POLARIS MINE – A CASE STUDY OF RECLAMATION IN THE HIGH ARCTIC

B. J. Donald, P.Eng.

Teck Cominco Limited
Bag 2000
Kimberley, B.C. V1A 3E1

ABSTRACT

Teck Cominco's Polaris Mine was the world's most northerly base metal mine situated in the high arctic of Nunavut. Zinc-lead mineralization was discovered in 1960. Reserves were 25 million tonnes grading 14% zinc and 4% lead. Underground mining commenced in 1981 and continued for 21 years. The mine closed in September 2002 and decommissioning and reclamation started immediately and continued until completion in September 2004.

Reclamation of the site was facilitated by favorable geology and climatic conditions. The ore body is hosted in an Ordovician limestone. Samples of representative strata underwent ABA testing confirming there was no potential for acid rock drainage. The site is located in the Northern Arctic Ecozone, an area that incorporates the coldest and driest landscapes in Canada. The permafrost in the area provides an additional mechanism to limit the potential for ML/ARD.

Decommissioning and reclamation of the site consisted of building demolition, disposal of metal and hydrocarbon contaminated soils within the permafrost zone, removals of the deep sea marine dock, decommissioning of the tailings facility dam, and recontouring of surface disturbances.

INTRODUCTION

Teck Cominco's Polaris Mine was the world's most northerly base metal mine situated on Little Cornwallis Island ("LCI") approximately 1,000 km north of the Arctic Circle in Nunavut.

The Polaris Mine was an underground zinc-lead mine. Mineralization was first discovered in 1960 during mapping for oil permits. The ore reserves were approximately 25 millions tonnes grading 14% zinc and 4% lead. The ore body is between 60m to 300m below surface and is situated completely within the permafrost zone. Construction of the mine began in 1980 and went into production by late 1981. Annual ore production was just over 1,000,000 tonnes per year producing between 250,000 and 300,000 wet tonnes of zinc and lead concentrates. The concentrates were stored in a large concentrate storage building until shipping season, when ocean going ore carriers transported the concentrates to Belgium for smelting. The mine closed in September 2002 after the ore reserves were exhausted.

Construction of the site had many challenges due to the remote location and the arctic climate. The mill, maintenance facilities, warehouse, and offices were constructed on a double-hulled barge in Trois-Rivières, Quebec. During the short ice free period in the summer of 1981 the barge was towed to site. A channel on the shore of Little Cornwallis Island had been excavated allowing the barge to be floated into position at high tide and then the channel was backfilled. Other major structures such as the concentrate storage building, the accommodations building, the thickener building, and the fuel tank farm were constructed on-site. The accommodation building was designed to house up to 240 people. Tailings were piped 5 km to a thickener with the excess water recycled back to the mill and the tailings deposited into the bottom of Garrow Lake. Garrow Lake is a meromictic lake that is chemically and thermally stratified with essentially no vertical mixing of the layers. The bottom of the lake is much denser due to high salinity (63 g/kg) and is anoxic. At closure approximately 15 million tonnes of tailings had been deposited in the lake. In 1990/1991 a dam was constructed on the outlet of Garrow Lake. During the remainder of operations, excess water from Garrow Lake was siphoned over the dam to control the lake level on an annual basis.

Underground mining at Polaris utilized a sublevel blasthole technique that left rib pillars between the primary stopes for subsequent recovery. As the primary stopes were mined, the voids were backfilled with quarried rock and mine development waste. Initially, the backfill was consolidated using water as the mine workings were in permafrost. To improve recovery, the mine switched to cemented rock fill which had much higher strength characteristics.

The site has a 1,200m gravel airstrip. Aircraft were the only means of transporting goods to and from the site other than during the shipping season when ocean going freighters brought in supplies or took out the concentrates. Air service to the site was via commercial airlines from the south to Resolute Bay twice per week, and then by charter aircraft to the site (100 km northwest of Resolute Bay).

