Appendix A

Work Plan

Appendices

BERM

DISCHARGE LINE

SOURCE OF CONTAMINATION

DISCHARGE POINT

ROAD

LIGHT POLE

ROAD

800 E

700 N

SS02-69

SS02-71

SS02-70

SS02-78

A1

SS02-76

SS02-74

SS02-73

SS02-72

HYDRAULIC/LUBE OIL/GLYCOL STORAGE PAD

A2

SS02-81

SS02-79

SS02-77

SS02-75

SS02-88

SS02-83

A3

SS02-85

SS02-82

SS02-80

SS02-95

SS02-92

SS02-89

SS02-86

SS02-84

A4

SS02-99

SS02-96

SS02-93

SS02-90

SS02-87

EAST INTERCEPTOR DITCH

SS02-97

SS02-103

SS02-100

SS02-98

SS02-91

ROAD

SS02-101

SS02-102

B1

SS02-104

ROAD

SS02-127

B2

SS02-110

SS02-107

SS02-106

SS02-105

B3

SOIL BEING EXCAVATED WHEN GARTNER LEE STAFF LEFT THE SITE JULY 13, 2002

SS02-126

SS02-114

SS02-111

SS02-108

SS02-109

B4

B5

FINAL EXCAVATION LIMITS JULY 12, 2002

SS02-119

SS02-115

SS02-112

SS02-113

SS02-129

BEDROCK KNOB

B6

SS02-131

SS02-132

SS02-128

SS02-120

SS02-116

SS02-130

B7

SS02-134

SOIL BEING EXCAVATED WHEN GARTNER LEE STAFF LEFT THE SITE JULY 13, 2002

SS02-133

SS02-118

SS02-121

SS02-117

SS02-135

SS02-136

SS02-140

SS02-123

SS02-137

SLOPED AREA

SS02-138

SS02-141

WEST INTERCEPTOR DITCH

SS02-139

INITIAL EXCAVATION LIMITS

ROAD

EAST INTERCEPTOR DITCH

SOIL BEING EXCAVATED WHEN GARTNER LEE STAFF LEFT THE SITE JULY 13, 2002

TP02-02

LOCAL MINE NORTH

TRUE NORTH

0 2.5 5.0 10.0 15.0

Metres

SCALE 1:300

LEGEND:

- SURVEYED HIGH TIDE CONTOUR (2:40 h JULY11/02)
- HYDROCARBON SURFACE STAINS
- ROADS

2002 EXCAVATIONS

- FINAL EXCAVATION
- INITIAL EXCAVATION

- TP02-01 TEST PIT – 2002
- SS02-124 FINAL EXCAVATION SOIL SAMPLE – 2002
- B4 CONFIRMATION SOIL SAMPLE – 2002
- VAPOUR CONCENTRATIONS IN SOIL WERE LESS THAN DETECTION TO 5.5 ppm
- VAPOUR CONCENTRATIONS IN SOIL WERE BETWEEN 5.5 AND 20 ppm
- VAPOUR CONCENTRATIONS IN SOIL WERE GREATER THAN 20 ppm

