Gartner Lee

Ketza River Mine

Environmental Liability Assessment
FINAL Report

Prepared for:
DIAND Contaminants / Waste Program, Whitehorse

Prepared by:
Gartner Lee Limited

GLL P21950

May, 2002

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1. Introduction

1.1 Overview of the Ketza River Mine

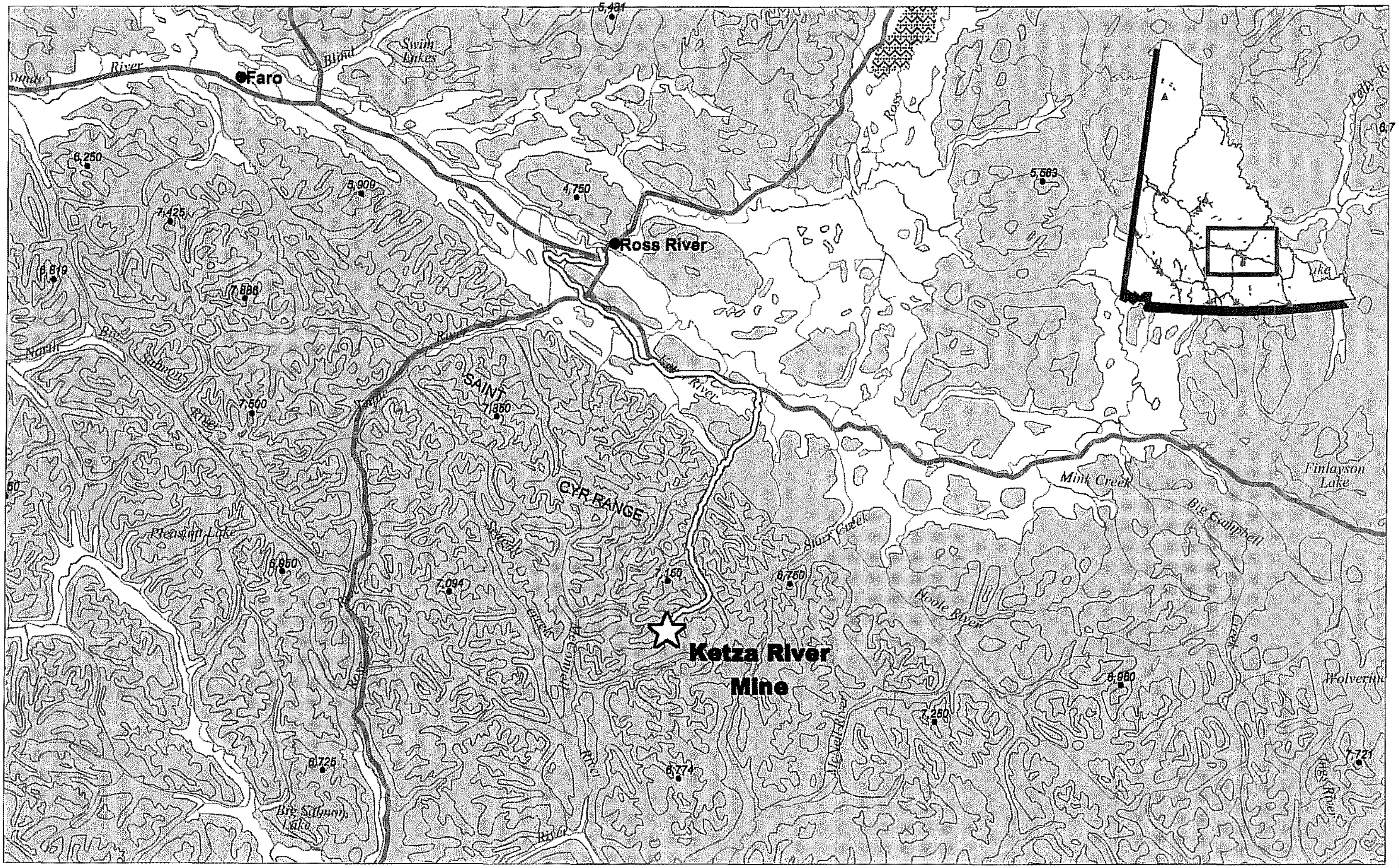
The Ketza River Mine is an underground and open-pit gold mine that is located in the Pelly Mountains of south-central Yukon Territory. The mine is located at 61° 32' 18" N and 132 ° 16' 10" W, as illustrated on Figure 1.1. The closest community, Ross River, is approximately 85 km north by road.

The property was first explored in 1955 and 1956, with extensive drilling occurring in 1958-59. The key claims were surveyed and leased in 1974. Canamax Resources Inc. ("Canamax") acquired the property in 1984 through a joint-venture arrangement with Pacific Trans-Oceans. Canamax became 100% owner of the mine property in 1989. Canamax sold the property to Wheaton River Minerals in 1992 and, subsequently, Ketza River Holdings Ltd. (then a wholly owned subsidiary of Wheaton River Minerals). YGC Resources Ltd. ("YGC") purchased the property in 1994 via purchase of Ketza River Holdings Ltd. and is the current owner of the property.

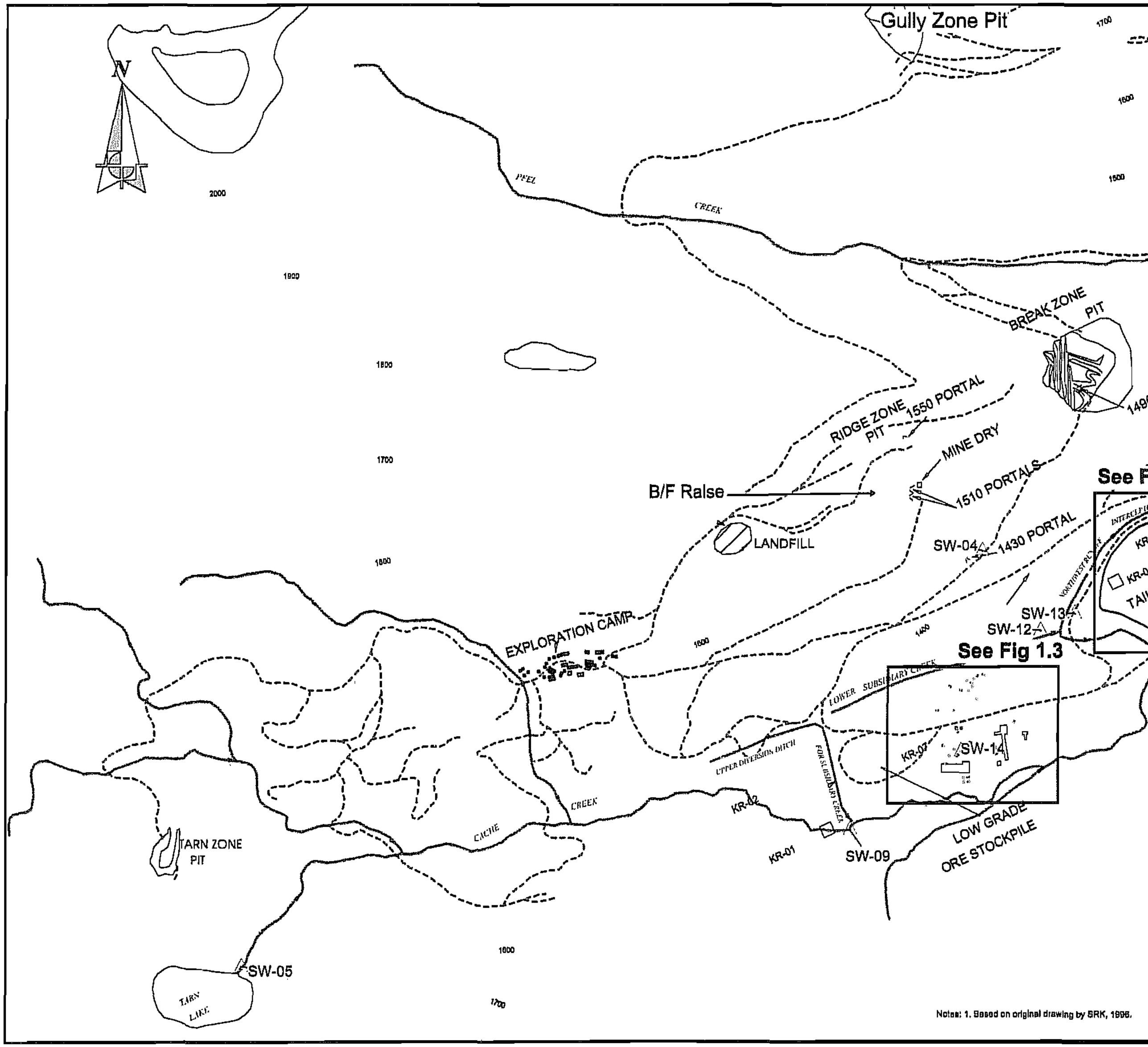
Canamax conducted extensive exploration work from 1984 to 1987 including the development of three exploration adits. Construction of the mill started in 1987 and production began in April 1988. Canamax operated the mine until September 1990 using both open pit and underground mining methods. Approximately 342,395 tonnes of ore were processed (DIAND 1996) using a conventional carbon-in-pulp ("CIP") process at a nominal rate of 364 tonnes per day to produce approximately 3.1 million grams of gold and approximately 342,000 tonnes of process tailings. The mine has not been operated since 1990.

