teckcominco

John B. Knapp
Manager

December 2, 2002

Mr. Wade Comin
Enforcement Officer, Northern Division
Environmental Protection Branch
Prairie & Northern Region
Environment Canada
P.O. Box 1870
Iqaluit, Nunavut X0A 0H0

Attention: Mr. Wade Comin, Enforcement Officer

Dear Mr. Comin:

Re: Polaris Mine – Gartner Lee Ltd. Fuel Spill Assessment Report

Please find attached a copy of Gartner Lee Limited's "2002 Fuel Spill Assessment" report pertaining to the fuel spill that occurred at Teck Cominco LTD's Polaris Operation in June, 2002. The scope of their work included characterizing the spilled hydrocarbons, site sampling of soils and water between the discharge point and the shoreline, and directing and evaluating the remediation efforts undertaken during and after their presence on-site. Additionally, Gartner Lee Ltd. was asked to draw conclusions regarding the efficacy of the remediation efforts, and areas where further efforts could potentially be required.

Immediately following the detection of the spill, Polaris began cleaning up free hydrocarbons by using oil-absorbent pads in conjunction with a vacuum collection system. Cut-off ditches were also placed to limit the movement of impacted groundwater, and to allow further use of vacuum and oleo-phillic pads. Under Gartner Lee Ltd.'s guidance, over 6,000 tonnes of soils, including some foreshore materials, were removed for disposal in a previously approved undergound location. In spite of these efforts, the potential remains for residual liquid petroleum hydrocarbon (LPH) trapped by capillary tension within intertidal sediments to become remobilized with the increased groundwater flow anticipated during spring thaw events.

Teck Cominco Ltd. remains committed to minimizing the impacts of this release of LPH. Monitoring of the impacted shoreline will be maintained to ensure that liquid petroleum hydrocarbon does not impact the aquatic environment. This monitoring will be conducted under the guidance of a qualified environmental consultant. If this monitoring indicates that the aquatic environment is at significant risk due to the impacted sediments, further remediation will be undertaken, potentially including the removal and disposal of the impacted soils and sediments.

Please do not hesitate to contact myself with any questions or concerns. I would appreciate the opportunity to discuss Teck Cominco Ltd.'s plans further after you have had an opportunity to review the enclosed report.

Yours truly,

Cominco Mining Partnership

per JBK.

John B. Knapp,
Manager,
Polaris Operations

Attachment

cc: Mr. Jordan DeGroot, DFO
Mr. Constantine Bodykevich, DIAND
Mr. Philippe di Pizzo, NWB

Gartner Lee Limited

P.O. Box 98
4912 49th Street
Yellowknife
X1A 2N1

Tel: (867) 873-5808
Fax: (867) 873-4453
www.gartnerlee.com

Environmental Services Since 1973

Office Locations

- Vancouver
- Whitehorse
- Yellowknife
- Calgary
- Toronto
- St. Catharines
- Bracebridge
- Montreal
- Halifax

November 29, 2002

Teck Cominco Limited
Polaris Mine
Little Cornwallis Island
Polaris, Nunavut
X0A 0Y0

Attention: Mr. John Knapp, Mine Manager, Polaris Mine

Dear Mr. Knapp

Re: 2002 Fuel Spill Assessment – Polaris Mine, Nunavut

Please find attached a report that details our findings on the potential impacts of the hydrocarbon spill at the Polaris Mine this past summer. We have attempted to be as thorough as possible and trust this report meets your expectations.

Enclosed are eight hard copies and a digital copy of the report for your distribution. Please contact us if you require any further hard copies.

Thank you for contacting Gartner Lee to conduct this work and please feel free to contact the undersigned at (403) 262-4299, ext. 120 to discuss any of the findings.

Yours truly,
GARTNER LEE LIMITED

S.R. Morison

Stephen R. Morison, M.Sc.
Manager-Northern Canada

cc T. Pye, GLL, Calgary
A. Bath, R. Dickin, A. Laudrum, GLL, Burnaby
E. Denholm, GLL, Yellowknife

A Member Of
Environmental Strategies ALLIANCE

Gartner Lee

2002 Fuel Spill Assessment Polaris Mine, Nunavut,

Prepared for
Teck Cominco Limited

Prepared by:
Gartner Lee Limited

GLL 22-303

November 2002

Distribution:
8cc Client
4cc File

Gartner Lee Limited

P.O. Box 98
4912 49th Street
Yellowknife
X1A 2N1

Tel: (867) 873-5808
Fax: (867) 873-4453
www.gartnerlee.com

Environmental Services Since 1973

Office Locations
- *Vancouver*
- *Whitehorse*
- *Yellowknife*
- *Calgary*
- *Toronto*
- *St. Catharines*
- *Bracebridge*
- *Montreal*
- *Halifax*

A Member Of
Environmental Strategies ALLIANCE

November 29, 2002

Teck Cominco Limited
Polaris Mine
Little Cornwallis Island
Polaris, Nunavut
X0A 0Y0

Attention: Mr. John Knapp, Mine Manager, Polaris Mine

Dear Mr. Knapp

Re: 2002 Fuel Spill Assessment – Polaris Mine, Nunavut

Please find attached a report that details our findings on the potential impacts of the hydrocarbon spill at the Polaris Mine this past summer. We have attempted to be as thorough as possible and trust this report meets your expectations.

Enclosed are eight hard copies and a digital copy of the report for your distribution. Please contact us if you require any further hard copies.

Thank you for contacting Gartner Lee to conduct this work and please feel free to contact the undersigned at (403) 262-4299, ext. 120 to discuss any of the findings.