REVIEWED BY:	AL
DRAWN BY:	CPW
DATE ISSUED:	NOVEMBER, 2002
PROJECT NUMBER:	22-303
FILE NAME:	22303-D2-05.DWG
REVISION:	1

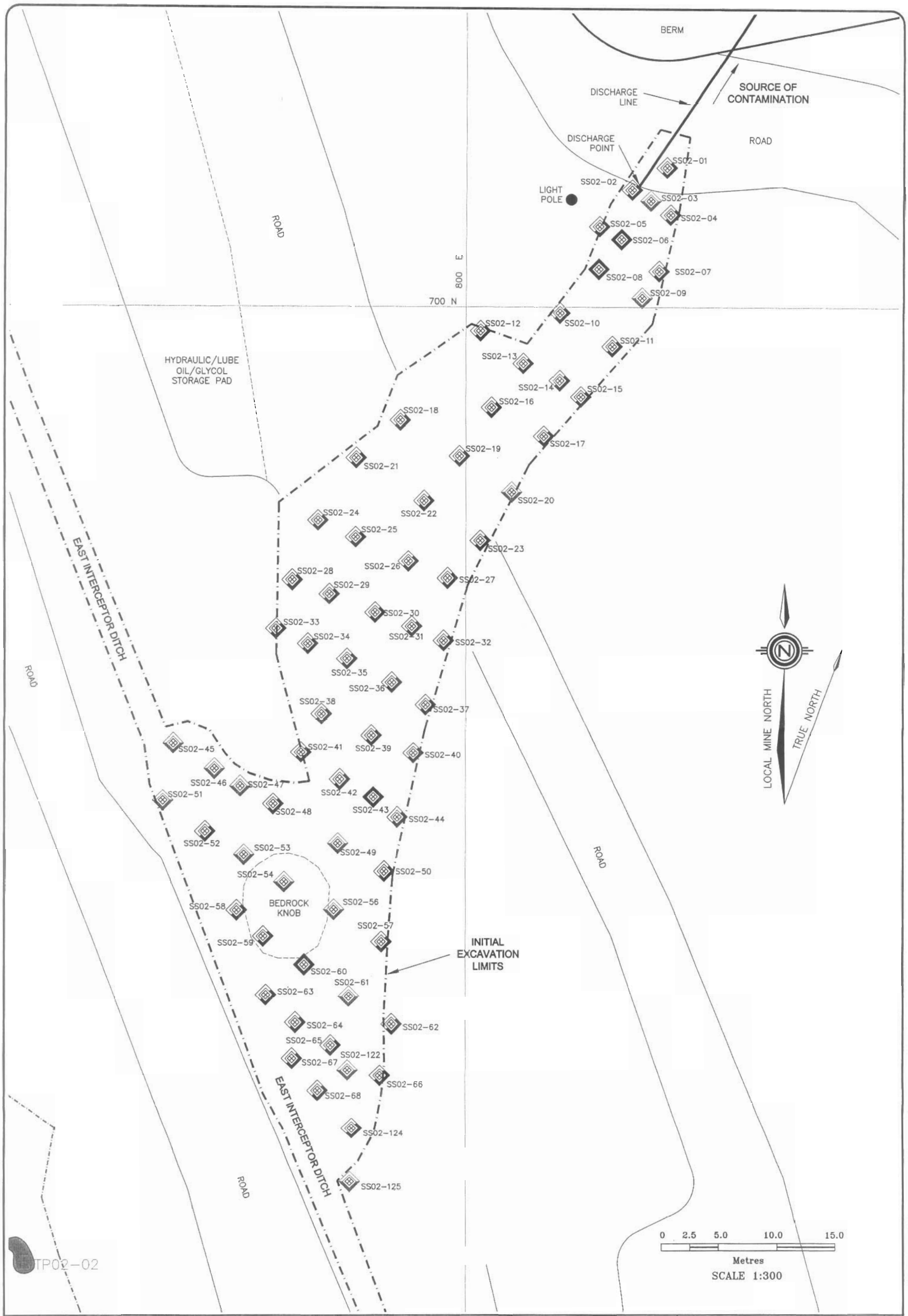
Gartner Lee Limited

DETAIL OF FINAL EXCAVATION FIELD SCREENING RESULTS

2002 FUEL SPILL ASSESSMENT
POLARIS MINE
LITTLE CORNWALLIS ISLAND, NUNAVUT

teckcominco

Figure No. 4



LEGEND:

- SURVEYED HIGH TIDE CONTOUR (2:40 h JULY11/02)
- HYDROCARBON SURFACE STAINS
- ROADS
- INITIAL EXCAVATION JULY 8, 2002
- TP02-01 TEST PIT – 2002
- SS02-124 INITIAL EXCAVATION SOIL SAMPLE – 2002
- VAPOUR CONCENTRATIONS IN SOIL WERE LESS THAN DETECTION TO 5.5 ppm
- VAPOUR CONCENTRATIONS IN SOIL WERE BETWEEN 5.5 AND 20 ppm
- VAPOUR CONCENTRATIONS IN SOIL WERE GREATER THAN 20 ppm

REVIEWED BY:	AL
DRAWN BY:	CPW
DATE ISSUED:	NOVEMBER, 2002
PROJECT NUMBER:	22-303
FILE NAME:	22303-D2-04.DWG
REVISION:	1

Gartner Lee Limited

DETAIL OF INITIAL EXCAVATION FIELD SCREENING RESULTS

2002 FUEL SPILL ASSESSMENT
POLARIS MINE
LITTLE CORNWALLIS ISLAND, NUNAVUT

teckcominco

Figure No. 3

- Installing an interceptor trench hydraulically up-gradient from the road to reduce the potential that contaminated surface water originating near the release point could flow into the ocean;
- Removing visible and accessible floating petroleum hydrocarbons from exposed seawater between the shore and pack ice located up to approximately 5 m off shore using absorbent pads and vacuum pumping;
- Removing visible and accessible floating petroleum hydrocarbons from the interceptor ditch and drainage culvert using absorbent pads and vacuum pumping;
- Removing visible and accessible staining on the shoreline sediment using absorbent pads;
- Excavating potentially impacted soil from between the discharge site and the road adjacent the shoreline;
- Excavating potentially impacted beach gravel along the shoreline after consultation with the DFO;
- Discussing with GLL the incident, soliciting input regarding the sufficiency of their response, mitigation, remedial activities and requesting that GLL design and undertake an investigation to assess environmental impacts resulting from the Spill.

Teck Cominco estimates approximately 1,000 L (or between approximately 67% to 83% of the estimated volume of petroleum hydrocarbons that was released) of liquid petroleum hydrocarbons product was recovered between June 26th (when the release was identified) and July 6th. Teck Cominco estimates that the majority of the remainder of the released product was recovered during excavation of impacted soils between the discharge site and the shoreline.

Potential Contaminants of Concern

Based on the information available to GLL at the time of the investigation, GLL determined that potential contaminants of concern (PCOCs) associated with the release would be limited to:

- Light non-aqueous phase liquids (LNAPLs) (floating petroleum hydrocarbons liquid);
- Benzene, ethylbenzene, toluene and xylene (BETX; components of gasoline and other petroleum hydrocarbons fuels);
- Gross petroleum hydrocarbons fractions defined by the Canadian Council of Ministers of the Environment (CCME)[1] as Canada –Wide Standards (CWS) fractions F1 through F4;
- Extractable petroleum hydrocarbons (EPHs); and
- Polycyclic aromatic hydrocarbons (PAHs).

The quality of soil sediment and water within Canadian federal lands and within Canadian oceans, with respect to the above PCOCs is, generally, evaluated using guidelines established by CCME.

[1] Canadian Council of Ministers of the Environment, a joint federal, provincial, and territorial council.

Proposed Work Plan

GLL proposed to undertake the following tasks.

Task 1 – Confirm the Preliminary Assessment of PCOCs

To confirm GLL's preliminary assessment that PCOCs associated with the release are limited to the constituents identified above, GLL would collect representative samples of the spilled liquid for visual classification and possible laboratory analysis.

Task 2 - Confirm the Quality of Exposed Soil on the Final Limits of Remedial Excavations

Prior to GLL's inspection of the spill area, Teck Cominco excavated soil between the point of release and the ocean shore that was suspected of being impacted with petroleum hydrocarbons and placed the excavated soil at an approved underground disposal location.

To confirm that contaminated soil is not present at the excavation limits, GLL would collect representative samples of exposed soil at the limits of the excavation(s) and submit selected samples of the soil for laboratory analysis of PCOCs. Procedures to be followed during the confirmatory sampling and forwarding of the samples to an analytical laboratory are identified in the following paragraphs.