Mine facilities include the mill building and ancillary facilities, the camp complex and ancillary facilities, a former exploration camp and a tank farm that consists of four 90,000 gallon diesel fuel tanks plus one 20,000 litre (estimate) gasoline tank as illustrated on Figure 1.2. A detail of the mill and camp area is illustrated on Figure 1.3. Some equipment was removed from the minesite in 1998 by the owner. This included primary components of the water treatment system, the grinding mills and primary components of the crushing system.

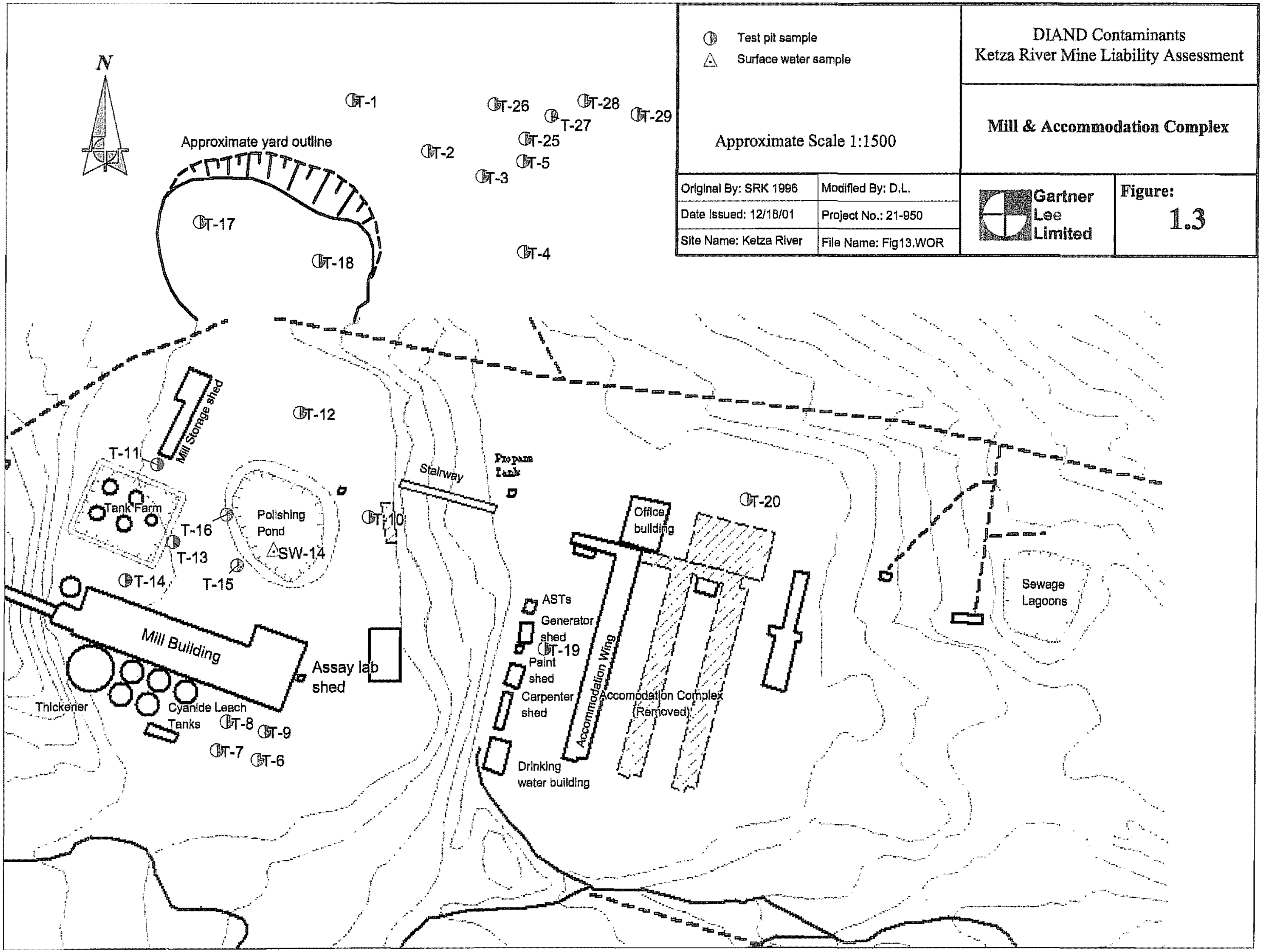
Process tailings are contained in a surface impoundment behind two earth-fill water retaining dams (Figure 1.4). During the period of mine operations, water was recycled from the tailings impoundment for use in ore processing. Excess water from the tailings impoundment was treated for removal of cyanide and heavy metals prior to release to the environment.

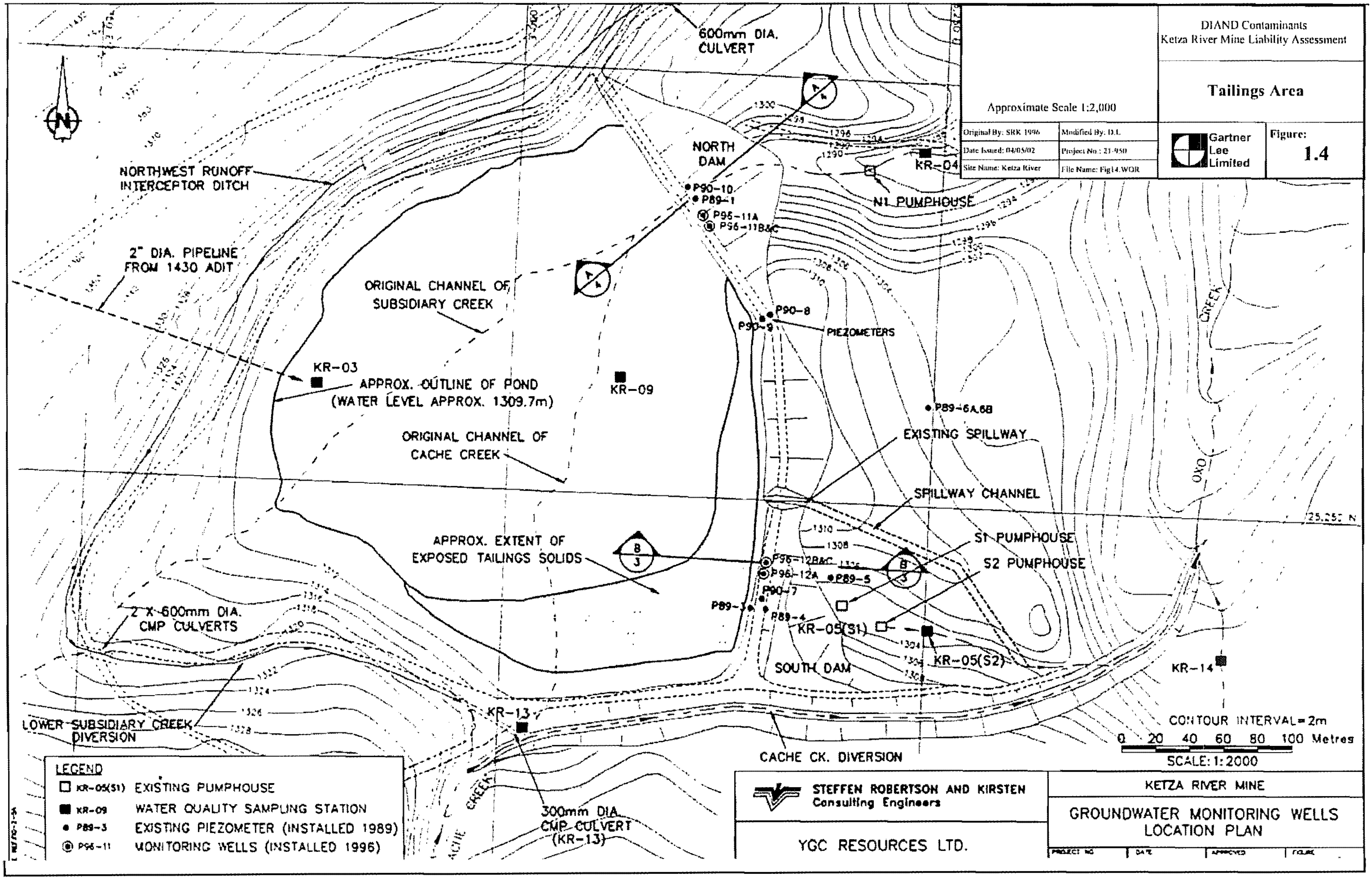


Site Name: Ketza	**DIAND Contaminants**	Project No: 21-950
File Name: Fig11.WOR	**Ketza River Mine Liability Assessment**	Date Issued: Dec. 2001
Gartner Lee Limited	**Project Location Map**	**Figure 1.1**



DIAND Contaminants Ketza River Mine Liability Assessment		
Mine Site General Arrangement		
Original By: SRK 1996	Modified By: D.L.	Gartner Lee Limited
Date Issued: 03/28/02	Project No.: 21-950	Figure: 1.2
Site Name: Ketza River	File Name: Fig21b.WOR	


Test pit sample
Surface water sample
DIAND Contaminants
Ketza River Mine Liability Assessment
Mill & Accommodation Complex
Approximate Scale 1:1500
Original By: SRK 1996
Modified By: D.L.
Date Issued: 12/18/01
Project No.: 21-950
Site Name: Ketza River
File Name: Fig13.WOR
Gartner Lee Limited
Figure:
1.3
N
Approximate yard outline
T-1
T-2
T-3
T-4
T-5
T-6
T-7
T-8
T-9
T-10
T-11
T-12
T-13
T-14
T-15
T-16
T-17
T-18
T-19
T-20
T-25
T-26
T-27
T-28
T-29
SW-14
Mill Storage shed
Tank Farm
Polishing Pond
Stairway
Propane Tanks
Mill Building
Assay lab shed
Thickener
Cyanide Leach Tanks
ASTs
Generator shed
Paint shed
Carpenter shed
Drinking water building
Office building
Accommodation Wing
Accomodation Complex (Removed)
Sewage Lagoons



