICPMS[3]
Cadmium	mg/L			0.000034	0.000044	0.000097	*0.000020*	SPR-IDA[2], ICPMS[3]
Iron	mg/L			0.012	0.043	0.014	*0.010*	SPR-IDA[2], ICPMS[3]
Mercury	mg/L			<0.000010	<0.000010	<0.000010	*0.000010*	Cold Vapour Atomic Florescence Spectrophotometry
Molybdenum	mg/L			<0.0050	<0.0050	<0.0050	*0.0050*	ICPMS[3]
Ammonia	mg/L			0.036	0.037	<0.020	*0.020*	APHA Method 4500-NH3 (selective ion electrode)
Nitrate	mg/L			0.032	<0.050	0.072	*0.025 - 0.050*	APHA Method 4110 (determination of inorganic ions by ion chromatography)
Arsenic	mg/L	0.50	1.00	<0.00020	<0.00020	<0.00020	*0.00020*	Hydride-Vapour Atomic Absorption Spectrophotometry
Copper	mg/L	0.30	0.60	0.000240	0.000424	0.000516	*0.000050*	Chelation SPR-IDA[2], ICPMS[3]
Cyanide	mg/L	1.00	2.00	<0.0050	0.0444	<0.0050	*0.0050*	Colourimetry - APHA Method 4500-CN (cynate hydrolosis using NH_3 selective electrode)
Lead	mg/L	0.20	0.40	0.000166	0.000415	0.000467	*0.000050*	Chelation SPR-IDA[2], ICPMS[3]
Nickel	mg/L	0.50	1.00	0.000601	0.000807	0.00166	*0.000050*	Chelation SPR-IDA[2], ICPMS[3]
Zinc	mg/L	0.50	1.00	0.0127	0.0179	0.0356	*0.00050*	Chelation SPR-IDA[2], ICPMS[3]
TSS	mg/L	15.00	30.00	4.0	<3.0	<3.0	*3.0*	Gravimetry - APHA Method 2540 (filtration through glass fibre filter)
Radium 226	Bq/L	0.37	1.11	0.0050	0.009	<0.0050	*0.0050*	Radio Chemistry[5]
pH	pH units	<6.0 or >9.5		7.49	7.59	7.65	*0.010*	APHA Method 4500-H (pH electrode meter)

Notes:
NS = no sample
< = Less than the detection limit indicated.
(a) Results are expressed as Becquerels per litre (Bq/L). This analysis is subcontracted to SRC, Saskatoon.
[1]Original data reports are available upon request
[2]SPR-IDA = Suspended Particulate Resin consisting of immobilized iminodiacetate on a divinyl benzene polymer is used to chelate and preconcentrate metals in seawater (preparation technique).
[3]Instrumental analysis is by ICPMS = Inductively Coupled Mass Spectrometry.
[4]This analysis is carried out using procedures adapted from "StandardMethods for the Examination of Water and Wastewater" 20th Edition 1998, published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the USEPA. The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emissionspectrophotometry ICPOES (EPA Method 6010B).
[5]All radium isotopes in the sample solution are separated by coprecipitation with lead sulfate. The precipitate is redissolved and the radium isotopes are separated by coprecipitation with barium sulfate. The precipitate is filtered and mounted on stainless steel disk. It is then counted on an alpha spectrometer. The radium 226 alpha energy is distinct and the peak can be clearly identified.

Table 2-2. Polaris Mine Water Quality Monitoring Results - Exposure and Reference Stations, 2003 - 2005.

Year:		2003							2004				
Station:		Exposure Area			Reference Area[1]				Exposure Area			Reference Area	
Description:		Garrow Bay at Mouth of Garrow Creek Confluence			Garrow Bay ~1km NE of exposure station (confluence with Garrow Creek)[1].				Garrow Bay at Mouth of Garrow Creek Confluence			Garrow Bay ~1km NE of exposure station (confluence with Garrow Creek).	
Northing:		75°22'15"			75°22'40"				75°22'15"			75°22'40"	
Easting:		96°48'30"			96°47'12"				96°48'30"			96°47'12"	
Facility Name:		Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)			Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)				Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)			Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)	
FDP Name:		Garrow Lake Syphons			Garrow Lake Syphons				Garrow Lake Syphons			Garrow Lake Syphons	
Area Name:		Garrow Bay Exposure			Tigumiavik Bay[1]	Garrow Bay Ref.	Garrow Bay Ref.		Garrow Bay Exposure			Garrow Bay Reference	
Sample ID:		G-Bay-072903	G-Bay-081903	G-Bay	T-Bay-072903	T-Bay-Ref-081903	T-Bay		G BAY	G BAY	G Bay	REF	Ref
Sampling Date:		29-Jul-03	19-Aug-03	16-Sep-03	29-Jul-03	19-Aug-03	16-Sep-03		27-Jul-04	17-Aug-04	24-Aug-04	17-Aug-04	24-Aug-04
Sample Method:		Grab	Grab	Grab	Grab	Grab	Grab		Grab	Grab	Grab	Grab	Grab
Parameters	**Units**							***Detection Limit***					
Hardness	mg/L	456	1120	3620	989	5830	5930	*6*	482	2270	1750	2960	1560
Alkalinity	mg/L	46	104	117	33	115	113	*1*	37.5	45	38.8	46	36.1
Aluminum	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	*0.1*	0.033	<0.1	<0.1	<0.1	<0.1
Cadmium	mg/L	0.00015	0.00038	0.00024	<0.00002	0.00003	0.00003	*0.00002*	0.00007	<0.00002	0.000028	<0.00002	<0.00002
Iron	mg/L	0.03	0.05	0.03	0.01	<0.01	0.02	*0.01*	0.046	<0.01	<0.01	<0.01	<0.01
Mercury	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	*0.00005*	<0.00005	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	mg/L	<0.002	<0.002	0.006	<0.002	0.010	0.011	*0.002 - 0.005*	0.00156	<0.005	<0.005	0.0062	<0.005
Ammonia	mg/L	0.04	0.03	0.03	0.03	<0.02	0.08	*0.02*	<0.02	<0.02	0.02	<0.02	<0.02
Nitrate	mg/L	0.098	0.229	0.159	<0.005	<0.005	<0.005	*0.005*	0.0372	<0.02	<0.02	<0.02	<0.02
Arsenic	mg/L	<0.0004	<0.001	0.001	<0.0004	0.0020	<0.001	*0.0004 - 0.001*	<0.001	<0.0002	0.00027	0.00044	<0.0002
Copper	mg/L	0.00080	0.00106	0.00059	0.00023	0.00044	0.00028	*0.00005*	0.000405	0.000216	0.000209	0.000231	0.000205
Cyanide	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Lead	mg/L	0.00435	0.00108	0.00043	0.00032	0.00021	0.00052	*0.00005*	0.00026	<0.00005	0.000267	0.000052	<0.00005
Nickel	mg/L	0.00121	0.00304	0.00169	0.00021	0.00033	0.00026	*0.00005*	0.000979	0.000252	0.000267	0.000217	0.000186
Zinc	mg/L	0.0594	0.1490	0.0881	0.0010	0.0007	0.0011	*0.0005*	0.0242	0.00118	0.00092	0.0005	<0.0005
TSS	mg/L	4	8	10	<3	32	9	*3*	3.7	3.3	8.4	9.3	7
Radium226	Bq/L	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	*0.005*	<0.005	<0.005	0.006	<0.005	<0.005
pH	pH units	7.86	8.13	7.85	7.67	7.87	7.78	*0.01*	7.91	7.79	7.64	7.92	7.62
Water Temp.	°C	0.47	1.08	-0.76	-0.27	0.18	-1.36	-	0.2	0.2	0.9	0.1	1.2
Diss. Oxygen	mg/L	10.29	5.01	5.45	9.27	5.50	3.42	-	13.23	13.78	15.2	14.04	15.13

Notes

The Garrow Bay exposure area (mouth of the creek) was frozen during the July 7, 2004 sampling event.
The Garrow Bay reference area was ice free in 2004 only during August 17 and August 24, 2004 sampling events.
The Garrow Bay exposure area (mouth of the creek), and Garrow Bay reference area were frozen during the July 6, 2005 sampling event.
< = Less than the detection limit indicated.
(a) Results are expressed as Becquerels per litre (Bq/L). This analysis is subcontracted to SRC, Saskatoon.
(b) n/a for August 6, 2005 sample = not available, the sample was lost during analysis by SRC with no additional sample remaining to repeat the analysis.

[1]Tigumiavik Bay was originally desugnated as the reference station. However, access to Tigumiavik Harbour was very difficult over land (terrain & polar bears) and unsafe over water (shifting ice flows, wind conditions). Therefore, the reference station was relocated to Garrow Bay (~ 1 km from mouth of creek), based on results of field plume delineation.

[2]SPR-IDA = Suspended Particulate Resin consisting of immobilized iminodiacetate on a divinyl benzene polymer is used to chelate and preconcentrate metals in seawater (preparation technique)

[3]Instrumental analysis is by ICPMS = Inductively Coupled Mass Spectrometry.

[4]This analysis is carried out using procedures adapted from "StandardMethods for the Examination of Water and Wastewater" 20th Edition 1998, published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the USEPA. The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emissionspectrophotometry ICPOES (EPA Method 6010B).