Yours truly,
GARTNER LEE LIMITED

S.R. Morison

Stephen R. Morison, M.Sc.
Manager-Northern Canada

cc T. Pye, GLL, Calgary
A. Bath, R. Dickin, A. Laudrum, GLL, Burnaby
E. Denholm, GLL, Yellowknife

Executive Summary

Gartner Lee Limited (GLL) was retained by Teck Cominco Ltd. (Teck Cominco) to provide immediate assistance in assessing and remediating the effects of a petroleum hydrocarbon release at the Polaris Mine Site (the Site), Little Cornwallis Island, Nunavut, on June 25, 2002. The release occurred as a result of the discharge of standing water from within the containment berm of the Site's Tank Farm that was impacted with diesel fuel. Water had accumulated in the containment berm, above what was considered normal operating volumes, as a result of spring melt and rainfall. The accumulated water and liquid petroleum hydrocarbons (LPH) were discharged, via a sump pump within the containment berm, to the drainage courses downslope from the Tank Farm and, ultimately, was described to have flowed to the beach area, where it pooled against the sea ice.

Between June 25 and July 6, 2002, Teck Cominco implemented a number of spill response measures to mitigate the spread and impact of the hydrocarbon release. These measures included but were not limited to: notification of regulatory agencies (Department of Fisheries and Oceans, Territorial Governments); recovery of liquid petroleum hydrocarbon from the drainage courses and the beach area downgradient from the release; excavation of impacted soils immediately below the discharge point; and transfer of the impacted soil to an on-site approved underground disposal area.

Between July 6 and July 13, 2002, GLL was on Site to characterize the soil, sediment and water quality issues that resulted from the release. GLL directed the supplemental remedial effort required to address outstanding issues identified during the course of the investigation.

The results of the investigation indicate that:

1. The source of the release had been addressed, and the potential of a recurrent release of hydrocarbon had been mitigated.
2. The quality of soil remaining within the extent of the excavation footprint was evaluated on the basis of organic vapour concentrations in soil and confirmatory soil sample analysis. With the exception of two small areas, soil at the base of the excavation is suitable for the current use of the Site. These two remaining areas were targeted for additional excavation and this work was ongoing when GLL staff demobilized from the Site July 13, 2002.
3. The results of test pit excavations, sampling and analyses indicate that hydrocarbon-impacted sediment and groundwater remains along the beach area within a "40 m Zone", down gradient of the point of discharge.
4. Based on visual observations and analyses of sediment and groundwater a lesser degree of impact has occurred within a "60 m Zone" to the south. This area will not require additional or supplementary remedial efforts.

5. Based on visual observations and extensive analysis of sediment and groundwater samples within a "175 m Zone" located north of the "40 m Zone", spotty hydrocarbon-impacted soil and groundwater is attributed to surficial staining of the sediments and not subsurface flow.

The hydrocarbon impacts within the "40 m Zone" appear to have been emplaced as a result of transport of mobile hydrocarbons along the permafrost table and expressed as a seeps along the beach area. The seepage resulted in discontinuous hydrocarbon stains within the beach sediment. This fraction of the liquid petroleum hydrocarbon is likely immobile and bound within the sediment by capillary forces. However, it may continue to impact the benthic environment during high tide conditions and provide a source of dissolved hydrocarbons to the aquatic environment.

Monitoring of these areas along the beach will be required to ensure that the hydrocarbon seeps or stains do not increase in size or impact to the environment. Residual impacted soil that is currently stable can be removed during the overall Site remediation in accordance with the approved *Polaris Mine Decommission and Remediation Plan*, March 2001.

Table of Contents

Page

Executive Summary ..... *i*

1. **Introduction** **1**
   - 1.1 Objectives 1
   - 1.2 Background 1
     - 1.2.1 Site Description 1
     - 1.2.2 Overview Of Spill History 2
   - 1.3 Scope Of Work 4

2. **Regulatory Setting** **5**

3. **Field Investigation Methodology and Observations** **7**
   - 3.1 Additional Immediate Spill Response Measures 7
   - 3.2 Sampling of Liquid Petroleum Hydrocarbon 8
   - 3.3 Remedial Excavation Confirmatory Soil Sampling 8
     - 3.3.1 Initial Remedial Excavation 9
     - 3.3.2 Final Remedial Excavation 9
     - 3.3.3 Confirmatory Soil Sampling 10
   - 3.4 Test Pit Investigation And Sediment Sampling 10
     - 3.4.1 Identification of Impacted Areas Along Beach 10
     - 3.4.2 Test Pit Investigation 11
     - 3.4.3 Sampling of Sediment 12
   - 3.5 Installation and Development of Wells 12
     - 3.5.1 Installation of Wells 12
     - 3.5.2 Well Sampling 13
     - 3.5.3 Laboratory Analyses 13
   - 3.6 Quality Assurance/Quality Control (QA/QC) 14

4. **Results** **15**
   - 4.1 Stratigraphy 15
   - 4.2 Stained or Odorous Soil or Sediment 15
   - 4.3 Laboratory Analyses 16
     - 4.3.1 Liquid Petroleum Hydrocarbon Chemistry 16
     - 4.3.2 Soil Chemistry 16
     - 4.3.3 Sediment Chemistry 16
     - 4.3.4 Groundwater Chemistry 18

5. **Discussion** **19**
   - 5.1 Hydrogeology 19
   - 5.2 Soil Quality 19
   - 5.3 Sediment Quality 19
   - 5.4 Groundwater Quality 20