DIAND Contaminants
Ketza River Mine Liability Assessment
Tailings Area
Approximate Scale 1:2,000
Original By: SRK 1996
Modified By: D.L.
Date Issued: 04/05/02
Project No.: 21-950
Site Name: Ketza River
File Name: Fig14.WOR
Gartner Lee Limited
Figure: 1.4
600mm DIA. CULVERT
NORTH DAM
KR-04
N1 PUMPHOUSE
NORTHWEST RUNOFF INTERCEPTOR DITCH
2" DIA. PIPELINE FROM 1430 ADIT
ORIGINAL CHANNEL OF SUBSIDIARY CREEK
P90-10
P89-1
P96-11A
P96-11B&C
P90-8
P90-9
PIEZOMETERS
KR-03
APPROX. OUTLINE OF POND (WATER LEVEL APPROX. 1309.7m)
KR-09
P89-6A,6B
ORIGINAL CHANNEL OF CACHE CREEK
EXISTING SPILLWAY
SPILLWAY CHANNEL
APPROX. EXTENT OF EXPOSED TAILINGS SOLIDS
S1 PUMPHOUSE
S2 PUMPHOUSE
P96-12B&C
P96-12A
P89-5
P90-7
P89-3
P89-4
KR-05(S1)
KR-05(S2)
SOUTH DAM
KR-14
2 X 600mm DIA. CMP CULVERTS
LOWER SUBSIDIARY CREEK DIVERSION
KR-13
CACHE CK. DIVERSION
CONTOUR INTERVAL=2m
0 20 40 60 80 100 Metres
SCALE: 1:2000
LEGEND
KR-05(S1) EXISTING PUMPHOUSE
KR-09 WATER QUALITY SAMPLING STATION
P89-3 EXISTING PIEZOMETER (INSTALLED 1989)
P96-11 MONITORING WELLS (INSTALLED 1996)
300mm DIA. CMP CULVERT (KR-13)
STEFFEN ROBERTSON AND KIRSTEN Consulting Engineers
YGC RESOURCES LTD.
KETZA RIVER MINE
GROUNDWATER MONITORING WELLS LOCATION PLAN

Regulatory Framework

Water Licence IN87-06L for the Ketza River Mine expired on December 31, 1998. There is currently no Water Licence in effect for the mine.

A Decommissioning Plan was filed with the Yukon Territory Water Board in 1994 per the requirements of the Water Licence. A CEAA screening report was subsequently issued by DIAND. An Addendum to the Decommissioning Plan was filed in 1996.

The mine property occupies mineral leases leased from the Government of Canada under the Yukon Quartz Mining Act. There are 62 full and fractural mineral leases held by Ketza River Holdings Ltd. The leases in the immediate area of the mine (approximately 25) are due to expire on December 14, 2009.

1.2 Project Objectives and Approach

The primary objectives of the project are to provide an assessment of the current environmental liability represented by the minesite and provide recommendations as to what actions may be appropriate to manage the environmental risks.

The approach to the project followed four general stages:

1. Review of existing environmental information.
2. Site visit to collect additional environmental information.
3. Assessment of environmental liability.
4. Recommendations for risk management actions.

The primary sources of information that were utilized for this study were:

1. 1999 Phase 1 Environmental Site Assessment (ESA), Gartner Lee Limited, 2001.
2. Ketza River Mine Decommissioning Plan, SRK, 1996.

Other sources of information were obtained from the Yukon Territory Water Board library and from the minesite office.

The community of Ross River was involved in the project as means of providing some benefits to the local community. A field assistant and a local equipment contractor were hired to excavate test pits for soil sampling and to perform other miscellaneous tasks. Additionally, a representative of the Land Claims Office visited the site during performance of the field work.

This report is structured into the following sections:

1. **Introduction**, provides an overview of the mine and the project.

2. **Environmental Setting**, is taken largely from the 1999 Phase 1 ESA (Gartner Lee Limited, 2001) and describes the biophysical environment and geology of the mine site.
3. **Description of Mine Facilities**, provides a description of the mine facilities in the context of the review of existing information and observations made during the October 2001 site visit.
4. **2001 Site Assessment**, provides and analyses analytical data and other information gathered during the October 2001 site visit or otherwise relevant to the assessment of environmental liability.
5. **Assessment of Environmental Liability**, describes the assessment of current environmental liability represented by the mine site.
6. **Conclusions**, presents the conclusions of the study.
7. **Recommendations**, provides recommendations for reduction of environmental liability in short, medium and long-term timeframes.
8. **References**, provides a listing of documents referenced in this study.

2. Environmental Setting

2.1 General

The Ketza River Mine is located within the discontinuous permafrost sub-zone of the Pelly Mountain Ecoregion. Zones of permafrost are known to be present in the mine area. The site is located at the treeline in a transition zone from stunted black spruce and alpine fir to birch, willow and sphagnum moss. Upper slopes are barren or support very sparse vegetation in the form of low shrubs, willow and lichen (Gartner Lee Limited 2001).

Mean annual precipitation from 1985 to 1995 as measured on site ranged from 718 to 728 mm per year (SRK 1996).

The mine site is located in the Cache Creek valley. The creek flows eastward and drains into Ketza River. The Cache Creek valley dips moderately eastward at slopes ranging from about 7% to 16%. The adjacent valley walls are steeper with slopes ranging from 30% to 80%.

The valley bottom consists primarily of limestone bedrock overlain by shallow deposits of compacted glacial till, which is in turn covered by a thin layer of relatively permeable outwash materials. The lower valley walls are commonly tills deposited as lateral moraines mixed with talus and colluvium. Upper slopes and mountain ridges are predominantly scree or rock outcrop (Gartner Lee Limited 2001).

The mine area has been identified as year-round sheep habitat that is utilized by thin-horn (Stone and Fannin) sheep. Wildlife habitat areas were identified in a 1999 study (Yukon Key Wildlife Habitat Inventory). Caribou and moose also utilize the mine area.

The 49 km long Ketza River road connects the mine to the Robert Campbell Highway. The road passes through a documented active sheep habitat area. A study of the short-term effects of road and mine activities on sheep was conducted by the Yukon Territorial Government (YTG) between 1986 and 1988. This study compared sheep population demographics in the Ketza River Mine area to a population of sheep in a similar area, adjacent to the Ketza River area and within the Pelly Mountain Ecoregion (Gartner Lee Limited 2001). This study found no negative effects on the sheep in the vicinity of the Ketza River Mine during mine development.

YTG Renewable Resources and the Department of Fisheries and Oceans (DFO) performed an assessment of the fishery resources of Cache Creek in 1991. The study was designed and implemented with the participation of the Ross River Dena Council. The study found that Slimy Sculpin, Round Whitefish and Arctic Grayling utilized Cache Creek as far upstream as the confluence of Oxo Creek.

Members of the Ross River Dena Council have stated that Ketza River was and is used by salmon species. However, no salmon species were found in Cache Creek in the 1991 YTG/DFO study or a previous 1986 fisheries assessment.

2.2 Background Geochemistry

Naturally occurring elevated metal concentrations in both soil and water are likely to be found in the Ketza River area. Systematic soil sampling for exploration purposes was conducted in the Ketza River mine area by YGC Resources during the mid-1990's. The results of this sampling were used by the exploration company to help locate potential mineral deposits but also document the naturally occurring elevated concentrations of metals in soils and, specifically, arsenic. Maps showing arsenic concentrations in soil in undisturbed areas of the Cache Creek and Peel Creek valleys frequently show soil arsenic concentrations in the range of 500 to 4,000 ppm, and occasionally as high as 10,000 ppm. Based on these findings, it is considered appropriate to develop site specific soil quality remediation objectives for this site (Gartner Lee Limited 2001).

2.3 Terrain

Terrain features in the vicinity of the Ketza River Mine Site, based on air photo interpretation, are shown on Figure 2.1.