1. The soil samples would be collected, to the extent that is practicable, at regularly-spaced intervals from both the excavation floor(s) and walls for visual classification and field measurement of the concentration of organic vapor in the headspace of the soil. The soil samples would be collected using standard GLL procedures that minimize the potential for cross contamination. It was recommended that soil samples be collected at a nominal sampling density of approximately one sample per 25 m^2 of excavation floor/wall area.
2. The concentration of organic vapor in the headspace of soil at each sampling location would be measured using a bag-headspace method. The concentration of organic vapour in the headspace of soil is measured as a field-screening method to help assess if the soil is likely to be impacted with volatile PCOCs. The bag-headspace method involves placing a fixed volume of soil in a plastic sampling bag of uniform capacity, sealing the soil in the bag, dis-aggregating the soil in the bag, allowing organic vapors in the soil to accumulate in the bag's headspace, and then measuring the concentration of organic vapor in the bag headspace. Concentrations of organic vapor would be measured in the field using a calibrated Photoionization Air Monitor (PID). The results of the PID measurements, along with the visual appearance and olfactory indicators, would be used to determine if additional excavation of potentially impacted soil is likely to be warranted and to select samples of soil for possible laboratory testing.
3. Soil from selected sampling locations would be placed into labeled, pre-cleaned, laboratory-supplied containers for possible chemical analysis, and placed in chilled coolers for storage and transport to an analytical laboratory. Soil samples selected for possible laboratory analysis would be transported under standard Chain-of Custody procedures to Aurora Laboratory Services Ltd. (ALS) of Vancouver, BC. ALS is an environmental laboratory certified through the Canadian Association for Environmental Analytical Laboratories (CAEAL) and specializes in the analysis of environmental materials, including soil, sediment and water.

4. For quality assurance/quality control (QA/QC) purposes, at approximately 10 per cent of the sampling locations, duplicate soil samples would be collected for possible laboratory analysis.

Task 3 – Screening Level Assessment of the Quality of Sediment in the Shoreline Smear Zone

Prior to GLL's inspection of the spill area, we understood that some floating petroleum hydrocarbons product (LNAPL) that was inferred to have been spilled was observed on the ocean surface. As ocean tides rise and fall, LNAPLs floating on the ocean surface typically contact shoreline sediment and other shoreline materials and, typically, a swath of surficial shoreline material becomes discontinuously coated with LNAPL. In addition, subsurface sediment beneath the shoreline swath may become discontinuously coated with LNAPL that infiltrates into the subsurface. The volume of shoreline sediment that becomes coated with LNAPL is often referred to as a LNAPL "smear zone".

Although the character of LNAPL smear zones varies on a site-specific basis, typically, the distribution of LNAPL within smear zones is discontinuous. For example, within a smear zone, irregularly shaped volumes of sediment that contain surficial films of LNAPL are separated by volumes of sediment that do not contain LNAPL films. The lateral dimensions of potentially impacted volumes of sediment within smear zones may be tens of meters or larger in dimension. It is important to assess, to the extent that is practicable, the distributions of potentially impacted sediments with smear zones because the actual volumes of impacted sediment within smear zones may be much smaller that the total volume of the smear zones themselves.

To assess, at the screening level, the distribution of potentially impacted sediment within the spill's smear zone, GLL proposed to do the following:

1. Obtain copies of local tide tables. The information in the tide tables would assist in estimating the approximate locations of the ocean shoreline during high and low tide conditions near the location where the spill is inferred to have entered the ocean. This information will assist in estimating the locations of the hydraulic up-gradient and down-gradient limits of any smear zone that may have been formed before and after the inspection.

2. Based on the information indicated in the tide tables and the results of a site reconnaissance, GLL would identify and temporarily mark the approximate inferred lateral limits of the smear zone that was caused by the Spill.

3. Based on the information shown on the tide tables, visual and olfactory observations and the results of measurements of concentrations of organic vapor in the headspace of soil, GLL would confirm the approximated extent of the smear zone and advance a series of test pits within the smear zone. Each test pit would be advanced using a backhoe or excavator supplied by Teck Cominco as authorized by DFO. To the extent practicable, each test pit would be located within the up-slope half of the smear zone to allow for exposure of a significant vertical thickness of the smear zone. The purpose of excavating the pits would be to allow visual characterization of soil at each test pit location, monitoring of the content of organic vapor in the headspace of soil and collecting selected samples of soil for possible laboratory analysis. The results of the test pit investigation would assist in assessing the quality of soil within the smear zone, the distribution of impacted soil within the smear zone and in confirming the locations of the smear zone boundaries.

4. To assess the vertical extent of the smear zone, each test pit, to the extent practicable, would be extended vertically through the smear zone to underlying sediment with a low potential to have been impacted by LNAPL.

5. Based on the assumption that potentially contaminated domains within the smear zone would be on the order of tens of meters in lateral dimension, to delineate these potentially impacted soil volumes at the screening level, the test pits would be spaced at nominal 5 m intervals.

6. At each test pit location, GLL would collect representative samples of sediment for visual characterization and measurement of concentrations of organic vapors in the sediment headspace as described above for the confirmation of the quality of soil at limits of excavated areas. Assuming that the smear zone's vertical thickness would be approximately 1 m, sediment samples would be collected from nominal depth intervals: 0.0 m to 0.5 m; 0.5 m to 1.0 m and 1.0 m to 1.5 m. The sediment sampling would be undertaken according to the standard GLL procedures described above. Samples of sediment would be collected for field screening using measurements of concentrations of organic vapor in the headspace of soil using a bag-headspace method and potential laboratory analysis. The samples would be placed in labelled laboratory-supplied containers and placed in chilled coolers for transport to ALS under Chain-of-Custody procedures.