6. **Conclusions** **21**

7. **Limitations** **22**

List of Tables

Table 1. Initial Excavation Organic Vapour Concentration Results in Soil ..... Back of Report
Table 2. Final Excavation Organic Vapour Concentration Results in Soil ..... "
Table 3. Summary of Analytical Results for Hydrocarbons in Soil ..... "
Table 4. Summary of Analytical Results for Polycyclic Aromatic Hydrocarbons in Soil ..... "
Table 5. Summary of Analytical Results for Hydrocarbons in Sediment ..... "
Table 6. Summary of Analytical Results for Polycyclic Aromatic Hydrocarbons in Sediment ..... "
Table 7. Summary of Analytical Results for Hydrocarbons in Groundwater ..... "
Table 8. Summary of Analytical Results for Polycyclic Aromatic Hydrocarbons in Groundwater ..... "

List of Figures

Figure 1. Location Plan ..... Back of Report
Figure 2. Site Plan ..... "
Figure 3. Detail of Initial Excavation Field Screening Results ..... "
Figure 4. Detail of Final Excavation Field Screening Results ..... "
Figure 5. Detail of Hydrocarbon Analytical Results ..... "

Appendices

Appendix A. Work Plan
Appendix B. Regulatory Framework
Appendix C. Photographs
Appendix D. Laboratory Reports
Appendix E. Acronyms

1. Introduction

As requested by Teck Cominco Ltd. (Teck Cominco), between July 6, 2002 and July 13, 2002, Gartner Lee Limited (GLL) inspected the environmental conditions at the Polaris Mine Site (the Site) on Little Cornwallis Island, Nunavut. Specifically, GLL was retained to document the effectiveness of Teck Cominco's response and remediation measures to a petroleum hydrocarbon release that occurred at the Site on June 25, 2002 (the Spill). The release occurred as a result of petroleum impacted standing water being pumped from within the containment berm of the Site's Tank Farm.

1.1 Objectives

The objectives of GLL's investigation were to:

1. Document environmental conditions within the source area of the hydrocarbon release and within areas hydraulically down gradient of the Spill; and,
2. Recommend additional mitigation measures, as appropriate, to supplement response measures that were undertaken by Teck Cominco prior to and/or during the GLL investigation.

1.2 Background

1.2.1 Site Description

The Polaris Mine is situated approximately 100 km northwest of the community of Resolute, Nunavut on Little Cornwallis Island (Figure 1). The Polaris orebody was discovered in the early 1970's and the construction of the mine and facilities began in 1980. The first concentrate was produced in late 1981. The existing Fuel Tank Farm was installed in 1980 and an additional storage tank constructed in 1986. The underground zinc-lead mine ceased operating in August 2002 due to the exhaustion of ore and is now in the process of implementing the Decommissioning and Reclamation Plan.

The Fuel Tank Farm is located southeast of the Foldaway Buildings at the old dock, as shown in Photograph 2 (Appendix C) and on the Site Plan (Figure 2). It consists of two above ground steel tanks, each with a capacity of 5.5 million litres, and one small tank with a capacity of 100,000 litres. The two large tanks have been used to store P20 and P60 diesel fuel. The small tank was originally used to store gasoline. At the time of the Spill it contained the remains of the Bent Horn crude oil used in a generator trial in the late 1980's. The tanks are located within a bermed area lined with an impermeable membrane.

Diesel fuel is delivered by ocean tanker each summer (typically late July). The tanker delivers the fuel by pipeline from the shiploading dock, located to the north of the Foldaway Buildings, to the two 5.5 million litre tanks. The diesel fuel is transferred to other storage tanks on Site by pipeline for dispensing.

1.2.2 Overview Of Spill History

On July 2, 2002, GLL was retained by Teck Cominco to provide immediate assistance in assessing and remediating the effects of a release of diesel fuel at the Site's Tank Farm containment berm. The release was the result of discharge of hydrocarbon impacted standing water from within the containment berm of the Tank Farm. The accumulated water and liquid petroleum hydrocarbons (LPH) were discharged via a sump pump, located within the containment berm, to the drainage courses down slope from the Tank Farm and ultimately was described to have flowed into Crozier Strait.

According to information provided by Teck Cominco:

- Water observed within the containment berm of the Tank Farm immediately prior to the release was present due to the accumulation of spring melt water and rainfall.
- On June 25, 2002, upon observing water in the containment berm, Teck Cominco activated the containment system's sump pump.
- On June 26, 2002, approximately 20 hours following the onset of pumping, Teck Cominco personnel observed what appeared to be liquid petroleum hydrocarbons on the road and hillside down gradient from the Tank Farm. Spill response procedures, as described in the following text, were immediately implemented.
- Following an investigation, Teck Cominco concluded that water retained by the Tank Farm containment berm became impacted with liquid petroleum hydrocarbons (mainly diesel fuel) due to leakage from a pipe within the containment area. The pipe was used to transfer fuel between two diesel storage tanks within the containment area.
- Volume measurements in the two diesel storage tanks involved in the fuel transfer were taken by Teck Cominco after the release. The volume measurements indicate that between 1,500 L and 4,500 L of diesel fuel may have leaked from the pipe into the containment area prior to and/or during the release.
- Following the release, approximately 3,000 L to 3,500 L of water impacted with liquid petroleum hydrocarbons was removed from within the containment berm of the Tank Farm and stored in 205 L drums on pallets on the north side of the containment berm.
- Teck Cominco estimates that between approximately 1,200 L and 1,500 L of liquid petroleum hydrocarbons were released to the environment via the sump pump.

According to Teck Cominco, conditions at the time of the release included a predominately northerly wind direction and the presence of sea ice frozen to the ocean bed within approximately one (1) m of the shore. Such conditions served to contain the release, and thereby assisted in Teck Cominco's efforts to

recover floating liquid petroleum hydrocarbons on the ocean surface and limited the size of the petroleum hydrocarbons "smear zone" (discussed below) that developed along the ocean shore.