The mine is located on Government of Canada land leases that expire in 2011. Water use and protection of the water resources at the site are regulated through a Type A water licence issued by the Nunavut Water Board. Both the land leases and water licence require a reclamation plan to be submitted for approval.

PHYSICAL ENVIRONMENTAL SETTING

Climatic Setting

The site is located in the Northern Arctic Ecozone, an area that incorporates the coldest and driest landscapes in Canada. The mean annual temperature is -17 degrees Celsius. On average there are 8 frost free days a year. Precipitation levels are low due to the extremely cold temperatures, which lowers the level of absolute humidity and hence the available moisture. Snow melt typically begins in June with sea ice break-up occurring from mid-July to early August. Annual precipitation is approximately 250mm of which 200mm is in the form of snow. Wind speeds average 20 km/hr. The mine is in an area of continuous permafrost. The active layer overlaying the permafrost is less than 1.4m thick.

Terrain

LCI is dominated by marine sediments overlying bedrock. It is believed that after the Queen Elizabeth Islands Glacial Complex melted about 10,000 years ago, the sea bottom uplifted due to isostatic rebound as the weight of the glaciers was removed. This is responsible for the subdued and rounded topography over most of the site. On the westward side of the island in the vicinity of the mine, the area is characterized by a step hillside from the Accommodations building down to the sea.

Geology

The ore body is a Mississippi Valley type deposit with the primary ore minerals being sphalerite and galena with the waste being predominantly dolomite with calcite and marcasite. The favored host strata for the ore is the Thumb Mountain Formation, an Ordovician limestone. Overlying the Thumb Mountain Formation is the Irene Bay Formation and the Cape Phillips Formation, both of which are exposed on surface. Erosion has removed any younger strata on LCI. The Thumb Mountain and Irene Bay Formations weather into well drained gravels. The Cape Phillips Formation weathers into a much higher proportion of fines. Due to the calcareous nature of these formations the resulting soils are alkaline in nature (pH 8).

Vegetation

The vegetation on Little Cornwallis Island is classified as “Arctic Tundra”. BC Research (1975, 1979) conducted surveys of vegetation types in the mine area. The active mine site was located in an area described as “Bare” with relatively low biological sensitivity due to the scarcity of vegetation and the associated low potential for wildlife use.

Wildlife

Baseline environmental studies conducted by BC Research (1975, 1979) included a survey of the population and distribution of animals and birds on LCI. Observations included the presence of Peary caribou, Musk ox, lemmings, Arctic hare, Arctic fox, Arctic wolf, Polar bear, and a number of migratory birds. In 1997 a survey by Bryant Environmental Consultants Ltd. also identified lemmings on LCI.

ACID ROCK DRAINAGE AND METAL LEACHING INVESTIGATIONS

Due to the permafrost all of the underground mine workings are colder than -4 degrees Centigrade eliminating the potential for acid rock drainage (“ARD”) or metal leaching (“ML”). There were three surface quarries used for construction materials and for cemented rock fill. The potential for ARD/ML was evaluated for each of the four major geologic units present in the quarries. Acid base accounting

(“ABA”) test results had neutralization potential ratios (“NPR”) ranging from a low of 8 for the Green Shale in the Old Quarry to a high of 1034 for the Limestone in Little Red Dog Quarry. Paste pH’s ranged from 8.2 to 8.7 and sulphide sulphur ranged from 0.78% for the Green Shale to 0.04% for the Limestone. Both the limestone and dolomite had very low leachable metals concentrations and as expected the Green Shale had higher leachable metals concentrations (Aqua Regia Digestible Metals leachate had 139ppm for zinc and the water leach test had <5 ppb zinc) but were not considered readily leachable.