7. To confirm the inferred locations of the smear zone limits, GLL would collect sediment from a series of test pits located, to the extent practicable, approximately 3 m or more distal to the inferred locations of the smear zone limits ("background" locations). These test pits would have a nominal spacing of 15 m or more. The pits were to be excavated and sediment/soil sampled as described for the test pits within the smear zone as described above.

8. For QA/QC purposes, at approximately 10 per cent of the soil sampling locations, duplicate sediment samples would to be collected for possible laboratory analysis.

9. Following sampling and to the extent practicable, each test pit would be filled using the excavated soil. For excavated soil that was suspected of being contaminated, the excavated soil would be transported to and disposed at an approved location as identified by Teck Cominco and the pits would be allowed to fill naturally via the action of tides.

10. Based on the results of the field investigations, selected samples of soil from the test pits would be submitted for analysis for PCOCs.

Task 4 – Screening Level Assessment of the Quality of Groundwater in the Shoreline Smear Zone

To assess, at the screening level, the quality of groundwater within and near the smear zone, GLL proposed to install a series of shallow groundwater monitoring wells. The purpose of installing the monitoring wells would be to allow sampling of groundwater within and near the smear zone for laboratory analysis. The monitoring wells would, to the extent practicable, be sampled according to the following rationale:

1. Each monitoring well would be installed within a pit advanced using a backhoe or excavator. Following the installation of the well, the pit would be filled using the excavated material.

2. Each monitoring well would be installed according to standard GLL procedures and constructed using new threaded 51 mm (2 inch) diameter schedule 40 polyvinyl chloride (PVC) pipe. Screened section of the wells would be constructed using compatible threaded new horizontal 010 slot (0.010 inch slot diameter) PVC pipe.

3. To the extent practicable, the monitoring wells would be installed to allow sampling of groundwater below the smear zone, within the smear zone and hydraulically up-gradient from the smear zone.

4. Following its installation, each monitoring well would be developed according to standard GLL procedures.

5. Following its development, groundwater in each accessible monitoring well would be sampled for possible laboratory analyses for PCOCs. Selected groundwater samples would also to be analyzed for nitrate, nitrite, ammonia and phosphate to assess the nutrient content of the groundwater.

6. For QA/QC purposes, approximately 10 per cent of the groundwater samples would be collected in duplicate for possible laboratory analysis.

Task 5 – Screening Level Assessment of the Quality of Seawater near the Smear Zone

To assess the quality of seawater above the smear zone, GLL would install, to the extent practicable, a screened PVC pipe to collect seawater above smear zone for possible laboratory analysis. The seawater samples would be collected according to standard GLL procedures and transported to ALS in chilled coolers under Chain-of-Custody procedures. Selected seawater samples would be analyzed for PCOCs as well as nutrients. Approximately 10 per cent of the seawater samples selected for analysis would be blind duplicate samples for QA/QC purposes.

Task 6 – Documentation of Overall Environmental Conditions of Spill Area and Down-Gradient Areas

GLL proposed to document environmental conditions using a combination of photographs, video images and field notes taken during the activities outlined above and interviews with individuals involved in Teck Cominco's response activities.

Task 7 – Reporting

Following receipt of the final analytical results, GLL would prepare a report documenting the investigations completed and the rationale for undertaking the investigations. A draft report would be prepared and submitted to Teck Cominco for review on August 19, 2002. The report would identify the activities completed and the results of the investigations, including the results of field monitoring, the locations of samples collected, the results of the laboratory analysis of soil, sediment and water, maps showing the inferred lateral limits of the smear zone(s) the distribution of significant stained areas within the smear zone(s) at the time of the investigation. The results of laboratory analyses of soil, sediment and water would be summarized in tables along with applicable land use and/or remediation criteria. The report would include GLL's assessment of the scope of Teck Cominco's spill-response measures, the potential (screening level) impacts of the discharge to soil, sediment, groundwater and seawater quality at the investigated locations and provide recommendations for additional investigations and/or remediation programs, if warranted.

Closure

GLL prepared this work plan based on our understanding of the spill incident and our knowledge of the Polaris Mine site at the time of the investigation. To meet the objectives of the investigation within the available time frame, modifications to the proposed work plan were implemented during the investigation. The field program conducted and observations made are documented in the attached Field Report.

The investigations completed and the rationale for undertaking the investigations will be documented in a report. The results of the investigations, including the results of field monitoring, the locations of samples collected and the results of the laboratory analysis of soil and water, will be summarized in tables along with applicable land use and/or remediation criteria. The report will include our assessment of the scope of the mitigation and remediation measures implemented by Teck Cominco, the potential (screening level) impacts of the discharge to soil, groundwater and seawater quality at the investigated locations and our recommendations for additional investigations and/or remediation programs.

Thank you for contacting Gartner Lee to conduct this work and please contact the undersigned.

Yours truly,
GARTNER LEE LIMITED

S.R. Morison, Principal
Manager, Northern Canada/Alberta

c.c. Arlene Laudrum, GLL, Burnaby
Alex Bath, GLL, Burnaby
Eric Denholm, GLL, Yellowknife
Rob Dickin, GLL, Burnaby

Attachment – Field Report, Spill Response Investigation, Polaris Mine, Nunavut, August 6, 2002

Attachment

Field Report, Spill Response Investigation, Polaris Mine, Nunavut

August 26, 2002

Field Report, Spill Response Investigation, Polaris Mine, Nunavut

On July 6, 2002 Ms. Arlene Laudrum of Gartner Lee Limited (GLL) arrived at the Polaris Mine site, Nunavut (the "Site") and began investigating environmental conditions at and near the location of the June 25, 2002 release of petroleum hydrocarbons from the Site's tank farm ('the Spill"). The proposed work plan was modified as required based on field conditions and available sampling equipment and supplies following daily telephone and/or email correspondence with the GLL project team.