Spill Response

The following is a summary of the spill response actions taken by Teck Cominco from the time that the release was discovered on June 26, until GLL staff arrived on the Site July 6, 2002:

- Reporting of the Spill to the NWT Spill Hotline on June 26, 2002;
- Contacting the Department of Fisheries and Oceans (DFO) on June 27, 2002;
- Identifying and isolating the source of the release to ensure that there was no risk of a further release to the environment;
- Installing hydrocarbon absorbent booms in a drainage culvert between the discharge site and the shoreline to remove liquid petroleum hydrocarbons on the surface of water flowing to the ocean (Photograph 1, Appendix C);
- Installing an interceptor ditch hydraulically up-gradient from the road ("the East Interceptor Ditch") to reduce the potential that impacted surface water originating near the release point could flow into the ocean;
- Removing visible and accessible floating liquid petroleum hydrocarbons from seawater ponded at the shore and on sea ice within approximately 5 m of the shore using absorbent pads and vacuum pumping equipment;
- Removing visible and accessible floating liquid petroleum hydrocarbons from the interceptor ditch and drainage culvert using hydrocarbon absorbent pads and vacuum pumping equipment;
- Removing visible and accessible staining on the shoreline sediment using hydrocarbon absorbent pads;
- Excavating potentially hydrocarbon impacted soil from between the discharge point and the road closest to the shoreline (Photograph 2);
- Excavating potentially impacted beach gravel along the shoreline after consultation with the DFO in Iqualit, Nunavut (Photographs 3 and 4);
- Transfer of excavated soil and sediment that contained petroleum hydrocarbons to the underground soil storage area designated under the approved Polaris Decommissioning and Reclamation Plan for the disposal of hydrocarbon impacted soil;
- Discussing the incident with GLL, soliciting professional input regarding the sufficiency of Teck Cominco's response, mitigation, remedial activities and requesting that GLL undertake an investigation to assess environmental impacts resulting from the Spill.
- Continuous consultation with federal and territorial government agencies and communities regarding the Spill and the measures taken to deal with this incident.

Teck Cominco estimates approximately 1,000 L (or between approximately 67% to 83% of the estimated volume of liquid petroleum hydrocarbons that was released) of liquid petroleum hydrocarbons product was recovered between June 26, 2002 (when the release was identified) and July 6, 2002. Teck Cominco estimates that the majority of the remainder of the released product was recovered during the excavation of suspected impacted soils between the discharge point and the shoreline.

Potential Chemicals of Concern

Based on the information provided at the time of the investigation, GLL determined that the potential chemical compounds of concern as a result of the release would be limited to:

- Light non-aqueous phase liquids (NAPLs); floating liquid petroleum hydrocarbon (LPH);
- Volatile petroleum hydrocarbon (VPH) compounds: benzene, ethylbenzene, toluene and xylene (BETX); components of gasoline and other petroleum hydrocarbons fuels;
- Extractable petroleum hydrocarbons (EPHs), which comprises the principal components of diesel fuel, motor oil, heating oil and hydraulic oil; and
- Polycyclic aromatic hydrocarbons (PAHs).

1.3 Scope Of Work

The scope of work is provided in Appendix A and was developed in consultation with the Polaris Mine Manager; the Polaris Operations Manager and senior GLL environmental professionals experienced in the assessment and remediation of hydrocarbon impacted soil and water. The specific tasks carried out during the investigation included:

- Recommending additional immediate spill response measures to be undertaken;
- Collection of representative samples of the spilled liquid petroleum hydrocarbon to confirm the preliminary assessment of the chemical compounds of concern;
- Sampling of the soil remaining in the area excavated by Teck Cominco between the discharge site and the shoreline to confirm that all of the hydrocarbon contaminated soil had been removed;
- Undertaking preliminary assessment of the quality of sediment in the shoreline smear zone; and
- Undertaking a preliminary assessment of the quality of groundwater in the shoreline smear zone.

2. Regulatory Setting

To allow and expedite the preliminary assessment of the quality of soil, sediment and groundwater at a screening level, the analytical results were compared to the generic Canadian Council of Ministers of the Environment (CCME) guidelines for the potential chemicals of concern. In the absence of some CCME guidelines with respect to water quality, reference was made to British Columbia provincial standards, again strictly for comparative purposes, for the assessment of water quality with respect to its content of petroleum hydrocarbons constituents.

However, for assessing the adequacy of remediation of soil, the appropriate soil quality objectives are the approved site-specific soil quality remediation objectives for petroleum hydrocarbons developed for the decommissioning of the Polaris Mine and documented in the *Polaris Mine Decommission and Remediation Plan*, March 2001.

The CCME guidelines, the site-specific remediation objectives, and the British Columbia provincial standards used in this assessment are described in Appendix B.

Assessing the Quality of Soil, Sediment and Groundwater

To assess the effects of the released liquids on the quality of soil, sediment and groundwater at the Site, the analytical results were compared to a framework of generic guidelines that are identified in the following documents:

- *Canadian Environmental Quality Guidelines* (CEQG) for soil, sediment and surface water, Canadian Council of Ministers of the Environment (CCME), Winnipeg MB, 1999.
- *Canada Wide Standards for Petroleum Hydrocarbons (PHC) in Soil*, Canadian Council of Ministers of the Environment (CCME), Winnipeg, MB, May 2001.
- *Protocol 7: Protocol for Regulation of Petroleum Hydrocarbons in Water under the Special Waste and Contaminated Sites Regulation*, BC Ministry of Water, Land and Air Protection, May 2002.