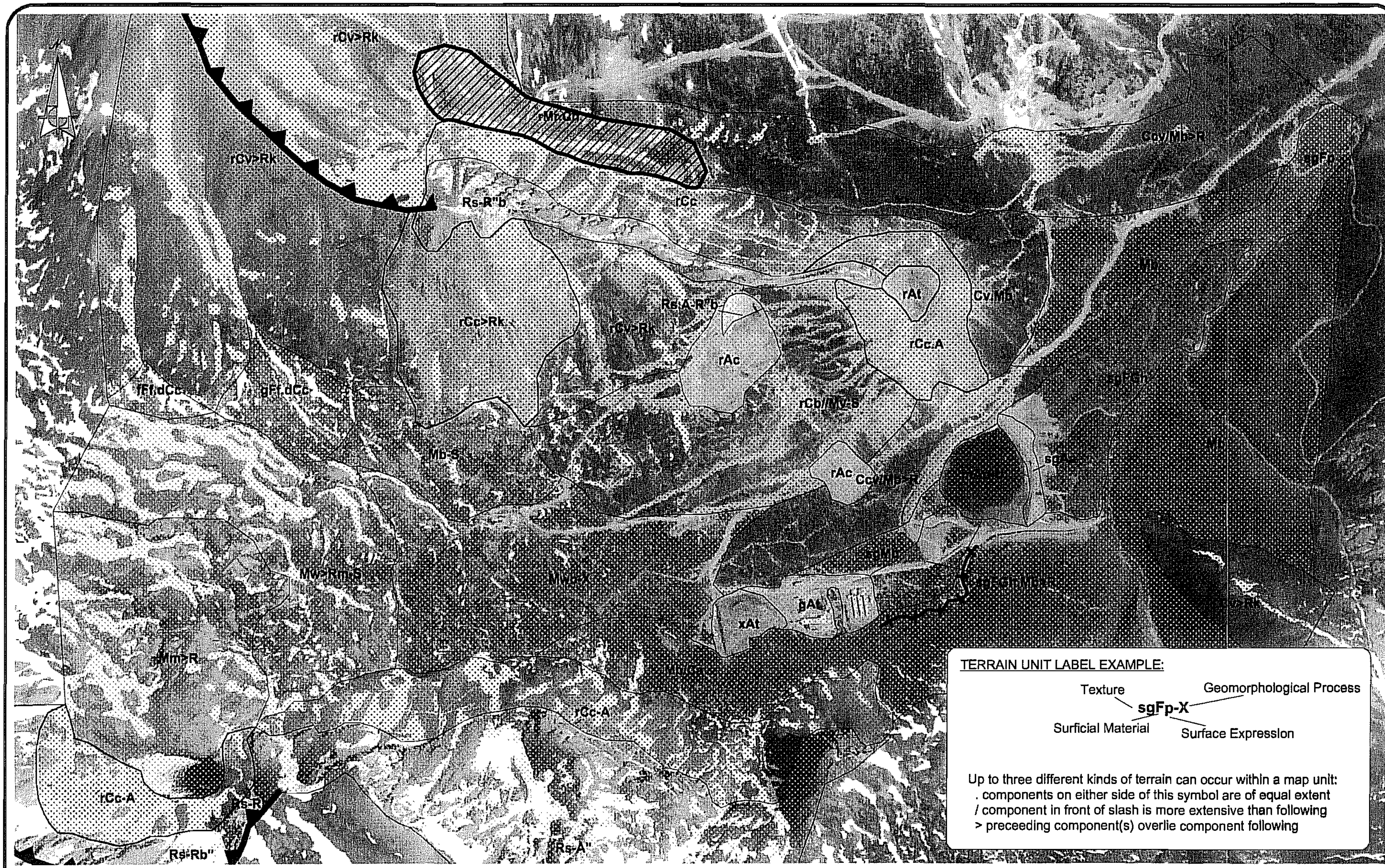
Most of the study area is dominated by weathered, frost shattered and colluviated bedrock. Glacial activity has over steepend the valley wall, forming cliffs that provide the backdrop of the mine site. Abundant talus slopes, or colluvial cones have formed at the base of these over steepend slopes. The base of the Cache Creek valley is characterized by a mix of rubbly colluvium from the valley walls and glacial till, or moranial deposits. Glacial outwash sands and gravels or terminal moraine form a portion of the tailings impoundment and are found in the Cache Creek valley downstream of the mine site.

2.4 Geology

The mine property lies near the center of a regionally up-faulted and domed area (the Ketza Uplift). This consists of a three kilometer diameter core of Late Proterozoic phyllite and quartzite strata, ringed by Lower Cambrian and younger Paleozoic carbonate and clastic strata. Stocks of Eocene to Cretaceous age have locally intruded, hydrothermally altering and mineralizing these sediments.

Strata are generally flat-lying, although there are numerous folds and faults. Mineralization predated most of the faulting. There are two general types of mineralization: limestone replacement deposits of sulphides and their oxidized equivalents and quartz-sulphide fissure vein and stockwork systems.

Eight stratigraphic units are present on the property, of which four have economic significance.



LEGEND:

Texture
- d - mixed fragments
- g - gravel
- r - rubble
- s - sand
- x - angular fragments

Surficial Material
- A - Anthropogenic
- C - Colluvium
- F - Fluvial
- FG - Glaciofluvial
- M - Morainal (Till)
- R - Bedrock

Surface Expression
- b - blanket
- c - cone
- f - fan
- h - hummocky
- k - moderately steep slope
- p - plain
- s - steep slope
- t - terrace
- v - veneer

Geomorphological Processes
- A - Snow avalanches
- Rb - Rockfalls
- S - Solifluction
- U - Inundation
- X - Permafrost process
- " - Zone of Initiation

100 0 100 200 300
Meters

Source of Drawing:
Aiphoto A27832-37. 1:40,000 scale.
June 1992

Reviewed By: F.K.P.

Drawn By: F.K.P.

Date Issued: 03..03.02

Project Number: 21-950

File Name: Fig21.PDF

Revision: 0

TERRAIN ANALYSIS

Ketza River Mine Liability Assessment
Ketza River, Yukon
DIAND Contaminants

Gartner Lee Limited

Figure No.
2.1

The Late Proterozoic phyllite and quartzite basal unit occupies the area between Peel and Misery Creeks and hosts a complex system of gold-bearing quartz-sulphide veins, including those mined as the QB and Gully Zones. The strata are variably metamorphosed (to hornfels), particularly in the southeast sector.

Strata are subhorizontal, weathered and weakly magnetic due to the presence of minor disseminated pyrrhotite related to the hornfelsing.

The Lower Cambrian limestone unit is roughly 200 m thick and hosts the main gold deposits at the mine property. The deposits consist of an extensive replacement type system, including both chimney (roughly perpendicular to bedding) and manto (roughly parallel to bedding) components. Mineralization is typically located in the top 100 meters of the grey, clean and uniformly bedded limestone unit. The flat lying manto deposits are located along the axis of gentle anticlines (Peel East Open pit), adjacent to normal faults (Peel Oxide Zone was bounded by such faults), and, in the majority of cases, with no apparent control. The steeply-plunging chimney deposits, which are less numerous than the mantos, are localized along shear zones (Ridge Zone) or zones of fracturing (Break, Nu Zones).

Above the Lower Cambrian limestone is a green mudstone that provides a distinct geologic marker unit on the property. Where mineralization occurred at the upper limestone contact immediately beneath the green mudstone, mining was more difficult due to the weaker nature of the mudstone unit. Above the green mudstone, Upper Cambrian black carbonaceous shale grades upward into phyllitic limestone, the host rock for the Knoll Zone.

The sulphide mantos typically consists of pyrrhotite (80%), arsenopyrite (10%), pyrite (5%), chalcopyrite (trace) and quartz. Magnetite and ankerite are present in mantos south of Cache Creek (i.e. Tarn Zone area) and magnetite is abundant as replacements in limestone immediately south of the 1430 East Oxide Zone. Inclusions of limestone could account for up to 30% of individual sulphide mantos. Gold occurs on the grain margins of all sulphide mineral species and also as submicroscopic inclusions within arsenopyrite. Visually, there is no difference between gold-bearing and barren sulphide mantos, however, an absence of arsenopyrite generally indicates an absence of gold. The economic gold zones terminate by grading laterally into barren sulphides, or by a lateral decrease in both sulphide thickness and gold grade. The limestone is locally dolomitized and recrystallized in the immediate vicinity of mineralization, notably at the Tarn and Knoll Oxide zones. Otherwise, alteration of the limestone wall rock adjacent to the mantos mineralization is almost non-existent. No skarn silicate minerals have been noted either within or peripheral to the deposits except for minor tremolite at the Break and 1430 East Zones.

The oxide mantos and chimneys, which were the focus of mining at the site, developed from oxidation of sulphide mantos in areas where:

- The slopes were south facing, without the presence of permafrost;
- There was moderate relief and, consequently, a deep water table; and
- The presence of faults provided access for oxidizing groundwater.

The oxide ore consists of limonite and hissingerite (a vitrous siliceous iron oxide). Generally, gold grade is directly proportional to the presence of hissingerite. There is very little gradation between sulphide and oxide deposits, although the oxides do contain minor remnants of sulphide inclusions.

The quartz-sulphide fissure veins and stockwork deposits (Gully and QB Zones) are characterized by a brecciated texture, with quartz fragments surrounded by a matrix of green scorodite (an oxidation product of arsenopyrite). The larger veins are up to 5 m wide and 100 m in strike length. Oxidation is generally restricted to the top several meters.

2.5 Environmental Implications

Mining and milling was reportedly limited to oxide ore (Canamax 1990). Oxide reserves were to be depleted by October 1990, at which time milling of sulphide ore was requested to keep the mine open (Canamax 1990), but was apparently never undertaken (SRK 1994).

From the geological description of the deposits, it appears that there is a potential for some sulphides to have been exposed during open pit mining, by excavating too deeply into the oxide zones. These sulphides present a potential source of acidic drainage and metals of environmental interest, particularly pyrrhotite, a relatively reactive sulphide, and arsenopyrite, a potential arsenic source. Most of the manto deposits located in the limestone host unit (Break, Nu, Ridge, Peel, 1430, Tarn and Knoll Zones) are likely to contain significant neutralization potential, which would offset the acid generating potential. Dolomitization of the limestone, reported in the Tarn and Knoll Zones, may render the limestone slightly less reactive. There is a greater potential for acidic drainage and metal leaching to occur in the vein and stockwork deposits hosted in the Late Proterozoic phyllilte and quartzite basal unit limestone (i.e. Gully and QB Zones, and miscellaneous exploration excavations) due to lack of limestone and its neutralization capacity.

In addition, the oxide zones are a potential source of leachable metals. In particular, scorodite (an oxidation product of arsenopyrite) has been identified in the oxide portions of the veins and stockwork deposits (Gully, QB), which represents a potential source of leachable arsenic (SRK, 1994).