Teck Cominco's Polaris Mine metallurgist, Ms. Yeen Shein Hwang, and the Polaris Mine surveyor, Mr. Richard Gamache, and two laborers residing in Resolute, assisted GLL with the investigation, which took place between July 6, 2002 and July 12, 2002.

Task 1

According to Ms. Hwang, the spilled liquid consisted of a diesel/water mixture that may have contained components of crude oil. At the time of the inspection, three above ground storage tanks (ASTs) were located within the tank farm containment berm: two diesel ASTs that were in use and one smaller "essentially empty" AST. According to Ms. Hwang, historically, the smaller AST was used for storing crude oil.

According to Ms. Hwang, following the Spill, Teck Cominco removed, by skimming, floating petroleum hydrocarbons liquid (a light non-aqueous phase liquid or LNAPL) within the tank farm containment berm and placed the recovered product into three 205 L (45 U.S. gallon) drums. On July 12, 2002, the drums were stored on pallets on exposed soil near the north side of the tank farm and the bung openings of the drums were not sealed.

On July 12, 2002, GLL collected two samples of liquid in the drums using a dedicated new disposable bailer. One sample was collected from the upper 20 cm of floating LNAPL in Drum 1. The other sample was collected from the entire column of liquid in Drum 2. Each liquid sample was placed into (1) 40 ml BETX vial containing a preservative (sulfuric acid) and (1) 250 ml amber glass bottle and (1) 500 ml amber glass bottle. The sampled liquid appeared, visually, to be more viscous than pure water, yellow in colour with an oily texture and contained an estimated 1 per cent to 5 per cent of immiscible green globules (less than 1 cm in diameter) that were denser than water. The green colour of the globules is similar to that of fresh antifreeze. The liquid samples were placed in a dedicated cooler with ice and shipped off site on July 13, 2002 to Aurora Laboratory Services Ltd. (ALS) of Vancouver, B.C.

Task 2

On July 8, 2002, GLL collected confirmatory samples of exposed soil from the limits of excavations located hydraulically down gradient from the point of release. The area was in the process of being excavated by Teck Cominco. (Additional excavation of a roadway located between the discharge area and the ocean shore was ongoing on July 13, 2002, when GLL left the Site). In addition, to intercept

potentially contaminated groundwater originating near the release area, a trench had been excavated down-slope from the roadway. The trench was advanced vertically into ice.

GLL collected a total of 67 samples of soil (from locations SS02-001 to SS02-054, SS02-056 to SS02-068) at approximately 5 m intervals from the floors and walls of the excavation. The sample locations were plotted by Ms. Laudrum on an excavation plan provided by Teck Cominco. Ms. Hwang and Mr. Gamache assisted GLL in collecting the soil samples and in surveying the locations of the samples.

During the investigation, GLL used a portable photoionization detector (PID), calibrated on July 5, 2002, to measure concentrations of organic vapours. Calibration gas for the PID was not brought to the site because of the shipping restrictions associated with transporting the gas.

On July 8, 2002, measurements of ambient concentrations in air upwind of the spill site were less than 0.1 parts per million (ppm), the instrument detection limit. Measured concentrations of organic vapor upwind of the spill location on July 12, 2002 were 0.2 ppm.

On July 8, 2002, measured concentrations of organic vapor in the headspace of soil (measured using a bag headspace method) were, typically, less than 2.9 ppm. However, two areas of exposed soil containing between 28 ppm and 60 ppm of organic vapor in its headspace were identified. These areas were surrounded by soil containing concentrations of headspace organic vapor of up to 5.5 ppm. Based on the visual appearance of soil within these two areas and olfactory indicators, this soil was suspected of being impacted.

The locations of samples sites with headspace organic vapor concentrations greater than 5.5 ppm were clearly marked in the field to facilitate additional excavation of this suspect material and Teck Cominco was then requested to excavate additional soil from the marked areas. On July 9, 2002, Teck Cominco excavated all marked areas to bedrock.

On July 11, 2002, the new excavation limits or the re-excavated areas were sampled using a nominal 5 m grid pattern. Teck Cominco and the laborers assisted GLL in collecting the soil samples. The results of measurements of the concentration of organic vapor in the headspace of soil from the re-excavated areas indicated that except for soil at one location (where the concentration of organic vapor in the soil's headspace was 44 ppm), concentrations of headspace vapor in soil at the limits of the re-excavated areas were less than 10 ppm. An area approximately 35 m south of the discharge point and adjacent the east wall of the excavation had previously returned bag-headspace readings of 37.2 ppm and 43.9 ppm. During the second set of limit sampling, a soil headspace concentration of 45.0 ppm was measured within this area and additional excavation of potentially contaminated soil was completed.

On July 11, 2002, the soil-sampling grid that was established for the excavation-limit sampling was extended to allow assessment of the quality of soil located hydraulically down-gradient from the spill, near the former location of a road. The concentration of organic vapour in the headspace of a single sample of soil that was collected from the excavation wall beneath the former road bed was 90 ppm.

Concentrations of organic vapour in the headspace of soil from the other sampling locations from the floor and walls of the extended excavation near the former roadbed ranged between 4.1 ppm and 8.0 ppm.

On July 11, 2002 and July 12, 2002, Teck Cominco further excavated the area containing soil with elevated organic vapor concentrations near the former location of the road. When soil at the excavation limits were sampled on July 12, 2002, two samples of soil from the re-excavated area contained headspace organic vapor concentrations of 198 ppm and 37.4 ppm. Concentrations of organic vapor in the headspace of the remaining samples of soil ranged from 3.7 ppm to 8.1 ppm. Confirmatory soil samples are scheduled to be collected by Teck Cominco when additional sample jars are delivered to site. GLL trained Ms. Hwang and Mr. Gamache regarding soil sampling methodology and sampling storage and transportation requirements.