The CCME generic guidelines apply to all Canadian federal lands for which no site-specific remediation objectives have been established. The CCME guidelines are not legislated standards. If soil, sediment or water at a federal site in Canada contains a concentration of a chemical compound that exceeds an applicable CCME guideline, although remediation and/or management might be recommended as potentially reasonable and prudent courses of action, there is no regulatory requirement that compels such actions be taken.

Assessing the Adequacy of Remediation

Site-specific remediation objectives for petroleum hydrocarbons in soil were developed for the decommissioning of the Polaris Mine prior to the endorsement of the *Canada Wide Standards for*

Petroleum Hydrocarbons (PHC) in Soil (PHC CWS) by CCME in May 2001. The Polaris Mine 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.

Samples collected during the current assessment were analyzed and quantified according to the most recent procedures endorsed by CCME in the PHC CWS. In the new federal guidelines, petroleum hydrocarbons are subdivided according to specified ranges of equivalent carbon number that are different than those specified in the Yukon Territorial Contaminated Sites Regulation. Therefore, a direct comparison of soil and sediment quality data obtained during the current assessment to the approved Polaris Mine remediation objectives for petroleum hydrocarbon parameters cannot be made.

3. Field Investigation Methodology and Observations

The field investigations consisted of:

- determining if additional immediate spill response measures were required and implementing them;
- the collection of two samples of the residual floating liquid that remained in the Tank Farm berm after the discharge ceased. The product samples were analyzed by Aurora Laboratory Services Ltd. (ALS) of Vancouver, BC to verify the presence and nature of the hydrocarbon compounds associated with the release;
- the collection of 141 soil samples within the area excavated between the Tank Farm and the shore. These soil samples were field screened for organic vapour concentrations and the results were used to direct the remedial excavation effort;
- the excavation and sampling of sediment from 21 shallow test pits located along the shoreline. Selected sediment samples were submitted to ALS for chemical analysis of hydrocarbon parameters;
- the installation of 12 wells within the beach area; and.
- upon delivery of additional sample containers to the Site following GLL field staff's departure, the collection of 11 confirmatory soil samples from the area excavated above the shoreline and the sampling of groundwater in 9 of the wells (before they were destroyed by the floating ice pack) within the beach area. The soil and water samples were submitted to ALS for chemical analysis of hydrocarbon parameters.

3.1 Additional Immediate Spill Response Measures

A site reconnaissance survey was conducted by GLL field staff and the results of this survey were reported to senior GLL environmental professionals. As a result of this initial site assessment, GLL recommended that Teck Cominco excavate a second ditch (the West Interception Ditch) closer to the shoreline and that the depth of the ditch be extended to the low tide elevation in order to intercept potentially impacted groundwater and surface water flows originating near the release area. Excavation of the West Interceptor Ditch commenced the evening of July 7, 2002 (Photograph 5).

A shallow cross trench through the road was extended to the shoreline on the evening of July 7, 2002 in order to control the levels and outlet path of water that had accumulated within the trenches. A berm was constructed at the West Interceptor Ditch on the morning of July 8, 2002 (Photograph 6) to divert surface runoff from the constructed channel. Hydrocarbon absorbent booms and absorbent pads were used to remove potential floating liquid petroleum hydrocarbons from the effluent of the constructed channel (Photograph 7).

Between July 7 and July 12, 2002, the West Interceptor Ditch was extended horizontally along the shoreline to intercept a greater volume of groundwater down gradient from the discharge point in the Spill area. The ditch was also enlarged vertically during this period as the depth to permafrost increased due to melting. Locally, the West Interceptor Ditch was advanced vertically into ice as shown on photograph 8, Appendix C.

3.2 Sampling of Liquid Petroleum Hydrocarbon

As discussed earlier, the 3,000 to 3,500 L of water and hydrocarbon mixture that remained within the containment berm was transferred into 205 L drums and stored on pallets adjacent to the Tank Farm (Photograph 9, Appendix C). According to Teck Cominco personnel, a majority of the liquid petroleum hydrocarbon remaining within the Tank Farm containment berm was skimmed off and transferred into three 205 L (45 U.S. gallon) drums and stored on the pallet closest to the fuel pipeline, as seen in Photograph 9. The remainder of the hydrocarbon impacted water was transferred into the other drums that were filled and stored in this location.

On July 12, 2002, GLL field staff collected two samples of liquid, using new disposable plastic bailers, from two of the three drums that received the skimmed liquid petroleum hydrocarbon and water mixture. One sample (Sample DRUM1) was collected from the upper 20 cm of floating liquid petroleum hydrocarbon in one of the three drums. The other sample (Sample DRUM2) was collected from the entire column of liquid in a second of the three drums. Each liquid sample was placed into (1) 40 ml glass 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 sheen and contained a trace of immiscible green globules (less than 1 cm in diameter) that were denser than the rest of the sampled liquid.

3.3 Remedial Excavation Confirmatory Soil Sampling

The quality of the petroleum hydrocarbon impacted soil in the excavated area was field screened by measuring the concentrations of organic vapours in soil samples using the bag headspace method. The bag headspace method involves placing soil in a sealable polyethylene bag, sealing the soil in the bag, dis-aggregating the soil in the bag, allowing organic vapours in the soil to accumulate in the headspace of the bag, and then measuring the concentration of organic vapour in the bag headspace. During the investigation, GLL used a portable photoionization detector (PID) to measure concentrations of organic vapours in the headspace of the sample bags. The PID instrument was calibrated with hexane by GLL staff on July 5, 2002, prior to departure to the Site. On-Site field calibration of the instrument was not possible due to shipping restrictions associated with transportation of the calibration gas.