CLOSURE PLANNING

Polaris Mine reserves were well defined so the rate of mining and the mine plans were used to identify the approximate closure date of the mine well in advance. In 1996 the mine closure and reclamation plan was updated but it was still at a preliminary conceptual stage. To assist in planning for closure, a staged environmental site assessment was initiated in 1999 with follow up investigations being undertaken in the summer of 2000. As the site is on Government of Canada land leases, the site investigations were done consistent with protocols adopted by the Canadian Council of the Ministers of the Environment (“CCME”). The site assessment was a key element in developing the Decommissioning and Reclamation Plan (“DRP”).

Prior to the mine being developed as well as during the mine life, a number of studies have provided a good understanding of wildlife in the area and local Inuit hunting practices. A study by Outcrop Ltd. (June 1980) entitled “Potential Socio-Economic Impacts of the Polaris Mine Project” identified the historical land use activities of hunting and trapping by local Inuit. The Outcrop study concluded “that the mine location will have little impact on the hunting/trapping harvest of the Resolute Inuit since Little Cornwallis Island is a low priority hunting area.” In 1997 environmental studies for the potential development of an adjacent mineralized area (Bryant Environmental Consultants Ltd., 1997) provided a good summary of wildlife and Inuit hunting practices on LCI. In 2000, interviews of local residents by Gartner Lee Ltd. staff further verified the historic land use of LCI. The combined information of land use and wildlife were used to develop a human health and ecological risk assessment to establish risk based remedial objectives for metal contaminated soils. The risk based remedial targets were approved by both the Water Board and INAC as part of the DRP. The remedial targets established were 10,000 ppm for zinc and 2,000 ppm for lead. Remedial target for hydrocarbon contaminated soils were selected based on the Yukon Territorial Contaminated Sites Regulations (“CSR”) standards for Parkland Land use (1,000 ug/g Light Extractable Petroleum Hydrocarbons and Heavy Extractable Petroleum Hydrocarbons).

In May 2000 a preliminary but detailed closure plan was presented to regulators and local residents to obtain comments prior to finalizing it. During the summer, additional field work and other studies were undertaken to refine the closure plan. In March of 2001 the Polaris Mine Decommissioning and Reclamation Plan (“DRP”) was submitted to both the Nunavut Water Board and the Department of Indian and Northern Affairs Canada (“INAC”) for joint approval. Conditional approval was received in April 2002.

Due to the cost of maintaining the site, it was decided to compress the decommissioning and reclamation activities into a two year period. It was planned to concentrate most of the work into the spring to fall periods to take advantage of the warmer weather and longer daylight hours. The implementation of the DRP was contracted so that the right skill sets and equipment would be available.

Teck Cominco committed to utilize northern personnel where possible during implementation of the DRP. The general contractor implementing the DRP, subcontracted much of the earth moving activities to Qikiqtaaluk Corporation, an Inuit owned and staffed company. Other local Inuit employees were utilized for other work at the site. The environmental consultant, Gartner Lee Ltd. ensured at least one Resolute Bay resident was working with them from the initial ESA throughout the implementation of the DRP.

DECOMMISSIONING AND RECLAMATION ACTIVITIES

Pre-Closure Reclamation Activities

In 1998 the mine site started reclamation activities as personnel and equipment became available. Initially, obsolete equipment and scrap materials were collected from storage yards around the site and were taken to a new landfill. The landfill was an area located over top of some underground mine workings that was actively subsiding and the debris and fill was used to fill in the depression of the ground surface. Equipment was drained of fuel, oils and glycol, and the batteries removed prior to being buried. Tracking forms were used to identify the date and the description of the equipment that were disposed of in the landfill. The form also had a check list identifying the substances removed from the equipment before it was disposed of. The mechanic preparing the equipment for disposal and his supervisor would sign the form confirming that it had been properly prepared. By the time the mine closed a substantial quantity of old equipment, steel, tires and other scrap materials had been buried. No chemicals or hazardous materials were disposed of in the landfill.

The site had an old landfill that had been used during construction. It was located just upslope of the foreshore of the ocean. Due to its proximity to the ocean, it was excavated and re-located to the primary landfill at the site. This excavation process was done during the winter months to avoid the potential for site run off while it was being excavated. The relocation of the landfill was completed prior to the mine closing.