[5]All radium isotopes in the sample solution are separated by coprecipitation with lead sulfate. The precipitate is redissolved and the radium isotopes are separated by coprecipitation with barium sulfate. The precipitate is filtered and mounted on a stainless steel disk. It is then counted on an alpha spectrometer. The radium 226 alpha energy is distinct and the peak can be clearly identified.

[6]Temperature and dissolved oxygen data from 2005 are estimated pending verification by Teck Cominco.

Table 2-2. Polaris Mine Water Quality Monitoring Results - Exposure and Reference Stations, 2003 - 2005.

Year:		2004 Cont'd	2005					
Station:			Exposure Area		Reference Area			
Description:			Garrow Bay at Mouth of Garrow Creek Confluence		Garrow Bay ~1km NE of exposure station (confluence with Garrow Creek)			
Northing:			75°22'15"		75°22'40"			
Easting:			96°48'30"		96°47'12"			
Facility Name:			Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)		Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)			
FDP Name:			Garrow Lake Syphons		Garrow Lake Syphons			
Area Name:			Garrow Bay Exposure		Garrow Bay Reference			
Sample ID:			G-BAY	G-Bay (b)	T-BAY REF	Ref		
Sampling Date:			16-Jul-05	6-Aug-05	16-Jul-05	6-Aug-05		
Sample Method:			Grab	Grab	Grab	Grab		
Parameters	**Units**	***Detection Limit***					***Detection Limit***	**Methods**
Hardness	mg/L	*2.7*	215	385	271	840	*0.54-5.4*	Calculation - EPA Method 3005A, ICPOES (EPA Method 6010B)[4]
Alkalinity	mg/L	*1.0*	44.2	63.2	23.0	53.5	*2.0*	Colourimetry - APHA Method 2320 (potentiometric titration)
Aluminum	mg/L	*0.1*	0.0519	<0.10	0.0619	<0.10	*0.001-0.2*	ICPMS[3]
Cadmium	mg/L	*0.0002*	0.000051	0.000081	<0.000020	<0.000020	*0.000020*	SPR-IDA[2], ICPMS[3]
Iron	mg/L	*0.01*	0.207	0.015	0.217	0.011	*0.010*	SPR-IDA[2], ICPMS[3]
Mercury	mg/L	*0.00001*	<0.000010	<0.000010	<0.000010	<0.000010	*0.000010*	Cold Vapour Atomic Florescence Spectrophotometry
Molybdenum	mg/L	*0.005*	<0.0050	<0.0050	<0.0050	<0.0050	*0.0050*	ICPMS[3]
Ammonia	mg/L	*0.02*	0.048	<0.020	<0.020	<0.020	*0.020*	APHA Method 4500-NH3 (selective ion electrode)
Nitrate	mg/L	*0.02*	<0.050	0.092	<0.050	0.0261	*0.025*	APHA Method 4110 (determination of inorganic ions by ion chromatography)
Arsenic	mg/L	*0.001, 0.0002*	<0.00020	<0.00020	0.00050	0.00024	*0.00020*	Hydride-Vapour Atomic Absorption Spectrophotometry
Copper	mg/L	*0.00005*	0.000748	0.000608	0.000563	0.000305	*0.000050*	Chelation SPR-IDA[2], ICPMS[3]
Cyanide	mg/L	*0.005*	<0.0050	<0.0050	<0.0050	<0.0050	*0.0050*	Colourimetry - APHA Method 4500-CN (cynate hydrolosis using NH_3 selective electrode)
Lead	mg/L	*0.00005*	0.00147	0.000517	0.000690	0.000078	*0.000050*	Chelation SPR-IDA[2], ICPMS[3]
Nickel	mg/L	*0.00005*	0.00126	0.00188	0.000554	0.000412	*0.000050*	Chelation SPR-IDA[2], ICPMS[3]
Zinc	mg/L	*0.0005*	0.0154	0.0224	0.00323	0.00122	*0.00050*	Chelation SPR-IDA[2], ICPMS[3]
TSS	mg/L	*3.0*	16.7	<3.0	<3.0	<3.0	*3.0*	Gravimetry - APHA Method 2540 (filtration through glass fibre filter)
Radium226	Bq/L	*0.005*	0.010	n/a	<0.0050	<0.0050	*0.0050*	Radio Chemistry[5]
pH	pH units	*0.01*	7.64	7.96	7.40	7.89	*0.010*	APHA Method 4500-H (pH electrode meter)
Water Temp.	°C	-	0.2	0.6	-0.1	0.2	*n/a*	Field - Campbell Scientific Hydrolab Model H20, or YSI Meter Model 85
Diss. Oxygen	mg/L	-	13.2	11.6	15.2	13.9	*n/a*	Field - Campbell Scientific Hydrolab Model H20, or YSI Meter Model 85

Notes

The Garrow Bay exposure area (mouth of the creek) was frozen during the July 7, 2004 sampling event.
The Garrow Bay reference area was ice free in 2004 only during August 17 and August 24, 2004 sampling events.
The Garrow Bay exposure area (mouth of the creek), and Garrow Bay reference area were frozen during the July 6, 2005 sampling event.
< = Less than the detection limit indicated.
(a) Results are expressed as Becquerels per litre (Bq/L). This analysis is subcontracted to SRC, Saskatoon.
(b) n/a for August 6, 2005 sample = not available, the sample was lost during analysis by SRC with no additional sample remaining to repeat the analysis.

[1]Tigumiavik Bay was originally desugnated as the reference station. However, access to Tigumiavik Harbour was very difficult over land (terrain & polar bears) and unsafe over water (shifting ice flows, wind conditions). Therefore, the reference station was relocated to Garrow Bay (~ 1 km from mouth of creek), based on results of field plume delineation.

[2]SPR-IDA = Suspended Particulate Resin consisting of immobilized iminodiacetate on a divinyl benzene polymer is used to chelate and preconcentrate metals in seawater (preparation technique).

[3]Instrumental analysis is by ICPMS = Inductively Coupled Mass Spectrometry.

[4]This analysis is carried out using procedures adapted from "StandardMethods for the Examination of Water and Wastewater" 20th Edition 1998, published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the USEPA. The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emissionspectrophotometry ICPOES (EPA Method 6010B).

[5]All radium isotopes in the sample solution are separated by coprecipitation with lead sulfate. The precipitate is redissolved and the radium isotopes are separated by coprecipitation with barium sulfate. The precipitate is filtered and mounted on a stainless steel disk. It is then counted on an alpha spectrometer. The radium 226 alpha energy is distinct and the peak can be clearly identified.

[6]Temperature and dissolved oxygen data from 2005 are estimated pending verification by Teck Cominco.

Table 2-3. 2003 Polaris Mine QAQC Sample Results[1] Including Field Duplicates, Field Blanks, and Transport Blanks.

Sample Type:		Original Sample	Field Duplicate		Original Sample	Field Duplicate		Original Sample	Field Duplicate	
Sample ID:		T-Bay-072903	Dup-072903		G-Bay-081903	Dup-081903		G-Creek	DUP	
Location:		Tigumiavik Harbour Reference			Garrow Bay Exposure			Garrow Lake Syphons		
Description:		Final Discharge Point		RPD[2]	Mouth of Garrow Creek Confluence		RPD[2]	Final Discharge Point		RPD[2]
Sampling Date:		29-Jul-03		(%)	19-Aug-03		(%)	16-Sep-03		(%)
Parameters	**Parameter Units**									
Hardness	mg/L	989	1020	3.04	1120	1140	1.75	1540	1470	4.76
Alkalinity	mg/L	33	33	0.00	104	104	0.00	122	119	2.52
Aluminum	mg/L	<0.1	<0.1	n/a	<0.1	<0.1	n/a	<0.1	<0.1	n/a
Cadmium	mg/L	<0.00002	<0.00002	n/a	0.00038	0.00034	11.76	0.00047	0.00047	0.00
Iron	mg/L	0.01	0.01	0.00	0.05	0.05	0.00	0.04	0.03	33.33
Mercury	mg/L	<0.00005	<0.00005	n/a	<0.00005	<0.00005	n/a	<0.00005	<0.00005	n/a
Molybdenum	mg/L	<0.002	<0.002	n/a	<0.002	<0.002	n/a	<0.005	<0.005	n/a
Ammonia	mg/L	0.03	0.04	25.00	0.03	0.03	0.00	0.04	0.02	100.00
Nitrate	mg/L	<0.005	<0.005	n/a	0.229	0.203	12.81	0.217	0.292	25.68
Arsenic	mg/L	<0.0004	<0.0004	n/a	<0.001	<0.001	n/a	<0.001	<0.001	n/a
Copper	mg/L	0.00023	0.0003	23.33	0.00106	0.00103	2.91	0.00099	0.00098	1.02
Cyanide	mg/L	<0.005	<0.005	n/a	<0.005	<0.005	n/a	-	<0.005	n/a
Lead	mg/L	0.00032	0.00102	68.63	0.00108	0.00213	49.30	0.00046	0.00071	35.21
Nickel	mg/L	0.00021	0.00024	12.50	0.00304	0.00266	14.29	0.00365	0.00326	11.96
Zinc	mg/L	0.001	0.001	0.00	0.149	0.138	7.97	0.186	0.187	0.53
TSS	mg/L	<3	5	n/a	8	12	33.33	5	5	n/a
Radium226	Bq/L	<0.005	<0.005	n/a	<0.005	<0.005	n/a	<0.005	0.008	n/a
pH	pH units	7.67	7.63	0.52	8.13	8.02	1.37	7.96	7.94	0.25
Salinity	o/oo	6	6	0.00	6	9	33.33	7	6	16.67
Calcium	mg/L	68.4	71.2	3.93	98	101	2.97	133	127	4.72
Magnesium	mg/L	199	205	2.93	211	216	2.31	294	279	5.38

Notes

[1]QAQC samples were collected during each EEM monitoring event. At least one field duplicate and/or one blank sample was collected during each event.

[2]RPD = Relative Percent Difference = [Absolute value (DUP-ORIG)/ORIG]*100%

Cells in grey shading have RPD values >50% for co-located field duplicates

[3]Commercial distilled water transported to mine site.

QAQC Results

A total of 3 duplicate samples and 2 blank samples were collected during the 2003 EEM program at Polaris mine. All RPD values were less than 50%, with the exception of one measurement of lead (July 29, 2003) and ammonia (September 16, 2003). This data indicate good reproducibility between co-located field duplicates (i.e., low measurement and analytical variability).

Blank samples were typically less than, or slightly higher than detection limits, revealing no background contamination issues.

Table 2-3. 2003 Polaris Mine QAQC Sample Results[1] Including Field Duplicates, Field Blanks, and Transport Blanks.

Sample Type:		Field Blank	Field Blank
Sample ID:		F-Blank-081903	F-Blank
Location:		n/a	n/a
Description:		Distilled Water[3]	Distilled Water[3]
Sampling Date:		19-Aug-03	16-Sep-03
Parameters	**Parameter Units**		
Hardness	mg/L	-	<10
Alkalinity	mg/L	-	-
Aluminum	mg/L	<0.1	<0.1
Cadmium	mg/L	<0.00002	<0.00002
Iron	mg/L	0.01	<0.01
Mercury	mg/L	<0.00005	<0.00005
Molybdenum	mg/L	<0.002	<0.005
Ammonia	mg/L	-	-
Nitrate	mg/L	-	-
Arsenic	mg/L	<0.001	<0.001
Copper	mg/L	0.00033	0.00033
Cyanide	mg/L	-	-
Lead	mg/L	0.00102	0.00018
Nickel	mg/L	<0.00005	0.00008
Zinc	mg/L	0.0014	0.0007
TSS	mg/L	-	-
Radium226	Bq/L	<0.005	<0.005
pH	pH units	-	-
Salinity	o/oo	-	-
Calcium	mg/L	<0.5	<1
Magnesium	mg/L	<1	<2

Notes

[1]QAQC samples were collected during each EEM monitoring event. At least one field duplicate and/or one blank sample was collected during each event.

[2]RPD = Relative Percent Difference = [Absolute value (DUP-ORIG)/ORIG]*100%

Cells in grey shading have RPD values >50% for co-located field duplicates

[3]Commercial distilled water transported to mine site.

QAQC Results

A total of 3 duplicate samples and 2 blank samples were collected during the 2003 EEM program at Polaris mine. All RPD values were less than 50%, with the exception of one measurement of lead (July 29, 2003) and ammonia (September 16, 2003). This data indicate good reproducibility between co-located field duplicates (i.e., low measurement and analytical variability).

Blank samples were typically less than, or slightly higher than detection limits, revealing no background contamination issues.

Table 2-4. 2004 Polaris Mine QAQC Sample Results[1] Including Field Duplicates, Field Blanks, and Transport Blanks.

Sample Type:		Field Duplicate	Original Sample		Field Duplicate	Original Sample		Field Duplicate	Original Sample	
Sample ID:		Dup	G Creek		DUP	G BAY		FIELD DUP	G CREEK	
Location:		Garrow Lake Syphons			Garrow Bay Exposure			Garrow Lake Syphons		
Description:		Final Discharge Point		RPD[2]	Mouth of Garrow Creek Confluence		RPD[2]	Final Discharge Point		RPD[2]
Sampling Date:		7-Jul-04		(%)	27-Jul-04		(%)	17-Aug-04		(%)
Parameters	**Parameter Units**									
Hardness	mg/L	1400	1400	0.00	532	482	10.37	997	973	2.47
Alkalinity	mg/L	132	138	4.35	38.6	37.5	2.93	113	111	1.80
Aluminum	mg/L	0.26	0.34	23.53	0.031	0.033	6.06	<0.10	<0.1	n/a
Cadmium	mg/L	0.000582	0.000588	1.02	0.000062	0.00007	11.43	0.000224	0.00023	2.61
Iron	mg/L	0.441	0.487	9.45	0.035	0.046	23.91	0.039	0.042	7.14
Mercury	mg/L	<0.000010	<0.00001	n/a	<0.000050	<0.00005	n/a	<0.000010	<0.00001	n/a
Molybdenum	mg/L	<0.0050	<0.005	n/a	0.00129	0.00156	17.31	<0.0050	<0.005	n/a
Ammonia	mg/L	0.069	0.071	2.82	<0.020	<0.02	n/a	0.163	0.146	11.64
Nitrate	mg/L	0.284	0.277	2.53	0.0371	0.0372	0.27	0.54	0.525	2.86
Arsenic	mg/L	<0.0010	<0.001	n/a	<0.0010	<0.001	n/a	<0.00020	<0.0002	n/a
Copper	mg/L	0.00252	0.00265	4.91	0.000342	0.000405	15.56	0.00121	0.00121	0.00
Cyanide	mg/L	<0.0050	<0.005	n/a	<0.0050	<0.005	n/a	<0.0050	<0.005	n/a
Lead	mg/L	0.0024	0.00269	10.78	0.000205	0.00026	21.15	0.00187	0.00177	5.65
Nickel	mg/L	0.00438	0.00442	0.90	0.000772	0.000979	21.14	0.00676	0.00644	4.97
Zinc	mg/L	0.196	0.198	1.01	0.019	0.0242	21.49	0.0418	0.0418	0.00
TSS	mg/L	120	117	2.56	7	3.7	89.19	<3.0	5.3	n/a
Radium226	Bq/L	0.02	0.02	0.00	<0.0050	<0.005	n/a	<0.0050	0.01	n/a
pH	pH units	8.06	8.05	0.12	7.76	7.91	1.90	8.02	7.95	0.88

Notes

[1]QAQC samples were collected during each EEM monitoring event. At least one field duplicate and/or one blank sample was collected during each event.

[2]RPD = Relative Percent Difference = [Absolute value (DUP-ORIG)/ORIG]*100%

Cells in grey shading have RPD values >50% for co-located field duplicates

[3]Distilled water from onsite distiller.

QAQC Results

A total of 4 duplicate samples and 3 blank samples were collected during the 2004 EEM program at Polaris mine. All RPD values were less than 50%, with the exception of one measurement of TSS on July 27, 2004. This data indicate good reproducibility between co-located field duplicates (i.e., low measurement and analytical variability).

Blank samples were typically less than, or slightly higher than detection limits, revealing no background contamination issues.

Table 2-4. 2004 Polaris Mine QAQC Sample Results[1] Including Field Duplicates, Field Blanks, and Transport Blanks.

Sample Type:		Field Duplicate	Original Sample		Field Blank	Transport Blank	Field Blank	Field Blank
Sample ID:		Dup	G Creek		F Blank	T Blank	F BLANK	FIELD BLANK
Location:		Garrow Lake Syphons			n/a	n/a	n/a	n/a
Description:		Final Discharge Point		RPD[2]	Distilled Water[3]	Distilled Water[3]	Distilled Water[3]	Distilled Water[3]
Sampling Date:		24-Aug-04		(%)	7-Jul-04	7-Jul-04	27-Jul-04	17-Aug-04
Parameters	**Parameter Units**							
Hardness	mg/L	1380	1380	0.00	<0.54	<0.54	-	<0.54
Alkalinity	mg/L	128	128	0.00	-	-	-	<1.0
Aluminum	mg/L	<0.10	<0.1	n/a	<0.10	<0.10	<0.0010	<0.0010
Cadmium	mg/L	0.000342	0.000335	2.09	<0.000020	<0.000020	<0.000050	<0.00020
Iron	mg/L	0.015	0.014	7.14	<0.010	<0.010	<0.030	<0.030
Mercury	mg/L	<0.000010	<0.00001	n/a	<0.000010	<0.000010	<0.000050	<0.000010
Molybdenum	mg/L	<0.0050	<0.005	n/a	<0.0050	<0.0050	<0.000050	<0.0010
Ammonia	mg/L	0.114	0.133	14.29	-	-	-	0.028
Nitrate	mg/L	0.529	0.531	0.38	-	-	-	<0.0050
Arsenic	mg/L	<0.00020	<0.0002	n/a	<0.0010	<0.0010	<0.0010	<0.00020
Copper	mg/L	0.00140	0.00134	4.48	0.00012	0.00012	0.00023	<0.0010
Cyanide	mg/L	<0.0050	<0.005	n/a	-	-	-	<0.0050
Lead	mg/L	0.00116	0.00119	2.52	0.00017	0.00021	0.000209	<0.0010
Nickel	mg/L	0.00971	0.00967	0.41	<0.00050	<0.00050	<0.00050	<0.0010
Zinc	mg/L	0.0514	0.0498	3.21	0.0012	<0.0010	0.0025	<0.0050
TSS	mg/L	3.7	4.4	15.91	-	-	-	<3.0
Radium226	Bq/L	<0.0050	0.008	n/a	<0.0050	0.006	-	<0.0050
pH	pH units	7.93	7.84	1.15	-	-	-	5.51

Notes

[1]QAQC samples were collected during each EEM monitoring event. At least one field duplicate and/or one blank sample was collected during each event.