Two periods of remedial excavation were conducted: the initial remedial excavation was generally conducted prior to July 8, 2002 and the final remedial excavation was conducted subsequent to July 8, 2002. At the conclusion of the final remedial excavation and following the delivery of sample containers to the Site, confirmatory soil samples were collected from the excavated area and submitted to ALS for analysis of hydrocarbon parameters. The following sections summarize the methodology employed during each phase of the soil sampling program.

3.3.1 Initial Remedial Excavation

On July 8, 2002, GLL collected samples of exposed soil from the limits of excavations located hydraulically down gradient from the point of release. The area around the East Interceptor Ditch was in the process of being excavated by Teck Cominco. A total of 67 samples of soil (from locations SS02-001 to SS02-054, SS02-056 to SS02-068) were collected at approximately 5 m intervals from the floors and walls of the excavation. The sample locations were plotted by GLL on a digital copy of the excavation plan provided by Teck Cominco (Figure 3). Teck Cominco personnel assisted GLL in collecting the soil samples and in surveying the locations of the samples.

Measured concentrations of organic vapour in the soil samples were, typically, less than 2.9 parts per million (ppm) (Table 1). However, two areas of exposed soil containing between 28 ppm and 60 ppm of organic vapour in its headspace were identified. These areas were surrounded by soil containing concentrations of organic vapour of up to 5.5 ppm. Soil suspected of being impacted, based on the visual appearance, olfactory indicators and elevated organic vapour concentrations within these two areas, was targeted for further excavation.

On July 11, 2002 exposed soil at the southern extent of the initial excavation was sampled and an area suspected of being impacted was immediately excavated. Three (3) samples of soil from locations SS02-122, SS02-124 and SS02-125 were collected prior to the re-excavation of the area and are therefore included in the following table of initial excavation field screening results.

3.3.2 Final Remedial Excavation

Following the soil screening conducted for the Initial Remedial Excavation, the locations of soil sample sites with headspace organic vapour concentrations greater than 5.5 ppm were clearly marked in the field to facilitate additional excavation of this suspect material. On July 9, 2002, Teck Cominco excavated the soil in all marked areas down to weathered bedrock (Photographs 10 and 11).

On July 11, 2002, the re-excavated area was sampled using a nominal 5 m grid pattern and the headspace concentration of organic vapours from the soil samples were measured as indicated in Figure 4 and listed in Table 2. Teck Cominco and two general laborers hired from Resolute assisted GLL in collecting the soil samples. The results indicated that, in general the concentrations of headspace vapour in soil at the limits of the re-excavated areas were less than 10 ppm.

Elevated headspace vapour concentrations were noted in separate areas located approximately 35 m south of the discharge point along the east wall of the excavation, and along the excavation walls beneath the former roadbed between the two interceptor ditches. The elevated vapour concentrations beneath the roadbed were observed to be confined vertically to a narrow horizon between the compacted roadbed surface and above the underlying permafrost. These areas were marked and additional excavation of these areas was ongoing on July 13, 2002, when GLL left the Site.

3.3.3 Confirmatory Soil Sampling

Confirmatory soil samples for laboratory analysis were scheduled to be collected by Teck Cominco upon delivery of additional sample jars to Site. GLL trained Teck Cominco personnel regarding soil sampling methodology, sample storage and transportation requirements. On September 6, 2002 soil samples A1 to A4 and B1 to B7 were collected along two transects across areas that had elevated organic vapour concentrations when sampled previously by GLL on July 11, 2002, as shown on Figure 4. The soil samples were collected at 5 m intervals. The sample sites were prepared by removing the upper 0.05 m to 0.1 m of soil/rock from a 0.3 m diameter area. Soil was collected in laboratory supplied sample jars with Teflon lined lids. Particles larger than 1 cm in diameter were removed from the samples and the soil was packed tightly within the jars to minimize headspace volumes. Two samples of soil were collected at each location.

3.4 Test Pit Investigation And Sediment Sampling

3.4.1 Identification of Impacted Areas Along Beach

Based on direct observations on Site and consultation of tide tables from July 5 to August 6, 2002,GLL marked the intertidal zone along the shoreline that was considered to have been most susceptible to hydrocarbon impact as a result of the release (Photograph 12). The tidal fluctuation during the period was noted to have a maximum relative amplitude of 1.7 m between low and high tides. These upper and lower markers denote the vertical limits of areas along the shoreline that may have been impacted.

Laterally, three zones within the intertidal zone defined above were identified based on visual indicators of hydrocarbon staining and the interpreted origin of the hydrocarbon (surficial staining in runoff or as a result of subsurface seeps expressed to surface). The three zones are referred to as the "40 m Zone", the "60 m Zone" and the "175 m Zone" as indicated in Figure 5. The "40 m Zone", encompasses a 40 m long portion of the intertidal smear zone located approximately hydraulically down-gradient of the discharge point in the Spill area. Within the "40 m Zone", GLL observed discontinuous areas up to approximately 2 m in dimension of stained sediment. This area was not subject to surficial flow of the water pumped from the Tank Farm containment berm through the drainage culvert. Therefore the impact has been interpreted to result from subsurface flow of impacted groundwater along the permafrost table and then expressed to surface as seeps that resulted in the stained areas along the beach. It is also

suggested that lateral migration of hydrocarbons would have occurred after the impacted groundwater flow was expressed to surface in this area.