Task 3

On July 7, 2002, GLL obtained tide tables for Little Cornwallis Island for the period between July 5, 2002 to August 6, 2002 from Teck Cominco. According to information shown on the tide tables, the lowest tidal conditions within this period (with a relative height of 0.2 m) occurred on July 12 at 21:10 hours and July 13 at 21:55 hours. The highest tidal conditions during the period (with a relative height of 1.7 m) occurred on July 11 (at 2:40 hours), July 12 (at 3:15 hours), July 13 (at 4:00 hours), July 25 (at 2:45 hours) and July 26 (at 3:20 hours).

On July 7, 2002, GLL marked the location of high tide at 11:25 hours (when the tide tables indicated the tide to have a relative elevation of 1.3 m) and the location of low tide at 17:50 hours (when the tide tables indicated the tide to have a relative elevation of 0.5 m) using stakes spaced at nominal 5 m for a length of approximately 250 m. Visual observations on by GLL July 7, 2002 suggested that the shoreline smear zone was likely confined within these upper and lower limits. On July 10, 2002, the low tide markers were relocated at 19:50 hours to correspond with water levels observed at that time (when 0.3 m low tide conditions were developed, according to the tide tables). On July 11, 2002, the high tide markers were relocated when the tide had a relative height of 1.7 m, according to the tide tables).

Within a 40 m long portion of the smear zone located, approximately, hydraulically down-gradient of the spill area (the "40 m Zone"), GLL observed discontinuously distributed areas up to approximately 2 m in maximum dimension of stained sediment. On July 7, 2002 and July 8, 2002, GLL observed some decimeter size stained areas of sediment within an additional 60 m long portion of the smear zone (the "60 m Zone") located south of the 40 m Zone. Staining within the 60 m Zone was not observed by GLL on July 9, 2002. Spotty areas of staining were developed for an additional 175 m to the north (the "175 m Zone") that extended as far as the old dock area at the "fold-away buildings". The 175 m Zone included a 50 m stretch located down-gradient from a culvert beneath a road that was excavated during the initial spill response.

GLL supervised the excavation of test pits by Teck Cominco and the laborers within and near the smear zone. The pits were excavated using shovels near the shore in areas suspected of being most highly contaminated. The pits were excavated using shovels to minimize the potential to remobilize LNAPL.

Approximately 25 per cent of the pits were excavated using a backhoe that was supplied and operated by Teck Cominco. In addition:

- Pits at locations TP02-17 to TP02-21 were excavated using a backhoe. Each test pit was excavated during low tide conditions and was extended, to the extent practicable, to an inferred depth of approximately 10 cm below standing water in the pit or into ice.
- Pits at locations TP02-01 to TP02-03, TP02-05 to TP02-08 are within the 40 m Zone.
- The pit at location TP02-04 is south of the area suspected of being contaminated.
- Pits at locations TP02-09 to TP02-15 are between the 40 m Zone and a culvert to the north in an area of spotty staining. Some of these pits were located to test suspected non-impacted areas.
- Pits at locations TP02-16 to TP02-20 are north of the culvert to the old dock within an area containing spotty staining.
- The pit at location TP02-20 is within an approximately 3 m^2 area of staining in the back eddy created by the old dock.
- The pit at location TP02-21 is north of the old dock and outside of the area suspected of being contaminated.

At each test pit location and to the extent practicable, continuous samples of soil or sediment were collected from within the inferred boundaries of the smear zone. Additional continuous samples of soil were collected, where practicable, from below the smear zone. At the first three test pit locations (TP02-1 through TP02-3), soil samples were collected from between 15 cm to 20 cm of grade. At subsequent test pit locations, this soil sampling procedure was generally not continued because no apparent variation in the distribution of potential contamination from the ground surface to the inferred base of the smear zone was detected. At each test pit location, the shoreline sediments consisted mainly of coarse sand and gravel with cobbles and traces of silt and fine sand. Teck Cominco surveyed the location and ground elevation at each test pit location.

Sediment samples TP02-11-1 to 11-3 were collected as blind field duplicates of samples TP02-01-1 to 01-3. Sediment samples from TP02-11 were numbered TP02-11-1R and TP02-11-2R to differentiate these samples. Sample TP02-22-1 is a blind field duplicate of TP02-21-1.

Sediment samples from TP02-01 to TP02-03 were transported off site to ALS via air on July 10, 2002. Sediment samples from TP02-04 to 21 were transported to ALS via air on July 13, 2002.

Task 4

GLL installed six polyvinyl chloride (PVC) groundwater monitoring wells below the low tide markers forming the inferred lower boundary of the smear zone (at locations inferred to be hydraulically down-gradient from the smear zone). Each well was completed between approximate depths of 20 cm to 50 cm below the low-tide elevation from just south of test pit TP02-04 and north to test pit TP02-17. One well near test pit TP02-13 was destroyed by ice within 12 hours of its installation and was not available for sampling. The stick-ups of the five wells that were not destroyed were reduced to within approximately 30 cm of the ground surface. This was done to allow the ice pack to float over top of the wells during high tide conditions and reduce the risk of the top portion of the well riser being sheared off by the ice.

An additional six PVC groundwater wells were installed at or above the midway point between high and low tide within the smear zone. The wells were installed at locations inferred to be hydraulically up-gradient from the low tide wells. The bottom of each screened interval was installed to low tide levels or approximately 20 cm into ice as proposed in the initial work plan.

GLL installed the groundwater monitoring wells during low tide conditions on July 11, 2002 and July 12, 2002. The installation of up-gradient wells was not possible due to the presence of a nearby road and proximity of the interceptor trench (approximately 5 m from the high tide mark).

On July 12, 2002, the laborers assisted GLL in developing the wells. The wells were developed using dedicated Waterra tubing and compatible inertial foot valves by removing approximately 50 L of water from each accessible well. Following development, water in the wells was generally clear. The Polaris Mine metallurgist was trained to purge and sample groundwater in the wells for BETX, EPH, PAH, metals and nutrients. Samples of groundwater from the wells are scheduled to be collected July 16, 2002 and shipped to ALS on July 17, 2002.