In the vicinity of the original exploration portal at the mine, development waste was stockpiled to create a level pad. At mine startup, and at various times during operations, this area was used to stockpile ore. During the last year of operations, the mine started to haul this material back underground, using it for backfill. By the time the mine closed only a portion of this material had been removed and the remainder had to be cleaned up during the site reclamation project.

During the last two years of operations, inventories in the warehouse were minimized. Some items were returned to suppliers for credit, others written off and identified for disposal. Inventories of reagents were kept to a minimum and many of the surplus chemicals were shipped off site in the summer of 2002 just prior to closure of the mine.

In preparation for removing the dam at Garrow Lake, starting in 1999, the amount of water siphoned out of the lake was increased to gradually lower the lake level back to its original level. This process was only partially completed at the time of closure and continued until 2003.

<u>Building Demolition</u>

The main buildings requiring demolition were the barge, concentrate storage building, accommodations building, thickener, cemented rock fill building and the fuel tank farm. There were a number of other smaller storage buildings located around the site. A company specializing in heavy industrial building demolition was used to demolish all of the buildings on site. One of the major scheduling difficulties faced was the gradual destruction of the site's infrastructure while still requiring the use of most of them. The services included power, heat, fresh water, sewage, maintenance facilities, accommodations and the airstrip. This was accomplished by working around these facilities for as long as possible, and then installing smaller scale, temporary services or facilities. At the end of the project accommodations consisted of a small exploration type camp, several old trailers, an old wood shed, and even sea shipping containers.

After removing any hazardous materials from the buildings and associated equipment, the buildings were cut to pieces with cutting torches and large hydraulic shearers mounted on excavators. Lighter portions of the buildings were pulled apart with excavator buckets equipped with thumbs. Due to the volume of gases required for cutting and the remote location, an oxygen generating plant was purchased. Some equipment was salvaged but unless it had sufficient value it was not worth the cost of shipping it south for sale. The debris was then hauled to the Little Red Dog ("LRD") Quarry for disposal. Materials disposed of in LRD Quarry were cut into small sizes or compacted with a car crusher to minimize void spaces in the landfill. Materials were placed in lifts of up to 4m deep and mixed with blasted rock fill to compact the lifts as much as practical. Prior to closure, engineering estimates were made of the volume of debris that would be generated. It was estimated that approximately 50,000 cubic metres of debris would be created. This volume would be increased by the addition of fill materials. To be conservative, it was assumed that up to 100,000 cubic metres may need to be disposed of in LRD Quarry.

<u>Decommissioning of the Marine Dock</u>

To facilitate the docking of large tonnage ore carriers, the shoreline was extended out into deeper water and a dock consisting of four large cells was constructed from sheet piles. Decommissioning required the cutting off of the sheet piles, at least 3 metres below the lowest low tide elevation and the fill excavated back at a 14H to 1V slope. Excavation of the dock cell was undertaken through all seasons of the year. During open water season, excavation behind the sheet piles was the priority to minimize the release of sediment into the water column. During the winter months of 2004, two teams of divers were brought in and crews worked around the clock for 12 weeks cutting off the sheet piles using cutting torches.

The shoreline adjacent to the dock was constructed of fill for several hundred metres. During mine operations, controlling erosion of this area was an on-going problem. On an annual basis, rip-rap was replaced during open water season. As a result, closure plans recognized the futility of armouring the shore adequately to prevent long term erosion. It was decided the best method of minimizing the rate of erosion and to mimic the natural beach that would eventually form was to re-contour the foreshore to a flat 14H to 1V slope. Earth berms providing a barrier between the foreshore and the ocean were left in place until re-contouring was complete. The berms were removed while the ice pack was still in place. By the end of the summer of 2004, ice flows impacting the beach had already substantially naturalized the look of the new foreshore.

Decommissioning of Garrow Lake Dam

Garrow Lake is a meromictic lake that is chemically and thermally stratified with essentially no vertical mixing of the layers. The bottom of the lake is much denser due to high salinity (63 g/kg) which creates the stability of the layering of the lake. As there is no vertical movement of water within the lake, the bottom layer is anoxic. Because of these properties, the bottom of Garrow Lake was selected as the location for tailings disposal. Through the life of the mine, approximately 15,000,000 tonnes of tailings were deposited on the bottom of Garrow Lake. In 1985 a tailings line break caused discharge of the tailings into the surface layer of the lake. Zinc concentrations in the surface layer increased and as a contingency, in 1990/1991 a dam was constructed at the outlet of the lake so that discharge from the lake could be halted until zinc concentrations stabilized. By 1990 the zinc level peaked at just over 0.4 mg/L and has been gradually decreasing since. Currently zinc concentrations in the surface layer are about 0.25 mg/L. In 1992 discharge from the lake was resumed by siphoning over the dam. The lake level had been increased by 2.5m by this time. In preparation for closure, since 1999 siphoning of the lake has been increased to gradually decrease the lake level back to its original elevation so that the dam could be decommissioned. Siphoning was concluded in the fall of 2003 and the centre portion of the dam was removed in March and April of 2004. The residual fill of the dam were contoured 4H to 1V slopes to ensure stability. The creek channel through the dam foundation area was armoured to ensure there was no erosion of the creek channel in the vicinity of the remaining dam slopes. Starting with the summer of 2004, Garrow Lake was again flowing in its original creek channel.

Landfill Closures

There are three landfills at Polaris. The Operational Landfill was the primary landfill during operations. Domestic garbage was incinerated and placed into the landfill. Reagent containers were washed prior to being placed into the landfill. Items such as lead batteries were shipped to southern Canada for disposal and were not placed into the landfill. As discussed earlier, the Construction Landfill which was located too close to the ocean was excavated and incorporated into the Operational landfill. This material was used to flatten the slope of the face of the landfill to a 4H to 1V slope for stability and to minimize the potential for erosion.

The second landfill was referred to as the Reclamation Landfill. It was used to dispose of obsolete equipment and materials and at the same time, to fill the surface depression created as the ground subsided over top of some underground mine workings. No hazardous materials, chemicals or hydrocarbons have been disposed of in this landfill.

The third landfill was the LRD Quarry landfill. The majority of the demolition debris was disposed of in this open pit quarry. It was a limestone quarry and all of the materials disposed of in the landfill were located below the surrounding ground surface. The LRD Quarry was also used to dispose of metal contaminated soils in 2004. No hazardous materials or chemicals were disposed of in LRD Quarry.

Closure of the landfills utilizes permafrost to encapsulate the contents of the landfills. The active layer at the site is less than 1.5m thick. Using conservative estimates for global warming, an engineered cap of blasted shale and/or limestone a minimum of 1.8m was designed and installed on the Operational Landfill and the LRD Quarry Landfill. The Reclamation Landfill has limited types of benign debris and for the most part has been covered with fill in excess of 2m in depth. This landfill was closed prior to the designing of the engineered cap so in the summer of 2004, test pits were dug to confirm there was at least 2m of cover over top of any debris. There were a few areas where the cover was not thick enough so additional fill was placed in these areas.

Monitoring of temperatures in the Operational Landfill has been on-going for a number of years and this information used in the modeling of the engineered cap. The LRD Quarry landfill had five pipes installed prior to filling so that thermistors could be added later to monitor the rate of freezing of the landfill debris and to monitor the temperatures in the landfill cover. The thermistors in LRD Quarry have just been installed and freezing of the landfill has already largely occurred, primarily because a lot of the fill and debris were already in a frozen state when they were placed in the landfill.

<u>Excavation and Disposal of Contaminated Soils</u>

The environmental site assessments ("ESA") conducted in 1999 and 2000 identified in the order of 110,000 cubic metres of metals and hydrocarbon contaminated soils that exceeded the remedial targets established for the site. The ESA also identified historic ore, waste and snow dumps as containing contaminated materials but without quantifying the volumes. The biggest challenge of the project was that during excavation, additional contamination was discovered so that by the end of the project the total volume of contaminated materials excavated totaled 337,000 cubic metres.

The original intrusive investigations conducted as part of the ESA were based on historic uses of fuels and storage locations of concentrates and ores. The ESA included some limited drilling (when equipment was available from operations), test pitting and surface sampling. Interviews with long term employees were also a source of information. The original assessments were conducted on the assumptions that:

- Hydrocarbon contamination would be restricted to the shallow active layer due to the permafrost being a barrier to downward migration of the contamination. An exception to this would be in the area around the perimeter of the barge where heat from the structure would expand the active layer. As the barge hull was 4m deep, potential contamination in this area was expected to be deep.
- Metals contaminated materials would be restricted to former ore and waste stockpiles, or else the contamination would be in relatively thin layers on the ground surface where it was caused by windblown concentrate dusts, or where the concentrates were spread by vehicle tracking.

During the ESA, some areas were identified as having contaminated soils but the ESA did not have time to quantify the volumes. Mine operations were to conduct further testing that did not get completed before operations ceased. Several of these areas turned out to have significant volumes of contaminated materials.

The main piece of the puzzle that was missed due to lack of documentation was related to activities that occurred during construction. Areas such as the channel excavated for berthing the barge were partially backfilled using mineralized rock. Significant oil contamination at depth was also discovered in several areas that had been backfilled during construction.

The DRP identified the best location to dispose of the contaminated soils was into the mine workings due to the capacity available and that the mine workings were entirely within the cold permafrost zone far below the active layer. By the end of 2003 it was clear that the volumes of contaminated materials would likely exceed the capacity to dispose of materials underground. Consequently, permission was sought to exclusively place the hydrocarbon contaminated soils in the mine and to re-direct the disposal of the metals contaminated soils into the LRD Quarry. Approval was granted early in 2004 and so during the remainder of the project, all hydrocarbon contaminated soils were disposed of in the mine and all the metals contaminated soils were placed into the LRD Quarry. The capacity of the LRD Quarry was sufficient to place the additional volumes of materials within the original planned area of the pit.

Management of the contaminated soils excavation was a major undertaking. Due to the remote location of the site, turn around times for soils samples to be analyzed by a commercial laboratory was in the order of weeks. To enable excavation to proceed with minimum interruptions, an x-ray fluorescent analyzer was purchased. This allowed for on-site field screening of metals concentrations in soils. This tool was used to direct excavation and when the field screening indicated that the remedial targets had been achieved, confirmatory samples were then taken and sent south to a commercial laboratory. The excavation would remain open until the laboratory results were received and only then, backfilled. A GIS database was set up on site due to the 1,000's of sample results that needed to be managed.

<u>Underground Mine Closure Issues</u>

The underground mine had three portals that were in use for either accessing the mine or for ventilation. Seals consisting of cemented rockfill (5% cement) were placed inside the portals deep enough so that the thickness of rock cover between the mine opening and the surface was at least two times the height of the tunnel. After the bulkhead was constructed, the tunnel was backfilled back out to the portal with waste rock. The backfilled was tightly backed to minimize void space at the top of the fill. A ventilation pipe was installed near the top of the tunnel from the mine side of the bulkhead to the portal entrance. Local native materials were then placed over the entrance to the portal to hide the location of the portal.

During mine operations, vertical raise bore holes were drilled from surface to the underground workings. These were used for ventilation and for transporting backfill underground. Throughout the life of the mine these were routinely installed and then closed by backfilling them with quarried rock. The same process was used to close off the few remaining raise bore holes upon completion of the reclamation program.

The ground surface over the underground mine workings typically subside for a number of years after mining occurs. During mine operations, precise level surveys of monuments anchored into bedrock measured theses movements. The movements are small enough that they are not visible by the eye on surface. One exception to this is the Reclamation Landfill area. Early in the life of the mine, some of the original stopes failed before they could be backfilled. This area was relatively close to surface and the failure of these stopes progressed upward causing significant subsidence of the ground surface. In this area, a narrow trough of subsidence was active during 1998 and 1999 and the depression that formed on the surface was filled by debris and quarried fill as the sink hole developed. The primary concern in this area is that if a steeply sloped surface depression formed, it could potentially be a hazard to humans and wildlife traveling in the area. Since 1999 the rate of movement in this area has decreased to the point that they are not visible by the eye. Annual surveys of this area are continuing as part of the post-closure monitoring program.

Re-Contouring of Disturbed Surface Areas

The majority of the site is classified as Barren from a Terrain Mapping perspective. There is little or no vegetation prior to the mine being constructed for the main areas disturbed by the mine. Restoration of the land consisted primarily of re-contouring the disturbed areas of the site to restore the natural look of the site as much as possible. All culverts were removed from roads and natural drainage paths restored. It is not possible to completely remove the visual impact of roads and other land disturbances due to the presence of permafrost.

Hazardous Wastes

The ESA identified the key hazardous wastes that were on site. Primary wastes identified were liquid hydrocarbons (waste motor oils, hydraulic oils, glycols, old fuel), lead acid batteries, paints, solvents, pool chemicals, solvents, Halone (fire suppression systems) and Freon (mine cooling system). Asbestos from boilers had been disposed of within the mine workings under permit years prior to mine closure. There were no PCB containing materials on-site.

A two stage incinerator was custom built for the project due to the large volume of liquid hydrocarbons that were either on site or would be generated during implementation of the DRP. Other hazardous wastes were manifested and shipped south to a certified hazardous waste company for disposal and/or recycling. A licensed refrigeration mechanic was used to remove and package the Freon and Halon gases for shipping to the hazardous waste disposal company.

POST-RECLAMATION MONITORING

The DRP included a post-reclamation monitoring phase for the project. Both the land leases and water licence expire in 2011 and a program for monitoring the site until that time was proposed by Teck

Cominco. As the mine was operating when the Metal Mining Effluent Regulations came into effect, they apply to the site. In excess of $0.5 million has been expended to comply with these regulations alone since 2002. At the end of 2005, application of these regulations to the site will end due to its Closed Mine status.

The major elements of the post-reclamation monitoring program currently include:

- 3 annual sampling events of vertical stratigraphy of Garrow Lake. Teck Cominco is currently proposing that this be reduced to twice per year as it is not possible to access the site during January.
- Weekly sampling of effluent from Garrow Lake when it is flowing during the summer. This is approximately a 10 to 12 week period. Now that Garrow Lake has been lowered and is discharging naturally, we are proposing to modify this schedule next year after the 2005 water quality results have been reviewed.
- Monthly thermistor temperature monitoring. We are proposing this be restricted to the summer season when it is practical to do and is the season when the maximum temperatures in the landfill cover will be experienced.
- Annual geotechnical inspection of all the earthworks at the site.
- Annual survey monitoring of the subsidence area. We are also proposing that surveys be used to monitor for any erosion of the marine foreshore area.
- Other miscellaneous surface water and soil sampling.

Monitoring requirements are onerous due to the remote location of the site, and while some changes are being suggested, the requirements are for the most part, appropriate to monitor and document the performance of the reclamation work.

CONCLUSIONS

The decommissioning and reclamation of the Polaris Mine site was a logistical challenge and a very costly project due to its remote northern location. The presence of permafrost made earth work very expensive but also provided an effective way to manage the disposal of contaminated soils and landfill closures. Teck Cominco is confident that the on-going monitoring of the site until 2011 will demonstrate that the reclamation activities have been successful.