On July 7 and July 8, 2002, GLL observed some small (0.1 m diameter) stained areas of sediment within 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. As the "60 m Zone" was not directly downgradient of the discharge area, the impact in this area is attributed to the lateral migration of hydrocarbons that originated from the "40 m Zone". Therefore, the staining in this area is interpreted to have been surficial and not extending to a significant depth within the saturated sediment.

The "175 m Zone" extends from the "40 m Zone" 175 m to the north as far as the old dock area at the Foldaway Buildings. The "175 m Zone" was typified by spotty areas of staining along the shoreline and included a 50 m stretch located down-gradient from a culvert beneath the road which reportedly discharged liquid during the Spill. Therefore, the hydrocarbon impact within this area is interpreted to be due to surficial flow of impacted water that has been distributed by currents along the shoreline.

3.4.2 Test Pit Investigation

Test pits were excavated at 21 locations along the shoreline within and near the intertidal zone as shown on Figure 5. The purpose of excavating the test pits was to profile the nature of the subsurface sediment and depth to permafrost and also to recover sediment samples for laboratory analysis. GLL supervised the excavation of test pits by Teck Cominco personnel. The pits were generally excavated by hand using shovels near the shore in areas suspected of being most highly impacted. The pits were excavated using shovels to minimize the potential to remobilize liquid petroleum hydrocarbons. Approximately 25 per cent of the pits were excavated using a backhoe that was supplied and operated by Teck Cominco. Additional details regarding the test pit locations and methods of excavation are described below:

- 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 a depth of approximately 0.1 m below standing water in the pit or into ice.
- Pits at locations TP02-01 to TP02-03 (Photographs 13 and 14), TP02-05 to TP02-08 are within the "40 m Zone".
- The pit at location TP02-04 is within the "60 m Zone" south of the area suspected of being impacted with hydrocarbons.
- Pits at locations TP02-09 to TP02-15 are within an area of spotty staining noted in the "175 m Zone". Some of these pits were located in non-impacted areas, such as pit TP02-12, shown in Photograph 15.
- 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.

3.4.3 Sampling of Sediment

At each test pit location (to the extent practicable), continuous samples of soil or sediment were collected from within the inferred boundaries of the intertidal smear zone. Additional continuous samples of soil were collected, where practicable, from below the smear zone. At the first three test pit locations (TP02-01 through TP02-03), soil samples were collected from between 0.15 m to 0.20 m below ground surface. 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 of each test pit.

Sediment samples TP02-11-1 to TP02-11-3 were collected as blind field duplicates of TP02-01-1 to TP02-01-3. Sediment samples from test pit 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.

3.5 Installation and Development of Wells

3.5.1 Installation of Wells

On July 11, 2002 and July 12, 2002, GLL installed twelve groundwater wells, WELL02-1 to WELL02-12, as shown on Figure 2. The wells were installed by Teck Cominco under GLL's supervision during low tide conditions using a backhoe (Photograph 16). In general, each well is constructed of slotted 50 mm Schedule 40 polyvinyl chloride (PVC) pipe and the annulus surrounding the well backfilled with native sediment. During the installation of the wells, any obviously contaminated soil that was excavated was relocated to above the high tide elevation and subsequently removed to the underground soil disposal area.

Six of the twelve wells were installed below the low tide markers (Photograph 17) at the inferred lower boundary of the intertidal zone. Well locations are shown on Figures 2 and 5. These six wells were completed between approximate depths of 0.2 m to 0.5 m below the low-tide elevation from south of test pit TP02-04 and north to test pit TP02-17. Well WELL02-10 was destroyed by ice within 12 hours of its installation and was not available for sampling. The length of PVC pipe that extended above ground surface of the five remaining wells were reduced to within approximately 0.3 m of the ground surface to reduce the risk of the PVC pipe being sheared off by the ice during high tide conditions (Photograph 18).

An additional six groundwater wells were installed at or above the midway point between high and low tide (Photographs 19 and 20). 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 0.2 m into permafrost.

On July 12, 2002, Teck Cominco personnel assisted GLL in developing the wells (Photograph 21). The wells were developed using dedicated Waterra tubing and compatible inertial foot valves. Approximately 50 L of water was removed from each accessible well. Following development, water in the wells was generally clear to milky coloured.

3.5.2 Well Sampling

Teck Cominco personnel were trained according to standard industry practices to purge and sample the water in the wells for BETX, EPH, PAH, metals and nutrients. The wells were purged the day before the samples were collected to allow suspended sediment to settle. Samples of groundwater from the wells were collected July 16, 2002 by Teck Cominco and shipped to ALS on July 17, 2002. The samples reportedly contained a significant amount of sediment.

On July 16, 2002, wells WELL02-8 and WELL02-10 were found to be destroyed by the floating sea ice and the top of well WELL02-12 was submerged below sea water. Therefore no groundwater samples were collected from these wells.

Each groundwater sample was placed into labeled, pre-cleaned, laboratory-supplied containers and was stored and transported to the laboratory using chilled coolers under standard Chain-of-Custody protocols.

3.5.3 Laboratory Analyses

The samples collected to characterize the liquid petroleum hydrocarbons pumped from the containment berm were placed in a dedicated cooler with ice and shipped on July 13, 2002 to Aurora Laboratory Services Ltd. (ALS) of Vancouver, B.C. ALS is accredited by the Canadian Association for Environmental Analytical Laboratories. To determine the chemical composition of the petroleum product, the samples were submitted for a gas chromatograph scan and analyzed for the following:

- volatile petroleum hydrocarbons: benzene, ethylbenzene, toluene and xylene (BETX) and styrene;
- methyl t-butyl ether (MTBE);
- polycyclic aromatic hydrocarbons (PAHs);
- volatile petroleum hydrocarbon PHC CWS fraction F1; and
- extractable petroleum hydrocarbon PHC CWS fractions F2 through F4.