3. Description of Mine Facilities

3.1 Overview

The general layout of the mine site is illustrated on Figure 1.2. Details of the mill and accommodation complex are illustrated on Figure 1.3. Details of the tailings area are illustrated on Figure 1.4.

In 1998, the water treatment plant, the grinding and crushing mills, and mill control systems were removed from the mine and taken to the Mt. Nansen Mine, located near Carmacks, Yukon. The primary diesel-fired power plants were removed following mine closure. Two of the three wings of the ATCO trailer camp and other equipment were also removed from the mine site.

The Ketza Mine was in operation from March 1988 to November 1990. Mining ceased due to the exhaustion of the oxide ore reserves. Production was an average 364 tonnes/day with a total mine production of 3,112,407 grams of gold over the mine's operating period. Current possible reserves remaining at Ketza are estimated at 234,000 tonnes of ore containing 11.1 g/t gold (Gartner Lee Limited 2001).

3.2 Mine Access Road

The mine access road from the Robert Campbell Highway (70 km to the mine site) is an all weather road that is suitable for light and heavy traffic except in several locations where the road bed has deteriorated such that access is generally restricted to 4x4 vehicles. None of these "problem" locations are well marked although road users have informally placed tree branches and other such markers on the roadway.

These "problem" locations effectively prevent access by heavy vehicles that would be required to mobilize heavy equipment to conduct emergency or scheduled environmental work at the mine site. As an example, a 3-tonne flat deck truck, used to mobilize a small CASE excavator/bulldozer to site for the 2001 investigation, could only drive to within approximately 6 km of the minesite. From this point, the excavator/backhoe had to be "walked" to the mine site.

The roadway has been washed out at two locations (km 12.3 and km 14.6) where narrow bypasses have been informally cut though the vegetation that allow access by small vehicles. There are a series of small bridges along the road, one of which is in disrepair (km 14.9). The bridge decking is broken through on one side and loose planks have been informally laid across the opening to permit access by light vehicles. There is one location where a tributary creek has completely washed out a culvert crossing under the access road such that vehicle access is accomplished by fording the creek upstream of the roadway (km 33.5). There is one location where sediment and rock has been deposited over the roadway by a tributary creek to a height of approximately 1 metre such that vehicle access is accomplished by driving over the irregular rock surface (km 35.3).

Access to the minesite is not restricted. The site is not fenced and, although there are gate posts at the entrance, no gate was in place at the time of the site visit.

3.3 Tailings Area

3.3.1 General

A visual inspection of the tailings area, comprised of two retention dams, one spillway and the three associated water diversion ditches (Northwest Interceptor, Lower Subsidiary Creek Diversion and Cache Creek Diversion), was conducted by Mr. Jim Cassie, P.Eng. (of BGC Engineering) on October 10 to 12, 2001. The physical conditions of the noted facilities were documented and photographs taken of selected features. In addition, water level readings were taken in accessible piezometers on the two dams. These collected observations, coupled with reviews of the noted references provided herein, provide the basis for the summary provided in this section.

At the time of the inspection, the ground surface was covered with a minor amount of snow cover. The tailings pond was still ice-free, although some of the smaller ditches were frozen over.

The purpose of the inspection visit was to characterize the current physical conditions of the various tailings/water retention and diversion structures. In addition, any signs of deteriorating performance (e.g. cracking) were to be highlighted to aid in identifying potential concerns. As such, potential geotechnical and hydrotechnical issues with the two dams and the three ditches were to be evaluated within the context of overall "environmental" liability for the site.

It should be noted that BGC staff had previously observed the site conditions on September 24, 1999. Section 7.9 of Gartner Lee Ltd. *et. al.* (2001) provides a summary of the observations made during that visit. Within that report, Appendix B, Figure 2-10 provides a view of the as-built sections for the two dams. Both dams are zoned earthfill dams, but their cross-sections are different. The North Dam is composed of three different fill types and has a vertical, relatively narrow core that is keyed 5 to 6 m into the underlying bedrock. The South Dam comprises four different fill types with a much wider core that is keyed only 1 to 2 m into the underlying bedrock.

It should also be noted that Section 9 of Gartner Lee Ltd. et. al. (2001) provides an assessment of the water balance for the tailings pond. The assessment was undertaken to evaluate the potential risk of an uncontrolled release from the tailings pond. Two different scenarios were evaluated. Based on the assumptions noted in those analyses, between 2 and 11 days is all the time required to fill the pond up to the spillway level.

3.3.2 North Dam

The North Dam, approximately 20 m high, has a crest width of approximately 4.5 to 5.5 m, generally in agreement with the design width of 5 m. The crest was level with no signs of significant settlement or deformation other than minor rutting due to vehicle traffic. No signs of standing water were noted on the crest.

Four piezometers were located on the crest and water level readings were taken, as summarized below (from north to south across the dam):

1. P10-A and B.
2. P11-A, B and C.
3. P9.
4. P8.

Table 3.1 provides a summary of the water level readings taken during the site visit.

Table 3.1: Summary of North Dam Piezometric Levels on October 10, 2001

Piezometer Number	Pipe Stickup (m)	Water Level BTOP[1] (m)	Water level BGS[2] (m)
P90-8	0.08	7.25	7.17
P90-9	0.08	5.86	5.78
P90-10A	0	14.76	14.76
P90-10B	0	dry	dry
P96-11A	0.92	19.90	18.98
P96-11B	0.93	dry	dry
P96-11C	0.89	15.89	15.00

Notes: 1. Below Top of Pipe
2. Below Ground Surface

Some of the North Dam piezometers were read on March 27, 2002 by Garner Lee Limited as described in the letter report prepared for that site visit that is provided in Appendix D. Two of the March 27, 2002 readings were higher and three were lower than October 10, 2001 (Table 3.1).

It should be noted that a significant settlement trough, approximately 1 m deep, was observed directly adjacent to the concrete cap provided for Piezometer P10. In addition, a smaller settlement trough was noted adjacent to the concrete cap at Piezometer P9. In both cases, verbal direction was provided to the on-site contractor to backfill both of these settlement troughs with local material in order to reduce the risk of water infiltration into the dam in the short term.

The upstream side slope angle was measured at 21° to 22° or approximately 2.5H:1V. This angle is flatter than the slope angle of 2H:1V noted on the design drawing, but the angle may be reflective of the short amount of upstream slope visible for measurement. The water level at the time of inspection was observed to be approximately 1.9 m below the physical crest level. A small erosional scarp is being formed on the upstream side where the water level interacts with the riprap. One longitudinal crack, approximately 6 m long, was noted near the north abutment of the North Dam, just below the crest level. No tailings beach is apparent just below the water level on the majority of the upstream side

The downstream side slope angle was measured at 20° to 21°, approximately 2.6H:1V that corresponds to the design side slope. The downstream slope had a consistent grade with no signs of bulging, cracking or settlement. Some minor erosional gullies, less than 0.5 m deep, were noted on the face; these small gullies are the result of the concentration of surface run-off. Seepage was noted from approximately three different point sources near the toe of the dam. The seepage was clear with no sign of entrained sediment. The granular material at the seepage location was unconsolidated and saturated (loose and difficult to walk-on without sinking in). This 'soft' area at the toe, previously noted in almost all other previous inspection reports, measured approximately 8 m long by 4 m wide. Seepage then drained into a small pond located adjacent to a pump house.

On a visual basis, the dam appears to be stable under the current static conditions with no significant concerns regarding settlement, deformation or cracking. The main issue with the dam appears to be the seepage discharge and the associated soft area near the toe of the dam. The soft area may be due to loose or liquefiable soils and/or artesian pressures within this area. The design cross-section for this dam notes that a granular blanket drain was placed under the downstream side of the dam. This drain was connected to the downstream shell, and hence, any seepage through this dam, should be collected within this element of the dam.

3.3.3 South Dam

The South Dam is approximately 15 m high above native grade in the area and the crest width varies from 5 to 6 m. No signs of cracking, settlement and/or standing water were noted on the crest.

Three piezometers were located on the crest and water level readings were taken, as summarized below (from north to south across the dam):

1. P12-A, B and C.
2. P7-A, B and C.
3. An unmarked piezometer that is likely numbered P3.

Additionally, piezometer P4 was located within the steel culvert on the downstream side berm, below the crest level. Table 3.2 provides a summary of the water level reading taken during the site visit:

Table 3.2: Summary of South Dam Piezometric Levels on October 10, 2001

Piezometer Number	Pipe Stickup (m)	Water Level BTOP[1] (m)	Water level BGS[2] (m)
Unmarked piezometer – likely P89-3	0	7.13	7.13
P89-4	0.46	5.17	4.71
P90-7A	0	6.50	6.50
P90-7B	0	5.60	5.60
P90-7C	0	8.53	8.53
P96-12A	0.90	8.17	7.27
P96-12B	0.95	7.96	7.01
P96-12C	1.01	7.59	6.58

Notes: 1. Below Top of Pipe
2. Below Ground Surface

It should be noted that two of the plastic pipes at P90-7 are labeled "P7-A" and hence, it is possible that the readings for the appropriate piezometers are confused within the table above.

The South Dam piezometers were read on March 27, 2002 by Garner Lee Limited as described in the letter report prepared for that site visit that is provided in Appendix D. All seven of the March 27, 2002 readings were lower than October 10, 2001 (Table 3.2).

Within the South Dam, a small spillway has been constructed, approximately 50 m north of the south abutment. The spillway has a bottom width of approximately 3 m, a depth of approximately 1 m and a top width of just over 9 m. The spillway is lined with angular rock fragments, typically sized in the 5 to 10 cm range, but with some fragments up to 20 cm in size. In addition, a small wooden support structure (for a power supply cable) runs across the spillway. On the downstream portion of the spillway, the adjacent topography is only 1 to 1.5 m higher than the channel bottom. This containment height will constrain the discharge quantity of this spillway.