Task 5

Samples of seawater overlying and./or adjacent to the smear zone were not collected due to the presence of floating ice.

Task 6

GLL took photographs, shot video images, recorded field observations and interviewed individuals involved in the Teck Cominco response activities to document the overall environmental conditions near the point of release, down-gradient of the release and within the shoreline smear zone

Appendix B

Regulatory Framework

REGULATORY FRAMEWORK

Soil, sediment and water quality for this assessment has been evaluated based on a framework of federal guidelines and site-specific soil quality remediation objectives for the identified potential chemical compounds of concern. Nunavut Territory refers to the Northwest Territory Remediation Guidelines and the required degree of remediation cited in the Northwest Territory guidelines is determined by the Canadian Council of Ministers of the Environment (CCME) guidelines. In the absence of select CCME guidelines with respect to water quality, reference has also been made to British Columbia provincial standards, strictly for comparative purposes, for the assessment of water quality with respect to its content of petroleum hydrocarbon content.

A three-tiered approach for the assessment and remediation of contaminated sites has been established by the CCME. Generic guidelines represent the first tier, while a second tier allows for the development of guidelines based on consideration of site specific variables (soil texture, geology, etc) to establish site-specific remedial objectives[1,2]. The third tier uses risk assessment procedures to establish remediation objectives at contaminated sites on a site-specific basis. The first tier guidelines represent generic recommendations that are based on a conservative application of the most current scientific information and are intended to provide a high level of protection for designated land and water uses. Site-specific soil quality remediation objectives for petroleum hydrocarbons in soil were developed and have been approved for the decommissioning of the Polaris Mine.

For the purposes of the present investigation, results are compared to the CCME generic guidelines to assess the effects of the release of petroleum hydrocarbon impacted water on the quality of soil, sediment and groundwater at the site. To assess the adequacy of remediation of the impacted soil and sediment the Polaris Mine remediation objectives for petroleum hydrocarbons in soil is applied.

SOIL QUALITY

To assess the quality of "residual" soil at elevations above the local high tide contour at the Polaris Mine, the analytical results were compared to the generic Parkland land use (PL) guidelines and site-specific soil quality remediation objectives in the following documents:

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[1] CCME. 1996a. *Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada*. The National Contaminated Sites Remediation Program. En 108-4/9-1996e.

[2] *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil - User Guidance*" submitted to CCME by O'Connor Associates Environmental Inc. and Meridian 'Environmental Inc., dated April 2001.

- *Canadian Environmental Quality Guidelines* (CEQG), Canadian Council of Ministers of the Environment (CCME), Winnipeg MB, 1999.
- *Canada Wide Standards for Petroleum Hydrocarbons (PHC) in Soil (PHC CWS)*, Canadian Council of Ministers of the Environment (CCME), Winnipeg, MB, May 2001.
- *Polaris Mine Decommission and Remediation Plan*, March 2001.

CCME Canadian Environmental Quality Guidelines for Soil

The Canadian Environmental Quality Guidelines (CEQG) provide criteria for soil based on land use activities (agriculture [AL], residential/parkland [RL/PL], commercial [CL] and industrial [IL]). Pending sufficient and adequate data for specific parameters CEQG soil quality guidelines (SQG) are also derived using different receptors and exposure scenarios (environmental health [SQG_E] and human health [SQG_{HH}]) for each land use.

The subject area is currently being used for industrial purposes. The residential/parkland land use criteria for the parameters of concern are equivalent to or more stringent than the commercial, which are equivalent to or more stringent than the industrial land use criteria. The remediation objective for the mine site is to restore the land to as close as possible to the natural condition, which was an arctic wild land. The closest generic criteria to this objective is Parkland land use, even though these criteria were developed for urban areas in southern Canada. The Parkland and Industrial land use designations have been used as a reference for assessing the quality of soil for the 2002 fuel spill assessment at the Polaris Mine. In cases where the recommended CEQG soil quality guideline (SQG) for specific parameters is presented for both "guidelines for environmental health" and "guidelines for human health", the guidelines for environmental health (SQG_E) has been used as the reference criteria.

CCME Canada-Wide Standard for Petroleum Hydrocarbons in Soil

The CCME Canada-wide standard for petroleum hydrocarbons in soil (PHC CWS) has been used to assess soil quality at the Polaris Mine. The PHC CWS is a CCME remedial guideline for petroleum-hydrocarbons impacted soil that was endorsed May 2001. In this guideline petroleum hydrocarbons are subdivided according to specified ranges of equivalent carbon number as follows:

- PHC CWS fraction F1 encompasses the range of equivalent carbon numbers from C_6 to C_{10}. Constituents of fraction F1 include the volatile fraction of most hydrocarbons mixtures (including gasoline) such as benzene, ethylbenzene, toluene and xylene (BETX).
- PHC CWS fraction F2 encompasses the range of equivalent carbon numbers from C_{11} through C_{16}. Constituents of fraction F2 are semi-volatile petroleum hydrocarbons and include constituents of gasolines and diesel fuels.
- PHC CWS fraction F3 encompasses the range of equivalent carbon numbers from C_{17} through C_{34}. Constituents of fraction F3 include typical lubricating oils and greases, heavy fuel oils, road oils and asphalts.

- PHC CWS fraction F4 encompasses ranges of equivalent carbon numbers from C_{35} through C_{50+}. PHC within this fraction often make up a significant proportion of crude oils.

Consistent with the CCME Canadian Environmental Quality Guidelines (CEQG) for soil, the PHC CWS was developed for four generic land uses: agricultural, residential/parkland, commercial and industrial. Different guidelines apply to coarse grained (>75µm) and fine grained soils (<75µm) and to surface soils from (0 to 1.5 m below grade) as well as subsoils at a depth of greater than 1.5 m.

Polaris Mine Soil Quality Remediation Objectives for Petroleum Hydrocarbons

Site-specific remediation objectives for petroleum hydrocarbons in soil were developed for the decommissioning of the Polaris Mine prior to the endorsement of the PHC CWS by the CCME Council of Ministers, May 1, 2001. The site-specific remediation objectives are based on the soil standards specified in the Yukon Territorial Contaminated Sites Regulation for light and heavy extractable petroleum hydrocarbons that indicate the presence of diesel fuel components. The soil quality remediation objectives for petroleum hydrocarbons are as follows:

- Light extractable petroleum hydrocarbons (LEPH) encompassing the range of equivalent carbon numbers from C_{10} through C_{19} is 1000 mg/kg.
- Heavy extractable petroleum hydrocarbons (HEPH) encompassing the range of equivalent carbon numbers from C_{19} through C_{32} is 1000 mg/kg

A direct comparison of soil quality data to the approved remediation objectives petroleum hydrocarbon parameters LEPH (C_{10}-C_{19}) and HEPH (C_{19}-C_{32}) cannot be made as the soil was analyzed and quantified according to PHC CWS. The closest comparison would be LEPH to fraction F2 and HEPH to fraction F3. However, the LEPH parameter includes a quantification of >C_{16}-C_{19} which is excluded in the fraction F2. Therefore, in order to make a suitable comparison, the total concentration of LEPH and HEPH was compared to the summation of fractions F2 and F3.

SEDIMENT QUALITY

CCME Canadian Environmental Quality Guidelines for Sediment

To allow and expedite assessment, at the screening level, of sediment quality in the investigated area and the likelihood that the investigated sediment is contaminated with petroleum hydrocarbons, GLL has used the CCME CEQG generic sediment quality guidelines.

The CEQG provides sediment quality guidelines that provide reference points for evaluating the potential for observing adverse biological effects in freshwater and marine aquatic systems. Sediment guidelines referenced in this report include the interim sediment quality guidelines (ISQGs) and the probable effect level (PEL) for freshwater sediment.

ISQGs are established if insufficient information exists to establish "full" sediment quality guidelines and are recommended for concentrations in surficial sediments (i.e. top 5 cm). The probable effect level (PEL) is a concentration at which adverse biological effects frequently occur.

CCME Petroleum Hydrocarbons Canada-Wide Standards for Soil

For the purposes of the present investigation, because sediment quality guidelines that are analogous to the PHC CWS soil guidelines have not been established, the PHC CWS guidelines are considered to be applicable to "active" marine sediments within the ocean's intertidal zone as well as to soil at higher elevations.

The PHC CWS are intended to manage the soil-to-groundwater pathway to minimize the potential for unacceptable transfer of contaminants from soil which may ultimately affect groundwater and surface water use (p. 4, report" *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil - User Guidance*" submitted to CCME by O'Connor Associates Environmental Inc. and Meridian 'Environmental Inc., dated April 2001). Because the intended use of the guideline does not distinguish between "soil" and "sediment" as used in this report, we consider that the PHC CWS apply to the quality of sediment as well as soil. For the purpose of applying the PHC CWS to sediment, we have assumed, for the reasons that are identified above, that the applicable land use class is that for parkland use.

Polaris Mine Soil Quality Remediation Objectives for Petroleum Hydrocarbons

The Polaris Mine remediation objectives for petroleum hydrocarbons in soil have been used to assess the remediation requirements of the beach sediments.

WATER QUALITY

CCME Canadian Environmental Quality Guidelines for Water

The CCME CEQG also provides drinking water and surface water quality guidelines. Criteria for surface water quality are based on usage (community water supplies, recreational use and aesthetics, aquatic life [freshwater and marine] and agricultural water uses). To allow and expedite assessment, at the screening level, the quality of groundwater in the investigated area and the likelihood that the investigated sediment is contaminated with petroleum hydrocarbons, water quality data has been assessed with respect to the CEQG generic water quality guidelines established for the protection of marine water aquatic life.

The nearest surface water body to the investigated area is the Crozier Straight (Arctic Ocean), which is located adjacent to or on the area investigated, depending on local tide conditions. According to Teck Cominco, the residents and users of the Polaris Mine area currently obtain and

in future are likely to obtain their supply of potable water from Frustration Lake, located approximately 5 km northeast of the area of investigation.

The CEQG guidelines are not, however, applicable to the evaluation of groundwater quality. Modifying factors for chemical limits in groundwater due to factors such as natural attenuation and dilution are not considered in the CEQG guidelines. Groundwater quality standards for the protection of marine water aquatic life have been developed for other jurisdictions generally apply a 10-fold dilution factor to regulated chemical parameters. These standards have also been presented with the analytical data to provide a more suitable comparison for the site-specific groundwater quality data.

British Columbia Water Quality Standards

Environmental criteria for the assessment of water quality on federal lands with respect to its content of PHC (analogous to the PHC CWS) have not been established. In British Columbia, the British Columbia Ministry of Water, Land and Air Protection has established a protocol (Protocol 7: *Protocol for Regulation of Petroleum Hydrocarbons in Water under the Special Waste and Contaminated Sites Regulation*, May 2002) that establishes that within British Columbia, the presence in water of a concentration of a gross hydrocarbons chemical class (EPHw10-19) of greater than 5 mg/L is considered to be proof of presence of petroleum hydrocarbons non-aqueous phase liquid (NAPL) or liquid petroleum hydrocarbon (LPH) in the water.

To assist in assessing the quality of groundwater in the investigated area, the groundwater was analyzed for EPHw10-19. These analyses were undertaken as a screening method to: (a) assist in assessing the likelihood that diesel fuel LPH was present in or in contact with the pore water and (b) assist in selecting groundwater samples for analysis for polycyclic aromatic hydrocarbons (PAHs), trace constituents of diesel fuels and crude oils.