Soil samples A1 to A4 and B1 to B7 were placed in a cooler with ice and transported off site to ALS via air on September 7, 2002. The samples were analyzed for extractable petroleum hydrocarbons PHC CWS fractions F2 and F3. Select samples were also analyzed for volatile petroleum hydrocarbons BETX, styrene and PHC CWS fraction F1 and PAHs. Extractable petroleum hydrocarbons PHC CWS fractions F2 and F3 and the PAH parameter naphthalene are chemical compounds typically associated with diesel fuel.

Sediment samples from TP02-01 to TP02-03 were transported off site to ALS via air on July 10, 2002. The remaining sediment samples from TP02-04 to 21 were transported to ALS via air on July 13, 2002. Selected samples of soil were analyzed for PHC CWS fractions F1 through F4, BETX, styrene, and PAHs.

Groundwater samples were shipped to ALS on July 17, 2002. The samples were analyzed for extractable petroleum hydrocarbon (EPH), which is associated with diesel fuel. Select samples were also analyzed for PAHs on September 5, 2002 following a review of the EPH results.

3.6 Quality Assurance/Quality Control (QA/QC)

Approximately 10 percent of the sediment samples and 100 percent of the groundwater samples submitted for laboratory analysis were submitted with blind duplicates for quality assurance/quality control (QA/QC) purposes.

4. Results

4.1 Stratigraphy

The Polaris mine Site is located in the high Arctic at latitude 75 degrees north, within the zone of continuous permafrost. Glacial processes have formed the subdued and rounded topography in the study area, while the surficial materials are dominated by marine sediments overlying carbonate bedrock (*Polaris Mine Decommission and Remediation Plan*, March 2001).

The Polaris mine Site soils are classified as Cryolsolic. The stratigraphy is generally characterized by a stony surface consisting of angular to subangular pebble/cobble and gravels, underlain by fine to medium sand with subangular to subrounded pebbles or silty fine sand with gravel and pebbles. The depth to bedrock varies, but is typically less than 0.5 metres in the area down slope of the Tank Farm on the western sloping hillside above Crozier Strait.

The active layer (the upper portion of soil, where annual freeze-thaw cycling occurs) varies in thickness depending on the extent of seasonal thermal variations, the soil thermal properties and the nature of the soil and snow cover. The active layer on the hillside below the Tank Farm extends to bedrock. Within the beach gravel along the shoreline, the active layer is relatively shallow, ranging from 0.3 m to 0.9 m in thickness.

4.2 Stained or Odorous Soil or Sediment

Obviously stained or unusually odorous sediment was identified in the beach area during the investigation as shown on the Site Plan (Figure 2) and the detail plan illustrating the soil, sediment and groundwater analytical results (Figure 5). Obviously stained or unusually odorous soil was not identified within the final limits of the excavation on the hillside below the Tank Farm.

Organic vapour concentrations were measured on bagged samples of sediment and soil recovered during remedial excavation sampling and the test pit investigation in the beach area and provided on Tables 1, 2 and 5. The measured organic vapour concentrations ranged from 0.4 ppm to 168 ppm in the area excavated and from 0.9 ppm to 685 ppm in the beach area. Additional excavation of sediment and soil was undertaken in the areas with the highest measured vapour concentrations.

4.3 Laboratory Analyses

4.3.1 Liquid Petroleum Hydrocarbon Chemistry

GLL analyzed one sample of the liquid petroleum hydrocarbon (LPH) (sample "DRUM1") that was collected from a barrel of diesel/water mixture removed from the within the Tank Farm berm shortly after the Spill was identified. The results of the chemical analyses are provided in ALS analytical certificate P7184, a copy of which appears in Appendix D.

The gas chromatograph results (appended to the analytical certificate) indicate that the distribution of single chain carbon molecules in the analyzed LPH sampled is similar to the distribution of the chemicals in diesel.

4.3.2 Soil Chemistry

The results of the laboratory analyses of confirmatory soil samples from the excavation limits are summarized in Tables 3 and 4 and shown on Figure 5. Also shown on the tables are the generic CCME *Canadian Environmental Quality Guidelines* (CEQG) for soil and the CCME *Canada Wide Standards for Petroleum Hydrocarbons (PHC) in Soil* (PHC CWS) for Parkland land use and the Polaris Mine's site-specific remediation objectives for petroleum hydrocarbons in soil. Copies of the analytical certificates appear in Appendix D.

A direct comparison of soil quality data to the approved Polaris Mine remediation objectives for 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. In order to make a suitable comparison, the total concentration of LEPH and HEPH in samples was compared to the summation of fractions F2 and F3, which is referred to as Total Extractable Hydrocarbons (TEH) on Table 3. All analyzed soil from the excavation limits meets the TEH soil remediation objective.

4.3.3 Sediment Chemistry

The results of the laboratory analyses of selected sediment samples from the test pits within the shoreline intertidal zone are summarized in Tables 5 and 6. Also shown on Table 5 are the generic CEQG and PHC CWS soil guidelines for Parkland land use and the Polaris Mine's site-specific remediation objectives for petroleum hydrocarbons in soil. The CCME CEQG marine sediment guidelines are shown on Table 6. Copies of the analytical certificates appear in Appendix D.

Analyzed sediment from between the ground surface and frozen sediment (permafrost) at a maximum depth of 0.9 m (at location TP02-17) was analyzed for BETX, styrene, PHC CWS fractions F1 through F4 and PAHs. The results of these analyses indicate that: