Polaris Mine EEM - Outline of Study Design for Biological Monitoring Studies

Highlights:

- Program builds on 1) results of historical studies covering pre-mining and operational periods; 2) findings of 2003 reconnaissance studies (i.e., field effluent plume delineation, underwater video survey, fish survey, and sediment survey); 3) theoretical effluent plume modeling; and 4) considerable feedback obtained during consultations with the Technical Advisory Panel (TAP) as part of two workshops (April and December 2003) and follow-up discussions.

- Approach consists of a Control/Impact design focusing on one high exposure area (i.e., aquatic receiving environment that is nearest to the mouth of Garrow Creek and that contains an appropriate habitat type with sufficient geographic area to accommodate the necessary number of replicate stations; Environment Canada, 2002) and one reference area. Both areas are located in Garrow Bay, approximately 1 km apart (see attached figure).

- Our rationale for targeting one high exposure area, rather than multiple near-field and far-field exposure areas, follows guidance from Environment Canada (2002) and reflects findings of the 2003 reconnaissance studies which clearly indicated the lack of an exposure gradient between the mouth of Garrow Creek and the reference area.

- The field program is planned from August 11th - 25th 2004, when the likelihood of safe access to Garrow Bay for sampling is optimal.

- Standard and accepted QAQC procedures will be used throughout the program.

- The proposed study design is optimistic. While every attempt will be made to achieve the goals of the program, field conditions and safety issues may require us to focus on a few priority study components. As discussed with members of the TAP, all clam, benthos, and sediment collections will be diver-assisted, so local weather and ice conditions will dictate level of effort. We propose the following priorities and would appreciate feeback from the TAP: 1) fish survey and tissue analyses; 2) supporting environmental variables (water and sediment quality surveys); 3) SIMS survey (faster to accomplish and provides semi-quantitative basis for evaluating any gross impacts to marine communities); and 4) benthic invertebrate community survey (time intensive given replication required to achieve statistically sound assessment).

Study Component	Sampling Areas	Sample Size and Replication		Mesurement Endpoints	Sampling Method
Fish Survey and Tissue Analyses - Species selected: softshell clam (*Mya truncata*)	**Garrow Bay high exposure area**: located in the area closest to the mouth of Garrow Creek where sufficient clams can be collected (approx. 6 - 8 m depth)	- Target of 40 clams[1]	- Individual clams	- Length - Width - Whole animal wet weight - Shell weight - Soft tissue fresh weight - Gonad fresh weight - Sex - Condition index - Gonadosomatic index[2]	- Diver-assisted sampling; collection of individuals by hand, only intact clams will be retained
			- 4 soft tissue composites of 10 undepurated clams	- Tissue chemistry: moisture and lipid content, suite of metals	
	Garrow Bay reference area: located approximately 1 km to the northeast, upstream of the predominant current direction (approx. 6 - 8 m depth)	- Target of 40 clams[1]	- Individual clams	Same as high exposure area	Same as high exposure area
			- 4 soft tissue composites of 10 undepurated clams	Same as high exposure area	
Benthic Invertebrate Community Survey	**Garrow Bay high exposure area**: located in the area closest to the mouth of Garrow Creek where benthic communities can be sampled (approx. 6 - 8 m depth)	- 5 replicate stations (approx. 10 m x 10 m each and separated by approx. 50 m)	- 5 x 1L subsamples per station	- Total invertebrate density - Taxon richness - Simpson's diversity index - Bray-Curtis index - Evenness - Taxon density - Taxon proportions - Taxon presence/absence	- Diver-assisted sampling; upper 10 cm of sediment will be collected for each subsample using a 1L plastic container - All 5 x 1L subsamples for a given station will be physically pooled prior to processing - Processing will be performed using a 1 mm mesh size - Identifications will be performed to the lowest practicable taxonomic level
	Garrow Bay reference area: located approximately 1 km to the northeast, upstream of the predominant current direction (approx. 6 - 8 m depth)	- 5 replicate stations (approx. 10 m x 10 m each and separated by approx. 50 m)	- 5 x 1L subsamples per station	Same as high exposure area	Same as high exposure area

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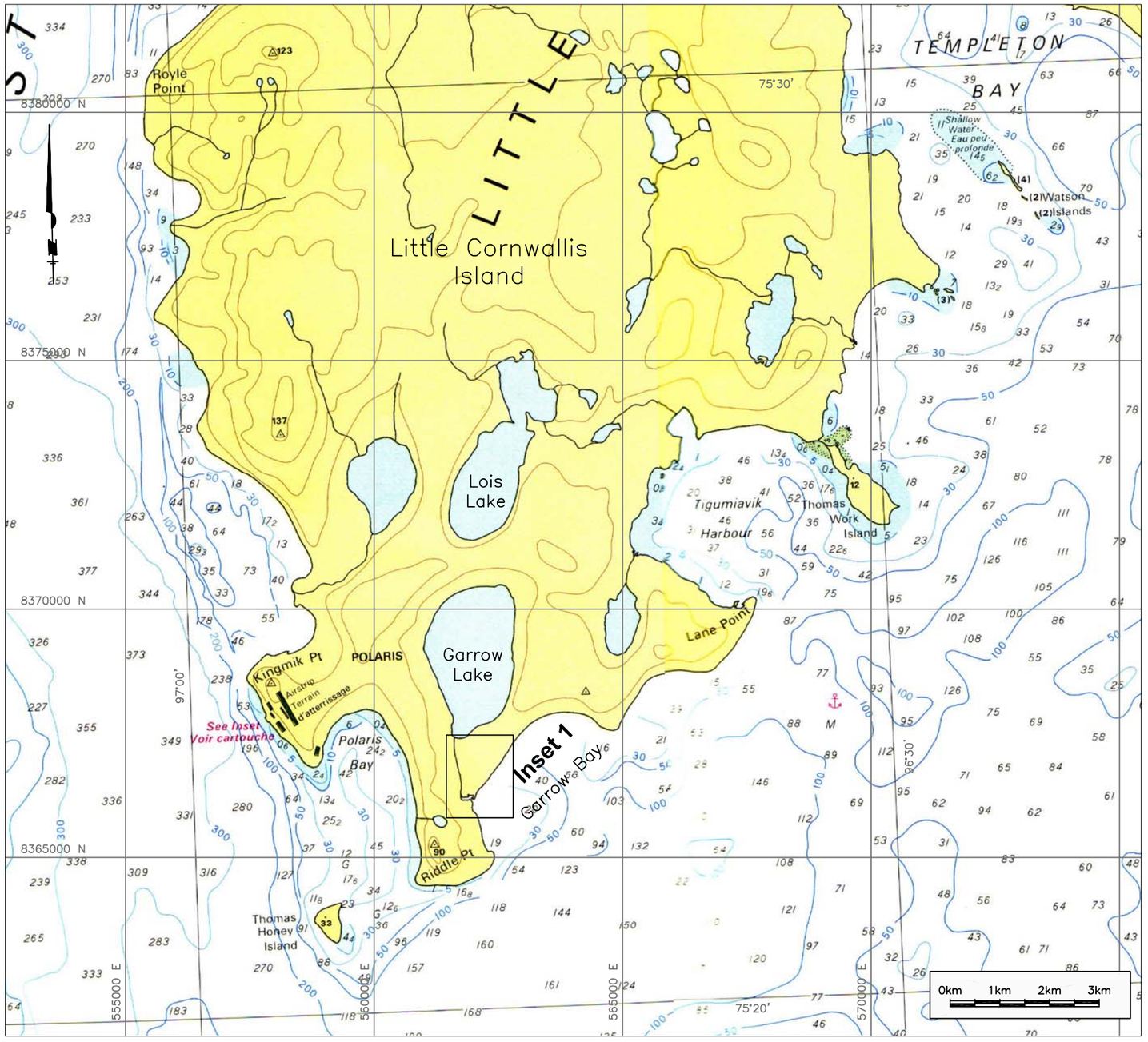
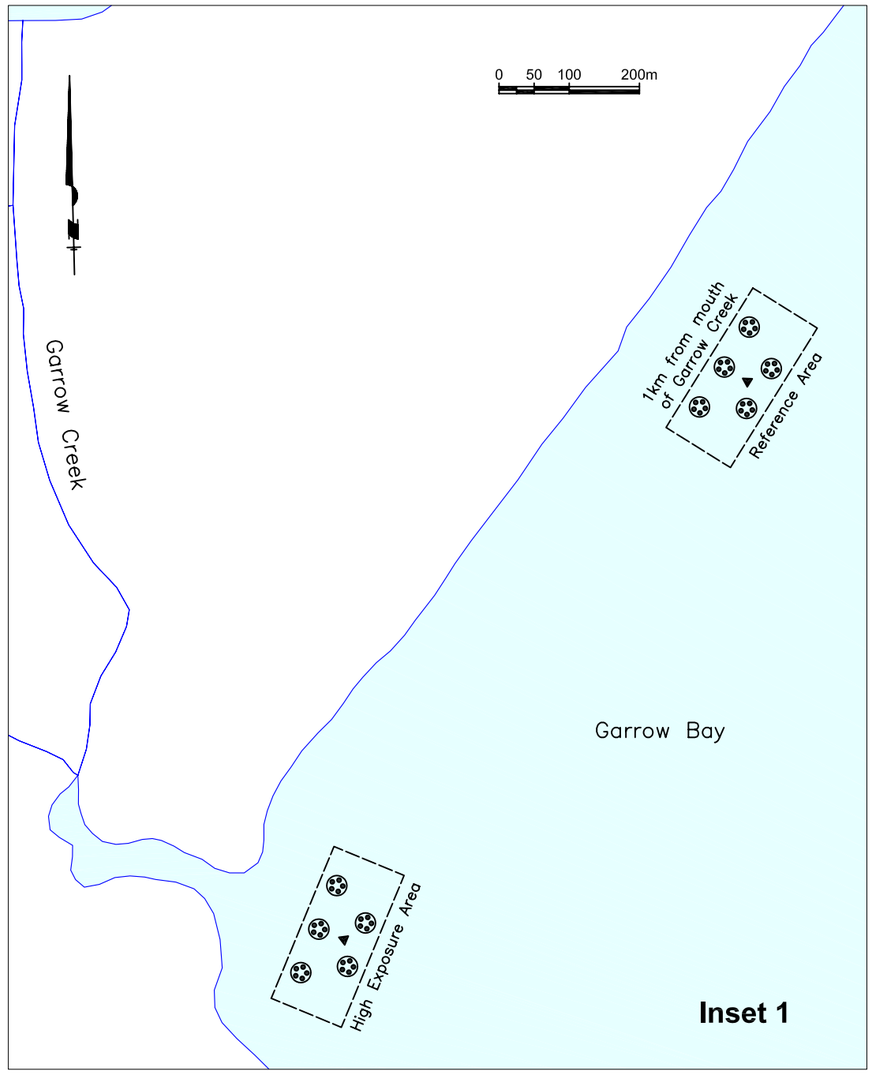
Study Component	Sampling Areas	Sample Size and Replication		Mesurement Endpoints	Sampling Method
Supporting Environmental Variables					
- Water quality monitoring	**Garrow Bay high exposure area**: location matching fish and benthic survey sampling area	- 5 replicate stations for field measurements (matching benthic replicate stations)	- Measurements made at 1 m depth intervals	- Field measurements: DO, pH, temperature, salinity, transparency and water depth	- Calibrated YSI meter, pH probe, and depthmeter will be used for all field measurements - Surface water samples will be collected directly into sample containers; all 5 subsamples for a given sampling area will be composited prior to analysis - Subsurface sampling will be conducted using divers; care will be taken not to disturb sediments during sampling; all 5 subsamples for a given sampling area will be composited prior to analysis - Timing of sampling will match routine MMER effluent characterization as well as EEM effluent and water quality monitoring
		- 1 composite surface sample for laboratory analysis	- 5 subsamples matching benthic replicate stations	- Laboratory analyses: pH, temperature, DO, hardness, alkalinity, Al, As, Cd, Cu, cyanide, Fe, Hg, Pb, Mo, Ni, Zn, TSS, ammonia, nitrate, radium 226	
		- 1 composite subsurface sample for laboratory analysis (0.25 m from bottom)	- 5 subsamples matching benthic replicate stations		
	Garrow Bay reference area: location matching fish and benthic survey sampling area	- 5 replicate stations for field measurements (matching benthic replicate stations)	- Measurements made at 1 m depth intervals	Same as high exposure area	Same as high exposure area
		- 1 composite surface sample for laboratory analysis	- 5 subsamples matching benthic replicate stations		
		- 1 composite subsurface sample for laboratory analysis (0.25 m from bottom)	- 5 subsamples matching benthic replicate stations		
- Sediment quality monitoring	**Garrow Bay high exposure area**: location matching fish and benthic survey sampling area	- 5 replicate stations (matching benthic replicate stations)	- 5 subsamples (matching benthic subsamples) per station	- Sediment chemistry: TOC, grain size, suite of metals	- Diver-assisted sampling; upper 10 cm of sediment will be collected for each subsample using a 1L plastic container - All 5 subsamples for a given station will be composited prior to analysis
	Garrow Bay reference area: location matching fish and benthic survey sampling area	- 5 replicate stations (matching benthic replicate stations)	- 5 subsamples (matching benthic subsamples) per station	Same as high exposure area	Same as high exposure area
Additional Studies - Seabed Imaging and Mapping System (SIMS)	**Garrow Bay high exposure area** and **Garrow Bay reference area**	- Numerous georeferenced tracklines within each area	- Continuous imagery	- Seabed classification maps including: substrate type, vegetation type and cover, distribution and relative abundance of macrofauna	- Towed underwater camera (SIMS) providing semi-quantitative survey of physical and biological features of the seabed

[1] During the 2003 reconnaissance studies, a total of 29 clams were collected by divers; access to Garrow Bay for diving was limited to 3 out of 14 field days due to harsh weather conditions (e.g., presence of ice flows, strong winds, blizzard). Every effort will be made during the 2004 field program to meet the mininum EEM requirement of 40 individuals per sampling area; however, the total sample size may be limited by field conditions. In addition, the inherent difficulty in identifying clam sexes in the field may result in a departure from the requirement for 20 males and 20 females.

[2] The gonadosomatic index will be determined under the supervision of Sylvie St-Jean, National Water Research Institute. The sample size will be assessed once field work is completed.





Sampling area for fish survey and benthic invertebrate community survey

Replicate station - benthos, sediment, water (field measurements)

Subsample - benthos, sediment

Surface and subsurface composite sample - water (laboratory analysis); note that subsamples will be taken from each benthic replicate station (see above)

Inset 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*

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PROJECT: Polaris

TITLE:

Polairs Mine EEM
Study Design for Biological Studies

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Figure 1