The upstream side slope angle was measured to range from 23° to 29° or approximately 2.0H to 2.3H:1V. This angle is equal to or flatter than the slope angle of 2H:1V noted on the design drawing. The wide variation in slope angle may be reflective of the short amount of upstream slope visible for measurement. No signs of cracking or deformation were noted on the upstream side of this dam. A tailings beach is evident just below the water level for most of the upstream side of the South Dam.

The downstream side of the South Dam has an intermediate berm that is situated approximately 3.5 to 4 m below the top crest. The slope angle was measured at 19.5° to 21.5° or approximately 2.75H:1V that is slightly flatter than the design side slope. The downstream slope had a consistent grade with no signs of bulging, cracking or settlement. Seepage was noted just beyond the toe of the dam. The seepage was clear with no sign of entrained sediment. Two small seepage collection ponds, with associated pump houses, are located just below the toe of the dam.

Again, this dam also appears to be stable under the current static conditions. No signs of significant cracking, deformation and/or settlement were noted. The significant concern for this dam likely relates to the discharge capacity of the currently configured spillway. Its discharge capacity should be reviewed within an overall hydrotechnical evaluation of the tailings area.

3.3.4 Cache Creek Diversion Ditch

Kerr, Priestman (1986) and Golder Associates (1986) provided the hydrotechnical design criteria and design sections for the main Cache Creek diversion channel. The channel was to be designed for the 1:100 year flood event of 5.6 m^3/s, with a freeboard of at least 1.0 m. For this amount, the channel was to have an inside width of at least 4 m with a longitudinal grade of at least 0.5%. It should be noted that design criteria of only a 1:100 year event is not appropriate for the closure phase of a mine, since a long time horizon should be considered for the evaluation of exceedance probability.

Visual inspection of this channel notes that the bottom width is only 2.5 to 3 m over significant portions of the alignment. As such, the channel may not be able to handle the design capacity as noted earlier. In addition, the channel appears to be actively down-cutting near its outfall portion.

As noted in Section 7.9.5 of Gartner Lee Ltd. et. al. (2001), the channel is situated in permafrost and the slope is actively creeping. This creeping may continue in a slow manner, in which case creek flow may remove any associated debris from the channel section resulting in sediment discharge into the creek. Alternatively, the side slope of the ditch section may fail catastrophically, blocking the channel and possibly leading to erosion of the downhill dyke and possibly, portions of the South Dam. This event has the potential consequence of leading to failure of the South Dam.

In the short term, it is important that the channel section be visually monitored so that any potential blockages (debris, ice, etc.) can be identified and removed so that no channel capacity is lost. Any further constriction of the channel width and/or erosion of the riprap should be repaired immediately. This task may necessitate the production and stockpiling of appropriately sized riprap at site.

For the longer term, an evaluation of the current size of this diversion channel, coupled with a reassessment of the hydrology of the area and the relevant design criteria for closure, should be undertaken. The closure plan provided by SRK (1996) notes that the lower portion of the diversion channel should be upgraded to handle flow from the 1:200 year event to one half of the expected PMF value. The actual design criteria for hydrotechnical design will need to be evaluated as a portion of the closure planning for the site. In conjunction with an assessment of the ditch capacity, it may be prudent to install some thermistors into the permafrost within the slope to monitor the thawing progression within these materials.

3.3.5 Lower Subsidiary Creek and Northwest Interceptor Diversion Ditches

Kerr, Priestman (1986) and Golder Associates (1986) provided the hydrotechnical design criteria and design sections for these two smaller diversion channels. The Lower Subsidiary Creek channel was to be designed for the 1:100 year flood event of 0.5 m^3/s, with a freeboard of at least 0.3 m. The Northwest Interceptor Diversion channel was to be designed for the 1:100 year flood event of 0.58 m^3/s, with a freeboard of at least 0.3 m. For these values, the channel was to be at least 1 m deep, have an inside width of 1 m and have a longitudinal grade of 1.0%.

The Lower Subsidiary Creek diversion channel was inspected and found to be in generally good condition. The bottom width generally was in accordance with the design width of 1.0 m, but in some areas, it was reduced to approximately 0.7 m. Some minor cracking and small slumps were noted on the backslope, indicating marginal stability for portions of the ditch. Several significant erosion gullies were noted on the downhill side of the ditch. These were formed as a result of channel blockage (slump failure or ice) and the seepage water exiting from the channel section. This diversion ditch water was then directed into the tailings pond. These erosional gullies, approximately 0.5 to 0.7 m deep, should be backfilled and graded over so that concentration of surface run-off is not exacerbated.

The 60 cm diameter culvert, at the downstream end of this ditch, should be cleaned out for proper operation. In addition, there are two culverts at the upstream end of this ditch section that passes under the main access road. One of these two culverts is significantly flattened and hence, has the potential for significantly reduced flow capacity.

The Northwest Interceptor Ditch is in poor condition. In some places, no bottom width exists (i.e. a V-channel has formed in place of the designed flat-bottom channel). The infilling of the channel bottom is due to sloughing of the side slopes. As a result, the channel section does not drain properly and hence, standing water exists in this ditch (forming ice as noted earlier). In addition, the downhill retention berm has failed, which was previously noted in Section 7.9.3 of Gartner Lee Ltd. *et. al.* (2001). A small berm has been placed within the channel section to prevent longitudinal drainage from reaching the breached area. As a result, and as previously noted, this ditch "has failed" and it "should not be relied upon to divert any large quantities of water…".

The culvert at the downstream end of the Northwest Interceptor Ditch was almost completely blocked with debris (although, given its overall poor condition, it is unlikely that it conveys an significant amount of water). The on-site contractor was directed to clean out both the intake and the discharge ends of this culvert, which was completed during the inspection visit.

In summary, the Northwest Interceptor Ditch requires a significant amount of maintenance in the short term, to re-establish its role in redirecting surface water around the tailings area. On-going inspection and some maintenance is also required for the Lower Subsidiary Creek diversion ditch.

As noted for the Cache Creek diversion ditch, the current configuration of these two ditches needs to be assessed within the context of an overall closure plan for the tailings area. The plan submitted by SRK (1996) notes that both of these diversion ditches should be upgraded to convey the 1:200 year flood levels. Again, the required design criteria for the closure design will need to be determined in the future. Additional geotechnical investigation and hydraulic design work along with placement of riprap may be required for design of long-term structures for closure.

3.4 Camp Area

The camp area is immediately upslope of the tailings area and immediately downslope from the millsite. The area consists of a leveled fill yard containing several small sheds, an office building and ATCO bunkhouse trailers aligned in one length of what was originally three lengths of bunkhouses, an electrical distribution shed, a cookhouse, and a raised boardwalk between the bunkhouse trailers and the cookhouse. The buildings and sheds are not locked with the exception of the cookhouse.

An uncovered stairway is present that initially provided walking access from the camp area to the millsite but is currently in a state of disrepair that is a safety hazard to any persons attempting to utilize it.

The north area of the camp yard is currently used for outside storage of materials. No hazardous or special wastes were identified at this location. This area was being actively used, at the time of the October 2001 site visit, as a fuel storage depot for helicopter refueling associated with geological exploration work being conducted off site. A helicopter landed in the yard during the site visit and refueled from 45 gallon drums that had been previously delivered to site by a local fuel supplier.

A sewage treatment building and sewage lagoon are located just downslope (east) of the camp yard.

3.5 Mill Area

The mill area is located immediately upslope from the camp area. The area consists of the mill building, fuel tank farm within a containment berm, polishing pond, laydown/storage area, sulphur dioxide (SO_2), storage shed, and other small peripheral sheds. Hazardous and special wastes are located at various locations in the mill area. The mill building is accessible both to light vehicles and person entry by numerous means, allowing unrestricted public access to the waste storage locations.

An ore stockpile area is located at the upper (west) end of the mill area. A (largely) wooden truck ramp that was used to dump ore into the crusher is in place but the crusher feeder bin has been removed such that a vertical drop off exists at that location. Powerline and powerpole guide wires are low, and on occasion, on the ground in the stockpile area such that they pose a risk to individuals and vehicles traversing the site.

Residual ore and a wooden rock screen are present in the stockpile area.

A pumphouse (unlocked) is located at a freshwater supply well located just to the west of the stockpile area and a plastic pipe from the pumphouse to the millsite is in place.

3.6 Landfill, Boneyard and Exploration Camp

A landfill area, a boneyard/scrap steel area and an exploration camp are located on the south facing slope to the north of, and above, the mill area. The landfill contains only a minor amount of uncovered material. The boneyard contains primarily scrap steel and used equipment including pipe, distribution boxes, wire, etc.

The exploration camp consists of several sheds, numerous core racks containing drill core boxes and a light vehicle ramp. The light vehicle ramp is assumed to have been used for washing and performing maintenance (oil changes, etc.) on light vehicles.

3.7 Open Pits

There are five small open pits on the mine site: Gully, QB, Break-Nu, Ridge and Tarn. The pits are largely side hill cuts which restrict the ponding of water in the pit bottoms.

The Gully and QB pits are located on the south facing slope located to the north of Peel Creek. Access to these pits was prevented by road blockages (fallen boulders, etc.) and they were not directly visited in 2001. The roadways to these two pits are narrow side hill cut roads on the relatively steep hillslopes. Access was not possible, even for ATV's, in spots due to fallen boulders.

The Break-Nu and Ridge pits are located north of Cache Creek and the mill site on the south facing slope. These pits were visited in 2001 and did not contain any ponded water. These pits were accessible by light vehicles via narrow side hill cut roads on the relatively steep hillslopes.

The Tarn pit is located west (up valley) from the millsite near Tarn Lake in the headwater area of Cache Creek. This pit has the potential to contain some ponded water but was dry at the time of the 2001 site visit. The roadway to this pit is relatively flat once past the exploration camp and was accessible by light vehicles.

3.8 Underground Access Points

There are six access points to the underground workings: 1430 portal, 1490 portal, 1510 double portal, 1530 fill raise and 1550 portal. All of these access points were visited in 2001.

The 1430 portal is open to approximately 10 metres where access is blocked by a timber bulkhead. The entrance to the portal contains loose overhanging blocks of rock supported by rock bolts, screen and timbers. Water drains through the timber bulkhead via a pipe and creates a pool at the entrance to the portal.

The 1490 portal is located at the Break-Nu pit and is covered by waste rock such that it is not visible or accessible.

The 1510 person access portal is open to approximately 10 metres where access is effectively blocked by a timber bulkhead. The entrance to the portal contains loose overhanging blocks of rock supported by rock bolts, screen and timbers. The 1510 ventilation portal contains large diameter (approximately 48 inches) ventilation pipes that are blocked with plywood inserts. A plywood barrier was present around the outside of the ventilation pipes to the walls of the portal. The internal and external plywood barriers would likely hamper, but not prevent, access by people or wildlife.

The 1530 fill raise is covered with rock such that the raise opening is not visible. The extent and nature of filling to the bottom of the raise and, therefore, the security of the raise is unknown.

The 1550 portal is effectively blocked at its entry by a timber bulkhead. The entrance to the portal contains loose overhanging blocks of rock supported by rock bolts, screen and timbers.

3.9 Rock Dumps

Small waste rock dumps have been constructed generally near the open pits and underground openings. The dumps are primarily end dump, side hill construction that are currently at angle of repose. The Tarn rock dump was built as a pile and has been sloped and contoured.

The 1430 rock dump is of particular environmental interest because it is located directly above the tailings area and the Northwest Diversion Ditch. This dump extends from just west of the 1430 adit and to the area of the Break-Nu pit. The dump crest has several levels that have been utilized as access roads at various times. Longitudinal cracking is visible in numerous locations. The dump slope is generally at angle of repose but has been locally oversteepened due to localized sloughing and movement in the dump. Drainage from the 1430 adit crosses the access road in a buried plastic pipe and then drains over the dump face towards the northwest interceptor ditch. This has resulted in erosion of dump material and formation of a gully in the dump face. Documents indicate that water flow from the 1430 portal was previously piped across the dump and into the Northwest Diversion Ditch but this piping system was not operational in 2001.

3.10 Hazardous and Waste Materials

The list of hazardous and waste materials that was compiled in the 1999 Phase 1 ESA (Gartner Lee Limited, 2001) was reviewed and generally confirmed. The compilation that was presented in the 1999 ESA Report is provided in Appendix A.

The following modifications to the 1999 listing were identified during the 2001 site visit:

1. An additional drum of used oil was located near the generator shed in the camp area.
2. Several additional pails of lead nitrate were located in the mill building.
3. Four drums of sulphuric acid that were inventoried and photographed during the 1999 Phase 1 ESA were no longer on site. These drums were previously located in the tailings area.

4. 2001 Site Assessment

4.1 Surface Water Quality

4.1.1 General

A suite of surface water samples were collected during the 2001 site assessment with the intent of characterizing surface water quality in the immediate vicinity of the mine site.

A total of 15 samples were collected at the locations illustrated on Figure 1.2. The sample sites included background reference locations (upstream of mine developments), direct drainage from the mine site, and receiving water downstream of the primary mine developments. Field measurements of temperature, conductivity and pH were recorded and the samples were shipped to a professional accredited laboratory for further analyses. The water quality analytical data are summarized on Table 4.1 and the raw data sheets, as received from the laboratory (ALS Environmental), are provided in Appendix B.

At the time of sampling (October), a minor snow cover was present and air temperatures were near or below freezing. Surface flows are assumed to be representative of a relatively low flow condition.

The data summarized in Table 4.1 indicate that the concentration of many parameters (particularly metals) exceed the 1999 CCME Guidelines for the Protection of Aquatic Life. A smaller suite of parameters also exceed the Yukon Contaminated Sites Regulations for Parkland Use. These two guidelines have been referred to as a means of providing context for the interpretation of water quality but are not considered to be objectives or requirements. The development of site-specific, risk-based remediation objectives, per the procedures provided in the Federal and Territorial Guidelines is considered to be appropriate for this site (Section 7).

The data confirm that arsenic is the contaminant of primary concern in the mine area. The concentrations of aluminum, cadmium, chromium, copper, iron, silver and zinc exceed the CCME and YCSR guidelines. Concentrations of manganese and lead levels were found to exceed the YCSR.

Sulphate concentrations in Cache Creek ranged from 92 mg/L to 158 mg/L. The lowest concentration was measured upstream of the mill site (SW-09) and the highest concentration was measured downstream of Peel Creek (SW-01). The sulphate concentrations in Cache Creek generally increased with distance downstream due to inflows from tailings dam seeps, Peel Creek and, possibly, other sources.

Cache Creek was found to be relatively hard with hardness measured in a range from 245 to 293 mg/L $CaCO_3$. Hardness and sulphate in Cache Creek were observed to increase with distance downstream.