[2]RPD = Relative Percent Difference = [Absolute value (DUP-ORIG)/ORIG]*100%

Cells in grey shading have RPD values >50% for co-located field duplicates

[3]Distilled water from onsite distiller.

QAQC Results

A total of 4 duplicate samples and 3 blank samples were collected during the 2004 EEM program at Polaris mine. All RPD values were less than 50%, with the exception of one measurement of TSS on July 27, 2004. This data indicate good reproducibility between co-located field duplicates (i.e., low measurement and analytical variability).

Blank samples were typically less than, or slightly higher than detection limits, revealing no background contamination issues.

Table 2-5. 2005 Polaris Mine QAQC Sample Results[1] Including Field Duplicates, Field Blanks, and Transport Blanks.

Sample Type:		Field Duplicate	Original Sample		Field Duplicate	Original Sample		Field Duplicate	Original Sample	
Sample ID:		Dup	G Creek		Dup	G Creek		DUP	G-Creek	
Location:		Garrow Lake Syphons			Garrow Lake Syphons			Garrow Lake Syphons		
Description:		Final Discharge Point		RPD[2]	Final Discharge Point		RPD[2]	Final Discharge Point		RPD[2]
Sampling Date:		29-Jun-05		(%)	6-Jul-05		(%)	16-Jul-05		(%)
Parameters	Parameter Units									
Hardness	mg/L	124	132	6.1	140	149	6.0	187	184	1.6
Alkalinity, Total	mg/L	-	30.7	n/a	28.0	28.1	0.4	29.0	29.2	0.7
Aluminum, Total	mg/L	<0.10	<0.1	n/a	<0.10	<0.20	n/a	0.0087	0.0085	2.4
Cadmium, Total	mg/L	0.000042	0.000035	20.0	0.000040	0.000034	17.6	0.000049	0.000044	11.4
Iron, Total	mg/L	0.026	0.024	8.3	0.013	0.012	8.3	0.043	0.043	0.0
Mercury, Total	mg/L	<0.000010	<0.00001	n/a	<0.000010	<0.000010	n/a	<0.000010	<0.000010	n/a
Molybdenum, Total	mg/L	<0.0050	<0.005	n/a	<0.0050	<0.0050	n/a	<0.0050	<0.0050	n/a
Ammonia Nitrogen	mg/L	-	0.089	n/a	0.032	0.036	11.1	0.044	0.037	18.9
Nitrate Nitrogen	mg/L	-	0.038	n/a	0.028	0.032	12.5	<0.050	<0.050	n/a
Arsenic, Total	mg/L	<0.00020	<0.0002	n/a	0.00021	<0.00020	n/a	<0.00020	<0.00020	n/a
Copper, Total	mg/L	0.000444	<0.0005	n/a	0.000295	0.000240	22.9	0.000376	0.000424	11.3
Cyanide, Total	mg/L	-	<0.005	n/a	<0.0050	<0.0050	n/a	0.0058	0.0444	86.9
Lead, Total	mg/L	0.000414	0.00037	12.5	0.000241	0.000166	45.2	0.000409	0.000415	1.4
Nickel, Total	mg/L	0.000799	0.00075	6.0	0.000673	0.000601	12.0	0.000819	0.000807	1.5
Zinc, Total	mg/L	0.0143	0.0137	4.4	0.0136	0.0127	7.1	0.0185	0.0179	3.4
Total Suspended Solids	mg/L	-	<3	n/a	<3.0	4.0	n/a	<3.0	<3.0	n/a
Radium-226 (a,b)	Bq/L	-	<0.005	n/a	<0.0050	0.0050	n/a	<0.0050	0.009	n/a
pH	pH units	-	7.98	n/a	7.62	7.49	1.7	7.58	7.59	0.1
Salinity	o/oo	-	-		<1.0	<1.0	n/a	<1.0	<1.0	n/a
Calcium, Total	mg/L	-	-		16.5	19.1	13.6	21.4	21.1	1.4
Magnesium, Total	mg/L	-	-		24.0	24.6	2.4	32.3	31.9	1.3

Notes

[1]QAQC samples were collected during each EEM monitoring event. At least one field duplicate and/or one blank sample was collected during each event.

[2]RPD = Relative Percent Difference = [Absolute value (DUP-ORIG)/ORIG]*100%

Cells in grey shading have RPD values >50% for co-located field duplicates

[3]Distilled water from onsite distiller, stored for 1 year in jerry cans onsite.

[4]Commercial distilled water transported to mine site.

QAQC Results

A total of 3 duplicate samples and 5 blank samples were collected during the 2005 EEM program at Polaris mine. All RPD values were less than 50%, with the exception of one measurement of cyanide on July 16, 2005. Cyanide is not used in the process and is typically measured at less than the detection limit. With the exception of the aforementioned cyanide measurement, which is questionable, the data generally indicate good reproducibility between co-located field duplicates (i.e., low measurement and analytical variability).

Blank samples from the on-site distilled water that had been stored indicated relatively high levels of zinc, copper, and lead. This contamination was considered to be a result of the storage procedure and metal leaching from the metal jerry cans that the water was stored in for the year. The transport blanks using commmercial distilled water indicated low concentrations of all paramters (i.e., typically less than, or slightly higher than detection limits), which indicate no background contamination issues with the analysis.

Table 2-5. 2005 Polaris Mine QAQC Sample Results[1] Including Field Duplicates, Field Blanks, and Transport Blanks.

Sample Type:		Field Duplicate	Original Sample		Field Blank	Field Blank	Field Blank	Field Blank	ALS Travel Blank	ALS Travel Blank
Sample ID:		Dup	Ref							
Location:		Garrow Bay Reference			n/a	n/a	n/a	n/a	n/a	n/a
Description:		~1km NE of confluence with Garrow Creek		RPD[2]	Distilled Water[3]	Distilled Water[3]	Distilled Water[3]	Distilled Water[3]	Distilled Water[4]	Distilled Water[5]
Sampling Date:		6-Aug-05		(%)	29-Jun-05	6-Jul-05	16-Jul-05	6-Aug-05	24-Aug-05	24-Aug-05
Parameters	**Parameter Units**									
Hardness	mg/L	852	840	1.4	0.61	3.07	<0.54	0.85	<0.50	<0.50
Alkalinity, Total	mg/L	53.8	53.5	0.6	-	3.2	<2.0	<2.0	<2.0	<2.0
Aluminum, Total	mg/L	<0.10	<0.10	n/a	<0.0010	<0.0010	<0.0050	<0.10	<0.0010	<0.0010
Cadmium, Total	mg/L	<0.000020	<0.000020	n/a	<0.000050	<0.000050	<0.000020	<0.000050	<0.000020	<0.000050
Iron, Total	mg/L	0.011	0.011	0.0	<0.030	<0.010	<0.010	<0.010	<0.010	<0.010
Mercury, Total	mg/L	<0.000010	<0.000010	n/a	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum, Total	mg/L	<0.0050	<0.0050	n/a	<0.000050	<0.000050	<0.0050	<0.0050	<0.000050	<0.000050
Ammonia Nitrogen	mg/L	<0.020	<0.020	n/a	-	<0.020	<0.020	<0.020	-	-
Nitrate Nitrogen	mg/L	0.0348	0.0261	33.3	-	<0.0050	<0.0050	<0.0050	-	-
Arsenic, Total	mg/L	<0.00020	0.00024	n/a	0.00033	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Copper, Total	mg/L	0.000321	0.000305	5.2	0.0151	0.00484	0.00167	0.0244	<0.000050	<0.00010
Cyanide, Total	mg/L	<0.0050	<0.0050	n/a	-	<0.0050	<0.0050	<0.0050	-	-
Lead, Total	mg/L	0.000062	0.000078	20.5	0.0143	0.00212	0.00607	0.0445	<0.000050	<0.000050
Nickel, Total	mg/L	0.000460	0.000412	11.7	<0.00010	<0.00010	<0.000050	<0.00050	<0.000050	<0.00010
Zinc, Total	mg/L	0.00165	0.00122	35.2	0.0084	0.0080	0.00440	0.0040	<0.00050	<0.0010
Total Suspended Solids	mg/L	<3.0	<3.0	n/a	-	<3.0	<3.0	<3.0	<3.0	<3.0
Radium-226 (a,b)	Bq/L	0.0060	<0.0050	n/a	<0.0050	<0.0050	<0.0050	<0.0050	-	-
pH	pH units	7.80	7.89	1.1	-	6.27	5.59	6.17	5.51	5.53
Salinity	o/oo	4.6	4.6	0.0	-	<1.0	<1.0	<1.0	<1.0	<1.0
Calcium, Total	mg/L	58.1	57.6	0.9	-	1.23	0.084	0.341	<0.050	<0.050
Magnesium, Total	mg/L	172	169	1.8	-	<0.10	<0.10	<0.10	<0.050	<0.050

Notes

[1]QAQC samples were collected during each EEM monitoring event. At least one field duplicate and/or one blank sample was collected during each event.

[2]RPD = Relative Percent Difference = [Absolute value (DUP-ORIG)/ORIG]*100%

Cells in grey shading have RPD values >50% for co-located field duplicates

[3]Distilled water from onsite distiller, stored for 1 year in jerry cans onsite.

[4]Commercial distilled water transported to mine site.

QAQC Results

A total of 3 duplicate samples and 5 blank samples were collected during the 2005 EEM program at Polaris mine. All RPD values were less than 50%, with the exception of one measurement of cyanide on July 16, 2005. Cyanide is not used in the process and is typically measured at less than the detection limit. With the exception of the aforementioned cyanide measurement, which is questionable, the data generally indicate good reproducibility between co-located field duplicates (i.e., low measurement and analytical variability).

Blank samples from the on-site distilled water that had been stored indicated relatively high levels of zinc, copper, and lead. This contamination was considered to be a result of the storage procedure and metal leaching from the metal jerry cans that the water was stored in for the year. The transport blanks using commmercial distilled water indicated low concentrations of all paramters (i.e., typically less than, or slightly higher than detection limits), which indicate no background contamination issues with the analysis.

Table 2-6. Summary of Polaris Mine acute toxicity tests, 2003 - 2005.

Facility Name: Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)
Final Discharge Point Name: Garrow Lake Syphons
Northing: 75°22'32"
Easting: 96°48'37"

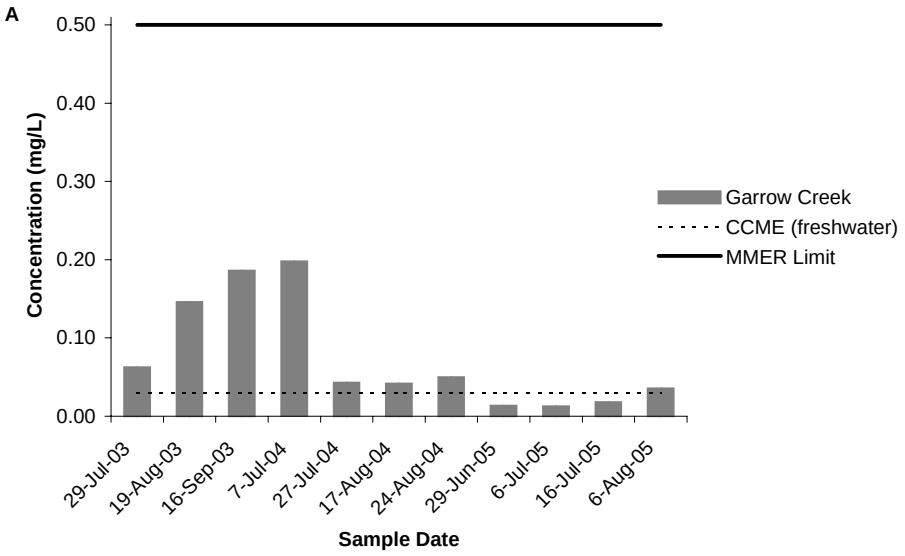
Test Date	Species Tested	Test Type	Sample Method	Consultant Laboratory	LC50 (% effluent)	LC50 Lower Confidence Limit (% effluent)	LC50 Upper Confidence Limit (% effluent)
Rainbow Trout 96-hr LC50							
29-Jul-03	*Oncorhynchus mykiss*	Survival	Grab	EVS Consultants, North Vancouver, BC	> 100	-	-
19-Aug-03	*Oncorhynchus mykiss*	Survival	Grab	EVS Consultants, North Vancouver, BC	> 100	-	-
16-Sep-03	*Oncorhynchus mykiss*	Survival	Grab	EVS Consultants, North Vancouver, BC	> 100	-	-
7-Jul-04	*Oncorhynchus mykiss*	Survival	Grab	EVS Consultants, North Vancouver, BC	> 100	-	-
27-Jul-04	*Oncorhynchus mykiss*	Survival	Grab	EVS Consultants, North Vancouver, BC	> 100	-	-
24-Aug-04	*Oncorhynchus mykiss*	Survival	Grab	EVS Consultants North Vancouver, BC	> 100	-	-
16-Jul-05	*Oncorhynchus mykiss*	Survival	Grab	EVS Consultants North Vancouver, BC	> 100	-	-
6-Aug-05	*Oncorhynchus mykiss*	Survival	Grab	EVS Consultants North Vancouver, BC	> 100	-	-
***Daphnia magna* 48-hr LC50**							
29-Jul-03	*Daphnia magna*	Survival	Grab	EVS Consultants, North Vancouver, BC	> 100	-	-
19-Aug-03	*Daphnia magna*	Survival	Grab	EVS Consultants North Vancouver, BC	> 100	-	-
16-Sep-03	*Daphnia magna*	Survival	Grab	EVS Consultants North Vancouver, BC	> 100	-	-
7-Jul-04	*Daphnia magna*	Survival	Grab	EVS Consultants, North Vancouver, BC	> 100	-	-
27-Jul-04	*Daphnia magna*	Survival	Grab	EVS Consultants North Vancouver, BC	> 100	-	-
24-Aug-04	*Daphnia magna*	Survival	Grab	EVS Consultants North Vancouver, BC	> 100	-	-
16-Jul-05	*Daphnia magna*	Survival	Grab	EVS Consultants North Vancouver, BC	> 100	-	-
6-Aug-05	*Daphnia magna*	Survival	Grab	EVS Consultants North Vancouver, BC	> 100	-	-
						-	-

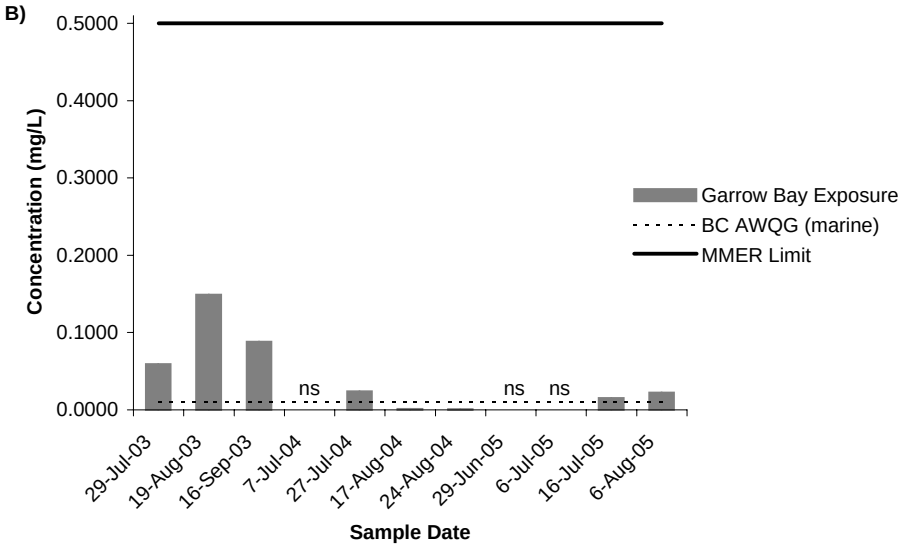
Table 2-7. Summary of Polaris Mine sublethal toxicity tests 2003 - 2005.

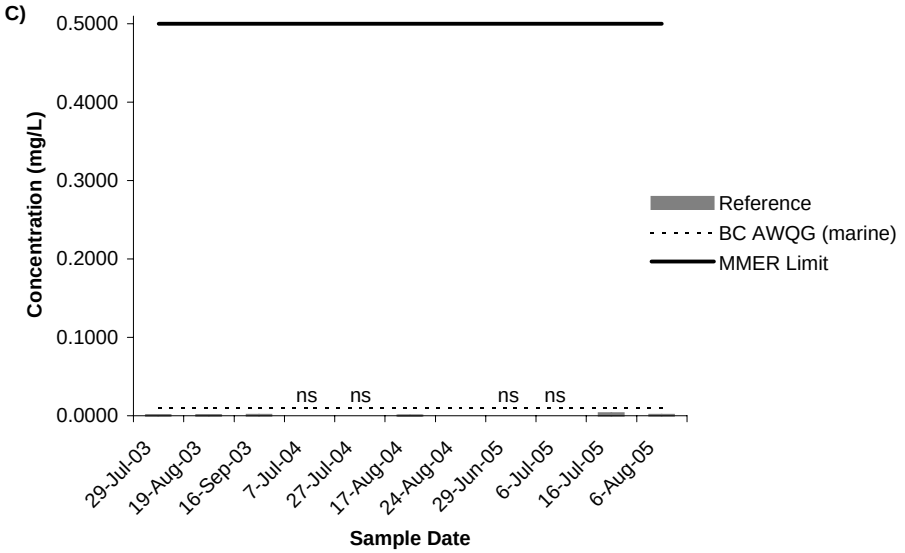
Facility Name: Teck Cominco Metals - Polaris Mine (Little Cornwallis Island)
Final Discharge Point Name: Garrow Lake Syphons
Northing: 75°22'32"
Easting: 96°48'37"

Test Date	Species Tested	Test Type	Sample Method	Consultant Laboratory	EC25 or IC25 (% effluent)	EC25 or IC25 Lower Confidence Limit (% effluent)	EC25 or IC25 Upper Confidence Limit (% effluent)
Topsmelt (*Atherinops affinis*) 7-d Growth and Survival Toxicity Test - Growth Endpoint							
19-Aug-03	*Atherinops affinis*	Growth	Grab	EVS Consultants, North Vancouver, BC	> 72.3	-	-
7-Jul-04	*Atherinops affinis*	Growth	Grab	EVS Consultants, North Vancouver, BC	> 72.6	-	-
27-Jul-04	*Atherinops affinis*	Growth	Grab	EVS Consultants, North Vancouver, BC	> 69.0	-	-
24-Aug-04	*Atherinops affinis*	Growth	Grab	EVS Consultants North Vancouver, BC	> 71.0	-	-
16-Jul-05	*Atherinops affinis*	Growth	Grab	EVS Consultants North Vancouver, BC	> 71.4	-	-
6-Aug-05	*Atherinops affinis*	Growth	Grab	EVS Consultants North Vancouver, BC	> 67.4	-	-
Topsmelt (*Atherinops affinis*) 7-d Growth and Survival Toxicity Test - Survival Endpoint					**LC50 (% effluent) for survival endpoint only**		
19-Aug-03	Atherinops affinis	Survival	Grab	EVS Consultants, North Vancouver, BC	> 72.3	-	-
7-Jul-04	Atherinops affinis	Survival	Grab	EVS Consultants, North Vancouver, BC	> 72.6	-	-
27-Jul-04	Atherinops affinis	Survival	Grab	EVS Consultants, North Vancouver, BC	> 69.0	-	-
24-Aug-04	Atherinops affinis	Survival	Grab	EVS Consultants, North Vancouver, BC	> 71.0	-	-
16-Jul-05	Atherinops affinis	Survival	Grab	EVS Consultants, North Vancouver, BC	> 71.4	-	-
6-Aug-05	Atherinops affinis	Survival	Grab	EVS Consultants, North Vancouver, BC	> 67.4	-	-
Sandollar Echinoderm (*Dendraster excentricus*) 92-h Echinoderm Fertilization Test							
19-Aug-03	*Dendraster excentricus*	Reproduction	Grab	EVS Consultants North Vancouver, BC	3.8	1.1	7.2
27-Jul-04	*Dendraster excentricus*	Reproduction	Grab	EVS Consultants North Vancouver, BC	8.7	7.6	9.9
24-Aug-04	*Dendraster excentricus*	Reproduction	Grab	EVS Consultants North Vancouver, BC	17.5	11.6	22.6
16-Jul-05	*Dendraster excentricus*	Reproduction	Grab	EVS Consultants North Vancouver, BC	5.2	4.4	6
6-Aug-05	*Dendraster excentricus*	Reproduction	Grab	EVS Consultants North Vancouver, BC	15.6	13.6	18.3
Red Algae (*Champia parvula*) 7-d Sublethal Algal Toxicity Test							
19-Aug-03	*Champia parvula*	Reproduction	Grab	Saskatchewan Research Council (SRC), Saskatoon, SK	13.6	9.0	16.0
27-Jul-04	*Champia parvula*	Reproduction	Grab	SRC, Saskatoon, SK	26.6	20.8	31.5
24-Aug-04	*Champia parvula*	Reproduction	Grab	SRC, Saskatoon, SK	45.3	36.3	58.1
16-Jul-05	*Champia parvula*	Reproduction	Grab	Stantec Inc, Guelph,ON	24.6	22.2	27.2
6-Aug-05	*Champia parvula*	Reproduction	Grab	SRC, Saskatoon, SK	45.3	27.5	52.4

Figure 2-1. Zinc concentrations at (A) Garrow Creek final discharge point (Garrow Lake Syphons), (B) Garrow Bay exposure station, and (C) Garrow Bay reference station, 2003 - 2005.

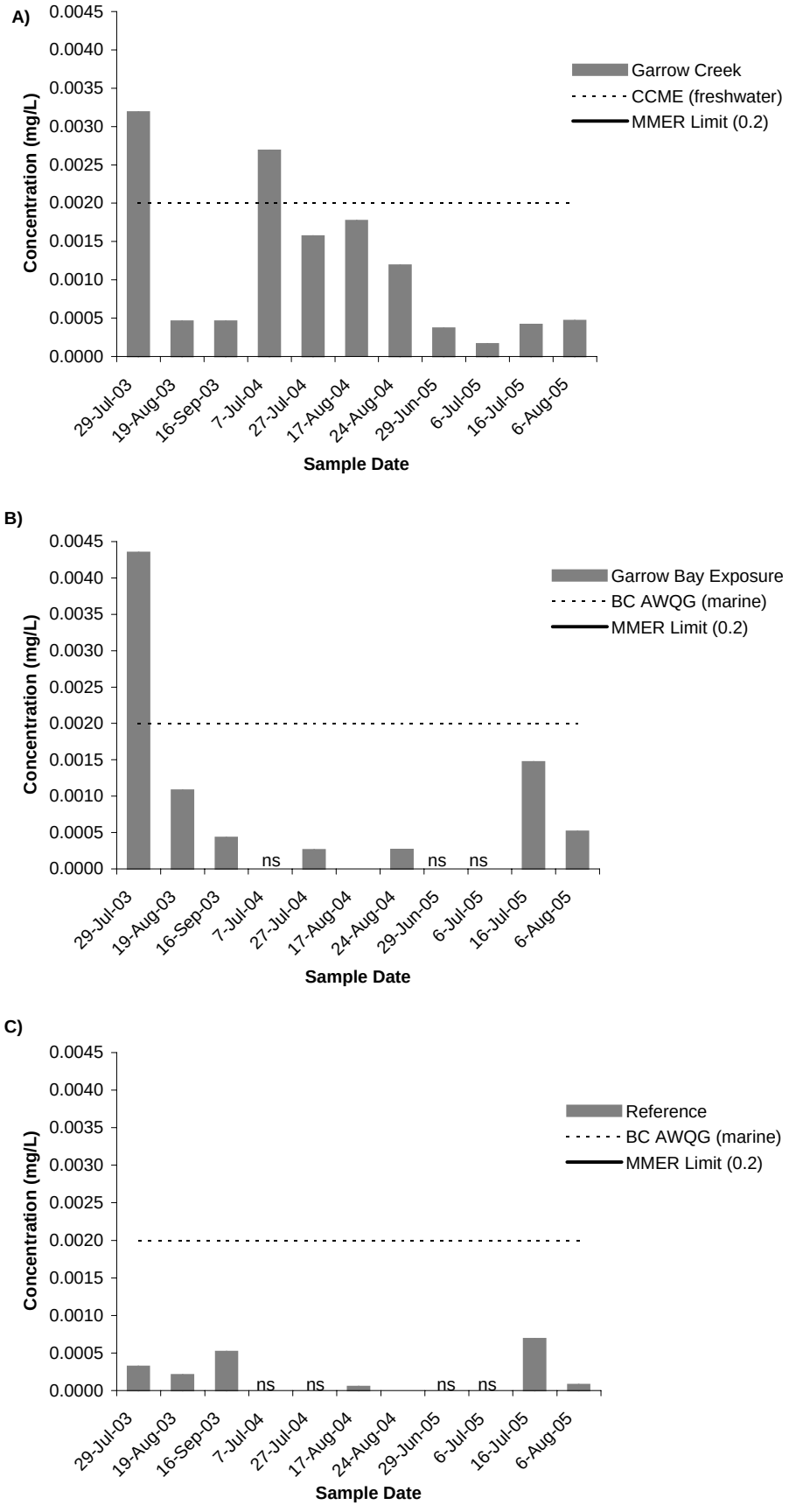






Note: ns = no sample due to ice covered conditions in Garrow Bay.
MMER criterion is monthly mean (Schedule 4, column 2)
The BC AWQG for zinc is a recommended guideline for marine waters

Figure 2-2. Lead concentrations at (A) Garrow Creek final discharge point (Garrow Lake Syphons), (B) Garrow Bay exposure station, and (C) Garrow Bay reference station, 2003 - 2005.



Note: ns = no sample due to ice covered conditions in Garrow Bay.
MMER criterion is monthly mean (Schedule 4, column 2)
The BC AWQG for lead is the 30-day chronic guideline for marine and estuarine waters

3 FUTURE TRENDS IN EFFLUENT CHARACTERISTICS

This section provides a discussion of anticipated future trends in effluent characteristics and was included in the interpretative report to provide some context for understanding potential implications for receiving environment quality in the long-term.

3.1 Summary of Garrow Lake Investigations (Appendix E)

As part of a 2002 DFO habitat authorization (02-HCAA-000-000063) during the decommissioning and dam removal process from the mouth of Garrow Lake, Teck Cominco was specifically required to measure the following:

- "TSS and turbidity in different strata of Garrow Lake to confirm the absence of contaminants in surface waters;
- metals concentration in sediment in the littoral zone of Garrow Lake; and
- whole-body metal concentration in fourhorn sculpin".

Garrow Lake was the recipient of all metals contaminated mine tailings during the 20 year operation of the mine and water discharge from the lake to Garrow Creek effectively represent the mine's effluent. Therefore, understanding the limnology and surface water chemistry of the lake is very relevant to understanding chemical features of the creek that is measured for chemistry and toxicity on a regular basis throughout the summer open water season.

Garrow Lake is small, ultra-oligotrophic and permanently chemically and thermally stratified (i.e., meromictic). Between 1981 and 2002, approximately 15 million tonnes of tailings solids were deposited into the lake within the monimnolimnion (i.e., unmixed deep layer). Prior to tailings deposition, the biologically active mixolimnion (i.e., well-mixed surface layer) ranged between zero and 12 m – 14 m in depth and was well oxygenated, cold and brackish (3 – 7 ppt salinity). The deep monimolimnion extended from about 18 m to the bottom and was unusually warm (8^{o}C), completely anoxic, sulphide rich and hypersaline, with a salinity of nearly 90 ppt. These layers were separated by a 6 m thick pycnocline (i.e., density barrier) where temperature increased, oxygen concentration fell and salinity increased rapidly with increasing depth.

Over time, tailings disposal caused upward displacement of the mixolimnion, thinning of the pycnocline and reduced total water depth of the lake from 46 m to 42 m. Discharge of tailings also caused vertical mixing within the monimolimnion and reduced mean salinity, from 90 ppt to 70 ppt. Although mixolimnion thickness was reduced by four or five meters vertical temperature, oxygen and salinity profiles do not appear to have changed since prior to mining.

As mentioned above, surface waters of Garrow Lake constitute the "effluent" or outflow from Garrow Creek. Early in spring (late June) when the creek channel thaws and discharge begins, the creek consists of melt water from the creek channel and surrounding terrestrial area that thaws before the lake does. One or two weeks after the creek channel begins to flow, ice on Garrow Lake melts and the discharge is comprised of melt-water from ice and snow from the lake and surrounding basin. During mid- to late summer (August), discharge to the creek consists primarily of surface water from Garrow Lake itself, as water chemistry of the creek more closely mirrors mixolimnion water chemistry from the lake.

To determine the possible effects of more than 20 years of tailings disposal, a comprehensive investigation of the limnology and ecology of Garrow Lake was conducted in August 2003 (see complete report in **Appendix E**). Prior to mining, the lake supported a depauperate biological community including a small, dwarf population of landlocked fourhorn sculpin (*Myoxocephalus quadricornis*). Despite routine monitoring of lake water quality and stratification during mine life, there was no evaluation of changes in sediment quality or biological community structure during tailings disposal to the lake bottom between 1980 and September 1992.

Tailings deposition has not changed limnological conditions of the mixolimnion (0 – 9 m). Winter and summer water temperatures remain cold, ranging from –0.5 ^{o}C to 4 ^{o}C with little difference between seasons. Salinity ranged from 3.8 ppt at the surface to 7.1 ppt at the pycnocline (9 m) with slight inverse stratification. Oxygen concentration was stratified and high in winter (13 – 20 mg/L) and supersaturated, a condition also noted during pre-mine conditions, presumably from algae and photosynthetic bacteria. During mid-summer, oxygen concentration was high but was not supersaturated because absence of ice cover and mixing by wind, allowing oxygen to escape to the atmosphere.
In 1984/85, a pipeline break caused tailings to spill into the littoral zone, resulting in widespread contamination of zinc in littoral zone sediment. This caused an increase in lead and zinc concentration of nearly two orders of magnitude in surface waters of Garrow Lake and the outflow creek. Pre-mine zinc concentration in surface waters was 0.003 mg/L. Shortly after the spill, zinc concentration was 0.23 mg/L and remained steady until the end of mining in 2002. Since 2001 (0.22 mg/L), zinc concentration in the mixolimnion has been gradually declining, from 0.18 mg/L in 2003 to 0.13 mg/L in summer 2005.

Vertical distribution of zinc concentration from the center and south end of Garrow Lake between 2003 and 2005 is depicted in **Figure 3-1**. Late-winter zinc concentration in the mixolimnion (to 9 m) averages 0.21 mg/L and is nearly double open-water (summer) zinc concentration because of dilution by ice and snow melt. Zinc concentration at the top of the pycnocline is highest at more than 1.0 mg/L because of accumulation within bacterial tissue that have settled at the top of the density barrier. Note that since tailings deposition to the monimolimnion has ceased, zinc concentration in deep water (>15 m) has declined

considerably, from 0.28 mg/L in 2003, to 0.04 mg/L in 2005. Thus, zinc concentration in surface and deep waters have declined by 50% and 80% respectively in the three years since cessation of tailings deposition. This suggests that water quality will continue to improve.

Nineteen sculpins were captured in 2003 and all appeared to be healthy with no external or internal tumors, scars or other abnormalities. Mean length (149 mm), weight (25 g) and condition (0.70) of sculpins from 2003 did not differ from sculpins collected in 1976 (155 mm, 26 g, 0.72), several years before mining.

Whole body concentration of manganese, lead (0.81 mg/kg ww) and zinc (72 mg/kg) in sculpins was higher in 2003 than prior to mining. Other metals including arsenic, cadmium, copper, mercury, and nickel were lower or did not differ among years. Elevated lead and zinc concentrations in sediment and the water column as a result of the spill appear responsible for elevated tissue concentration, however, the magnitude of increase in tissue was small, only 2 – 3 times higher than pre-mining concentration, despite a two-order of magnitude increase in lead and zinc concentration in sediment.

The size, distribution, growth rate and reproductive status of the sculpin community has not changed markedly since pre-mining studies, although sculpins were more difficult to capture and did not appear to be as abundant as pre-mine surveys. This may be related to reduced benthic habitat available to sculpins and their food sources because of gradual upward displacement of the mixolimnion. Nevertheless, sculpins have survived in Garrow Lake throughout the history of mining and tailings deposition to the lake, which is still designated as a tailings disposal facility. Presence and health of sculpins in Garrow Lake is circumstantially relevant because these fish have survived in what is in effect "100% effluent" during mine life and have not appeared to have suffered any ill effects.

3.2 Future Effluent Characteristics and Effects

Despite considerable planning and efforts spent in conducting biological monitoring studies in Garrow Bay, a formal EEM program could not be implemented due to the harsh field conditions encountered on Little Cornwallis Island. Notwithstanding this, historical information as well as more recent data, especially those collected in the field during the 2003 reconnaissance studies, were considered relevant for understanding the likelihood of adverse biological effects occurring in the Garrow Bay receiving environment.

Specifically, the following paragraphs summarize the findings of multiple lines of evidence compiled in this report (**Appendices A to E**). Together, they represent a weight-of-evidence assessment providing some context for evaluating long-term conditions:

- Water chemistry in Garrow Creek changes over the course of the summer. Local channel and terrestrial snow melt that is low in metals dominates early creek flow

and is gradually replaced by outflow from Garrow Lake that is higher in metals. All metals concentrations are well below MMER limits. The only metal to consistently exceed the CCME freshwater guideline for the protection of aquatic life (0.03 mg/L or 30 µg/L) was zinc. The mean zinc concentration in Garrow Creek during mining was consistently about 0.20 mg/L or about seven times the CCME guideline. Surface water zinc concentrations in Garrow Lake and Garrow Creek have diminished since mining ended in 2002. Total zinc concentrations (mg/L) in effluent from monthly samples between 2003 and 2005 illustrate this trend.

Total zinc concentration (mg/L) in monthly effluent samples

	2003	2004	2005
Late June	0.062	0.198	0.0127
July	0.146	0.043	0.0179
August	0.186	0.042	0.0356

Total zinc concentration in 2005 was consistently lower in concentration (3 – 6 times) than in 2003. This is a reflection of the reduced zinc concentration in mixolimnion of Garrow Lake (**Figure 3-1**). Thus, zinc concentration appears to be diminishing over time and is expected to continue to diminish. In 2005, zinc only slightly exceeded the CCME guideline of 0.03 mg/L on one occasion in August.

- Surface (mixolimnion) and deep (monimolimnion) zinc concentrations in Garrow Lake have diminished throughout the water column as can be seen from vertical zinc profiles during winter/summer since 2003 (**Figure 3-1**). It is expected that concentrations will continue to decline in the absence of mining.
- Despite 20 years of mining and discharge of creek water with elevated zinc concentrations, there has been no biologically significant accumulation of zinc in sediments of Garrow Bay (2003 reconnaissance sampling program; **Appendix B**). Zinc concentrations in intertidal sediments at the creek mouth ranged from 72 to 103 mg/kg in 2003, which is approximately twice background concentrations, but is lower than the conservative CCME interim sediment quality guideline (ISQG) of 124 mg/kg for marine sediments. Zinc concentrations in subtidal sediment ranged from 29 – 39 mg/kg, which is similar to reference area sediment and similar to pre-mining sediment concentrations. Pre-mine (1978) sediment zinc concentrations (Fallis, 1984) ranged from 29 – 38 mg/kg. These data

indicate that there has been no biologically significant accumulation of zinc in intertidal and subtidal sediments during 20 years of effluent discharge.

- Empirical data and theoretical modeling of brackish Garrow Creek water entering the marine environment of Garrow Bay confirmed that the plume is small, confined to a thin surface layer and is rapidly broken down and mixed by currents, wind-driven mixing and by ice. The low salinity creek water enters Garrow Bay as a thin (< 20 cm), narrow plume that likely becomes laterally and vertically dispersed well within the intertidal, ice-scour zone of Garrow Bay. Concentrations of zinc in marine water immediately below the plume are similar to background. There does not appear to be any exposure pathway of zinc or any other metal to marine sediments. This assumption is supported by the sediment data.

- No acute toxicity to rainbow trout or *Daphnia magna* was measured during three years of toxicity testing. No mortality or sublethal effects (growth) were observed for topsmelt (*Atherinops affinis*) during three years of testing. Sublethal toxicity was detected in Echinoderm sand dollar (*Dendraster excentricus*; 5 – 15% effluent concentration) and algae (*Champia parvula*; 25 – 45 % effluent concentration) in 2005. Based on comparisons between toxicity test results and calculated lead and zinc concentrations in matching effluent samples, it is likely that zinc was responsible for the sublethal effects observed in both the *Dendraster* and *Champia* laboratory tests. However, toxicity threshold levels appeared to be lower than the CCME freshwater guideline, which indicates that these species may have been unusually sensitive. Other lines of evidence presented in this section address potential implications of these results for marine organisms residing in the Garrow Bay receiving environment.

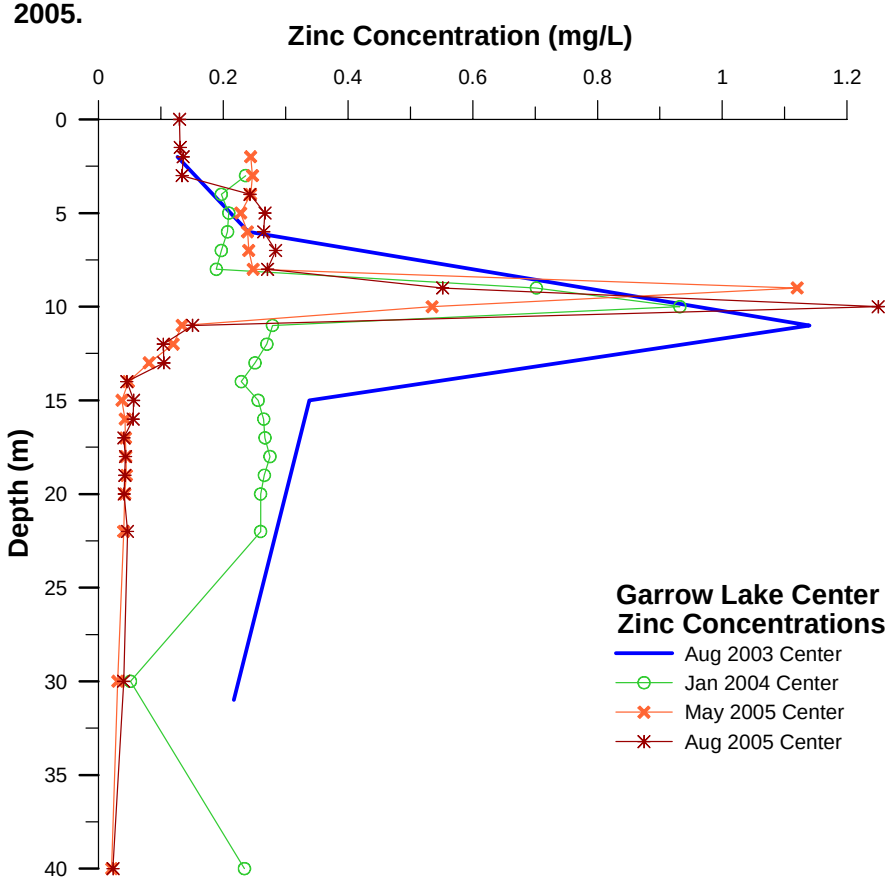
- During the 2003 reconnaissance studies (see **Appendix B**), marine clams (*Mya truncata*) were collected by divers from three exposure stations surrounding the mouth of Garrow Creek. These stations were located in the subtidal zone between 7 m and 10 m depth and were about 200 m offshore (i.e., the most near-field location where clams could be found). In addition, clams were also collected at a reference station located 1 km south of the creek. Zinc concentrations in tissue composites ranged from 15 – 39 mg/kg, 15 – 31 mg/kg, and 26 – 33 mg/kg for the three exposure stations. Zinc concentrations in reference clams ranged from 18 – 32 mg/kg, which is consistent with exposure stations. These tissue concentrations are also similar to clam data collected in Garrow Bay prior to mining (29 – 38 mg/kg; Fallis, 1984). Consequently, clams do not show any evidence of metals accumulation as a result of effluent exposure.

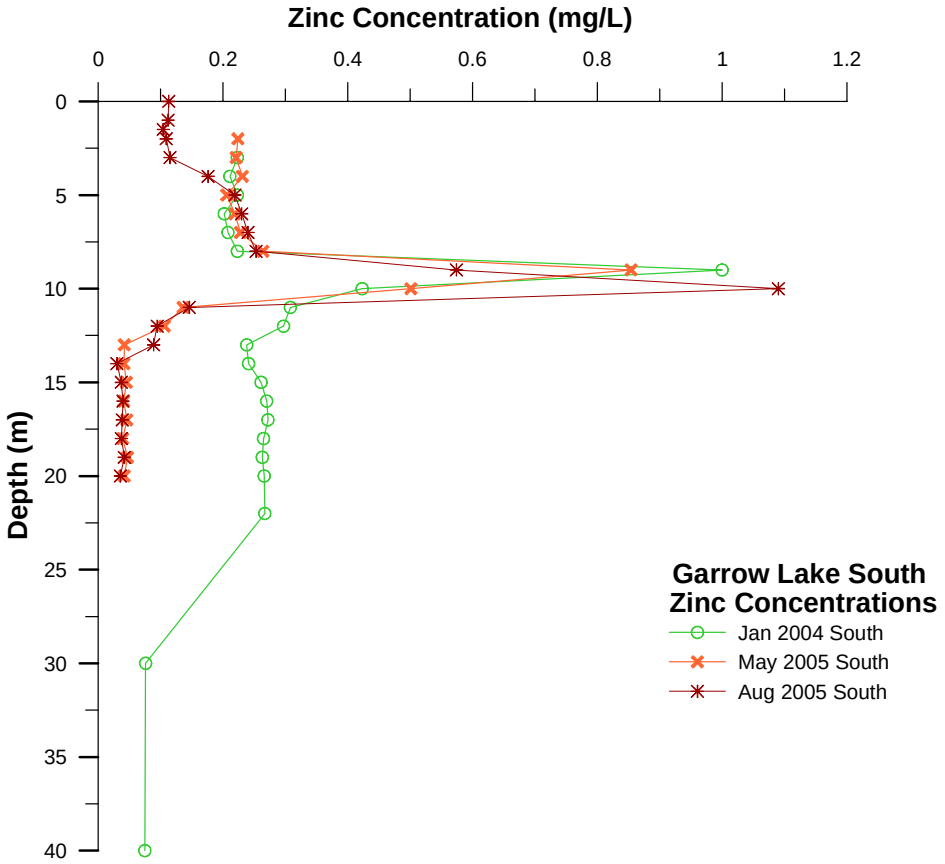
- Divers conducted an underwater video survey during the 2003 reconnaissance study (see **Appendix B**). The survey focused on the exposure area located near the mouth of Garrow Creek. Overall, growth and abundance of marine kelp and

other marine organisms did not appear to be impaired relative to observations made during clam tissue sampling at the reference location. Rather, distribution and abundance of marine organisms appeared strongly dictated by depth of ice within the ice-scour zone that extended for at least 100 m offshore.

Based on the above lines of evidence, the likelihood of potential effects to marine life in Garrow Bay under current conditions appears negligible to low. Furthermore, since concentrations of zinc in surface waters of Garrow Lake and Garrow Creek appear to have decreased considerably since mining ceased in 2002, the likelihood of future long-term effects is also considered negligible. Note that the latter prediction assumes that metals exposure will remain the same as present or continue to show improvements. This is predicated on the assumption that Garrow Lake will remain permanently chemically stratified. In 2000, Teck Cominco commissioned AXYS (2001) to determine whether lowering mixolimnion depth to 7 m risked turnover and mixing of the mixolimnion and metals-rich monimolimnion. If this occurred, this might result in contamination of the lake and therefore, Garrow Creek. AXYS (2001) concluded that the density barrier of the pycnocline was strong enough that it cannot be broken down or compromised by wind and wave action. Thus, no mixing of the mixolimnion and monimolimnion appears possible. There is on-going, twice annual monitoring of the water column to monitor this situation and verify this assumption.

Figure 3-1. Summary of zinc concentrations (mg/L) as a function of depth (m) at Garrow Lake center (left) and south (right) stations, 2003-2005.





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