Table 4.1: 2001 Surface Water Quality Data

Station	Generic Guidelines		SW01	SW02	SW03	SW04	SW05	SW06	SW07	SW08	SW09	SW10	SW11	SW12	SW13
Date	CCME[a]	MMLER[b]	10/10/2001	10/10/2001	10/10/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001
Field Measurements															
pH															
Conductivity (uS)															
Temperature (C)															
Physical Tests, Anions, Nutrients and Cyanides															
Hardness CaCO3			293	277	-	-	-	277	-	-	245	-	-	-	-
Total Suspended Solids			<3	<3	16	-	-	-	-	5	<3	-	<3	-	-
Sulphate SO4			158	108	309	-	-	110	-	176	92	-	130	-	-
Ammonia Nitrogen N			0.01	0.009	0.005	-	-	-	-	0.007	<0.005	-	0.013	-	-
Total Cyanide CN													<0.005		
Total Metals															
Aluminum	0.005-0.1		0.542	0.001	1.3	10.8	0.185	0.018	<0.005	0.023	<0.005	<0.005	0.005	<0.005	0.018
Antimony			0.001	0.0002	0.0002	0.042	<0.0001	0.0003	<0.0005	<0.0005	<0.0005	<0.0005	0.0014	<0.0005	<0.0005
Arsenic	0.005	1.0	0.158	0.0077	0.0533	22.7	0.0024	0.016	0.0495	0.0081	0.0161	0.0132	0.706	0.0261	0.0385
Barium			0.029	0.0125	0.0115	0.12	0.00277	0.00766	0.0062	0.0122	0.0085	0.0077	0.0055	0.0071	0.0078
Beryllium			<0.0005	<0.0005	<0.0005	<0.005	<0.0005	<0.0005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Bismuth			0.0007	<0.0005	<0.0005	0.134	<0.0005	<0.0005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Boron			<0.01	<0.01	<0.01	<0.1	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.000017		0.00023	<0.00005	0.00059	0.0167	0.00029	<0.00005	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Calcium			86.2	73.1	115	778	37.3	81.2	88.8	129	65.5	73.3	75.8	89.7	108
Chromium	0.001		0.0064	<0.0005	<0.0005	0.015	<0.0005	<0.0005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cobalt			0.0098	<0.0001	0.0485	0.026	0.0064	<0.0001	0.0018	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	0.002-0.004	0.6	0.0042	0.0002	0.0046	0.394	0.0013	0.0002	0.001	<0.0005	<0.0005	<0.0005	0.0011	<0.0005	<0.0005
Iron	0.3		1.99	<0.03	5.56	124	0.2	<0.03	<0.03	0.05	<0.03	<0.03	0.04	<0.03	0.03
Lead	0.001-0.007	0.4	0.00654	<0.00005	0.00035	0.912	0.00016	0.00012	<0.0003	0.0003	0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Lithium			<0.005	<0.005	<0.005	<0.05	<0.005	<0.005	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Magnesium			23.5	22.1	26.9	29.1	15.6	17.1	13.7	15.8	17.3	16.4	12.9	10.1	11.3
Manganese			0.0985	0.00575	0.319	2.33	0.108	0.023	0.386	0.0047	0.0006	0.0005	0.0102	0.004	0.0017
Molybdenum	0.073		0.00029	0.00035	0.0001	0.0029	0.00012	0.00027	0.0014	0.0005	0.0003	<0.0003	0.0005	<0.0003	<0.0003
Nickel	0.025-0.15	1.0	0.0081	<0.0005	0.0322	0.054	0.0277	<0.0005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Phospherous			<0.3	<0.3	<0.3	0.4	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Potassium			<2	<2	<2	3	<2	<2	<2	2	<2	<2	<2	<2	<2
Selenium	0.001		<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silicon			3.26	2.18	4.73	19.7	1.05	2.21	2.37	3.3	1.83	1.87	2.06	3.12	3.37
Silver	0.0001		0.00004	<0.00001	<0.00001	0.003	<0.00001	<0.00001	0.00006	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Sodium			<2	<2	<2	<2	<2	<2	5	3	<2	<2	3	3	<2
Strontium			0.194	0.185	0.27	1.92	0.0954	0.168	0.203	0.262	0.16	0.18	0.213	0.226	0.186
Thallium	0.0008		<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.0001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Tin			0.0003	<0.0001	<0.0001	0.003	<0.0001	<0.0001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Titanium			0.02	<0.01	<0.01	0.23	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium			0.00206	0.00229	0.0011	0.0114	0.00116	0.00163	0.00143	0.00105	0.00216	0.00182	0.00134	0.00099	0.00119
Vanadium			<0.001	<0.001	<0.001	0.01	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	0.03	1.0	0.073	<0.001	0.185	1.03	0.022	<0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Station	Generic Guidelines		SW01	SW02	SW03	SW04	SW05	SW06	SW07	SW08	SW09	SW10	SW11	SW12	SW13
Date	CCME [a]	MMLER [b]	10/10/2001	10/10/2001	10/10/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001
Dissolved Metals															
Aluminum			0.113	0.002	0.018	<0.01	0.129	0.003	-	<0.005	<0.005	<0.005	<0.005	-	<0.005
Antimony			0.0002	0.0002	0.0002	<0.001	<0.0001	0.0003	-	<0.0005	<0.0005	<0.0005	0.0014	-	<0.0005
Arsenic			0.0071	0.0086	0.0016	0.266	0.0017	0.016	-	0.0064	0.0156	0.0141	0.693	-	0.0397
Barium			0.0112	0.0136	0.0106	0.0033	0.00266	0.00714	-	0.012	0.0082	0.0072	0.0057	-	0.0073
Beryllium			<0.0005	<0.0005	<0.0005	<0.005	<0.0005	<0.0005	-	<0.003	<0.003	<0.003	<0.003	-	<0.003
Bismuth			<0.0005	<0.0005	<0.0005	<0.005	<0.0005	<0.0005	-	<0.003	<0.003	<0.003	<0.003	-	<0.003
Boron			<0.01	<0.01	<0.01	<0.1	<0.01	<0.01	-	<0.05	<0.05	<0.05	<0.05	-	<0.05
Cadmium			0.00007	<0.00005	0.00042	<0.0005	0.00027	<0.00005	-	<0.0003	<0.0003	<0.0003	<0.0003	-	<0.0003
Calcium			78.9	74	115	125	37.3	82.2	-	125	68.1	74.6	78.9	-	108
Chromium			<0.0005	<0.0005	<0.0005	<0.005	<0.0005	<0.0005	-	<0.003	<0.003	<0.003	<0.003	-	<0.003
Cobalt			0.0086	<0.0001	0.0487	<0.001	0.0064	<0.0001	-	0.0005	<0.0005	<0.0005	<0.0005	-	<0.0005
Copper			0.0045	0.0003	0.0003	<0.001	0.0012	0.0002	-	<0.0005	<0.0005	<0.0005	0.0011	-	<0.0005
Iron			0.15	<0.03	<0.03	<0.03	0.09	<0.03	-	<0.03	<0.03	<0.03	<0.03	-	<0.03
Lead			0.00019	0.00007	<0.00005	<0.0005	0.00011	<0.00005	-	<0.0003	<0.0003	<0.0003	<0.0003	-	<0.0003
Lithium			<0.005	<0.005	<0.005	<0.05	<0.005	<0.005	-	<0.03	<0.03	<0.03	<0.03	-	<0.03
Magnesium			22.6	22.4	27.3	17.1	15.6	17.4	-	16.2	18.1	16.7	13.3	-	11.4
Manganese			0.0651	0.00582	0.326	0.0267	0.109	0.0215	-	0.0024	<0.0003	<0.0003	0.0061	-	0.0006
Molybdenum			0.00028	0.00036	0.00009	<0.0005	0.00013	0.00027	-	0.0006	<0.0003	<0.0003	0.0005	-	<0.0003
Nickel			0.0059	<0.0005	0.0324	<0.005	0.0281	<0.0005	-	<0.003	<0.003	<0.003	<0.003	-	<0.003
Phospherous			<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	-	<0.3	<0.3	<0.3	<0.3	-	<0.3
Potassium			<2	<2	<2	<2	<2	<2	-	<2	<2	<2	<2	-	<2
Selenium			<0.001	0.001	<0.001	<0.01	<0.001	<0.001	-	<0.005	<0.005	<0.005	<0.005	-	<0.005
Silicon			2.55	2.22	3.99	4.7	1.02	2.21	-	3.31	1.91	1.92	2.13	-	3.38
Silver			<0.00001	<0.00001	<0.00001	<0.0001	<0.00001	<0.00001	-	<0.00005	<0.00005	<0.00005	<0.00005	-	<0.00005
Sodium			<2	<2	<2	<2	<2	<2	-	3	<2	<2	3	-	<2
Strontium			0.188	0.192	0.276	0.255	0.0957	0.169	-	0.244	0.152	0.176	0.207	-	0.187
Thallium			<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.0001	-	<0.0005	<0.0005	<0.0005	<0.0005	-	<0.0005
Tin			<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.0001	-	<0.0005	<0.0005	<0.0005	<0.0005	-	<0.0005
Titanium			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	-	<0.01
Uranium			0.00194	0.00231	0.00085	0.0034	0.00109	0.00159	-	0.00095	0.00203	0.00176	0.00131	-	0.00117
Vanadium			<0.001	<0.001	<0.001	<0.01	<0.001	<0.001	-	<0.005	<0.005	<0.005	<0.005	-	<0.005
Zinc			0.016	0.004	0.125	<0.01	0.02	<0.001	-	<0.005	<0.005	<0.005	<0.005	-	<0.005
Extractable Hydrocarbons															
EPH10-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPH19-32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

4.1.2 2001 Arsenic Concentrations

Two surface water samples were collected upstream of the primary mine developments. Sample SW-05 was collected at the outlet of Tarn Lake and sample SW-09 was collected in Cache Creek just upstream of the mill area. The concentrations of total and dissolved arsenic were 0.0024 mg/L and 0.0017 mg/L, respectively, at SW-05 and were 0.0161 mg/L and 0.0156 mg/L, respectively, at SW-09. The increase in concentration from SW-05 to SW-09 may be related to runoff over natural mineralization in soils and outcrops, to influences from the Tarn Pit and/or to influences from the exploration camp area.

Five samples were collected of runoff from mine developments. Sample SW-14 was collected from the Polishing Pond, which was not overflowing. The concentration of total arsenic in the Polishing Pond was 0.107 mg/L or approximately 10 times that in Cache Creek. Sample SEEP-5 was collected in a small runoff stream draining into Lower Subsidiary Creek and sample SW-12 was collected in Lower Subsidiary Creek. The concentrations of total arsenic at SEEP-5 and SW-12 were 0.0112 mg/L and 0.0261 mg/L, respectively. These concentrations suggest that surface runoff was increasing the concentration of arsenic in Lower Subsidiary Creek to approximately twice the background in Cache Creek but that the increase was not directly due to the single observed runoff stream from the mill site. The increased concentration in Lower Subsidiary Creek may be related to runoff from the mill site and/or to influences from mineralized outcrops on the hillslope to the north. Sample SW-04 was collected from a trickle drainage from the 1430 adit and sample SW-13 was collected in the Northwest Interceptor Ditch near the inflow of the adit drainage. The concentrations of total and dissolved arsenic were 22.7 mg/L and 0.266 mg/L, respectively, at SW-04 and were 0.0385 mg/L and 0.0397 mg/L, respectively, at SW-13. The high concentration of total arsenic at SW-04 is considered to be an artificial result of sampling a trickle flow in a "dirty" sump. The concentrations at SW-04 and SW-13 confirm that some arsenic is released from the 1430 adit and that the concentration in the Northwest Interceptor Ditch is elevated (approximately 3 times Cache Creek background) due, likely, to the influences of the 1430 adit, rock dumps, and natural mineralized outcrops.

One sample was collected from the tailings containment facility. The concentrations of total and dissolved arsenic in the tailings pond (SW-11) were 0.706 mg/L and 0.693 mg/L, respectively. This was the greatest concentration of dissolved arsenic recorded for the 2001 suite of samples.

The two dam seepage streams were also sampled. The concentrations of total and dissolved arsenic at the North Dam Seep (SW-08) were 0.0081 mg/L and 0.0064 mg/L, respectively. The concentration of total arsenic at the South Dam Seep (SW-07) was 0.0495 mg/L. Dissolved arsenic could not be determined for the South Seep sample (SW-07) and the reason for the elevated concentration of total arsenic has not been identified at this time.

The upper and lower ends of the Cache Creek Diversion Channel were sampled at locations SW-10 and SW-06, respectively. The concentrations of total and dissolved arsenic were 0.0132 mg/L and 0.0141 mg/L, respectively, at SW-10 and were 0.016 mg/L and 0.016 mg/L, respectively, at SW-06. The concentrations at SW-10 were slightly lower than at the upstream reference location (i.e. SW-09) which may be related to the influences of "clean" water runoff from the southern catchment area. The concentrations at SW-06 (downstream of inflow from the South Dam Seep) were the same as at the upstream reference location (SW-09).

Three samples were collected at the confluence of Peel and Cache Creeks. Sample SW-02 was collected in Cache Creek just upstream of Peel Creek, sample SW-03 was collected from Peel Creek and sample SW-01 was collected from Cache Creek just downstream of Peel Creek. The concentrations of total arsenic at SW-02, SW-03 and SW-01 were 0.0077 mg/L, 0.0533 mg/L and 0.158 mg/L, respectively. The concentrations of dissolved arsenic at SW-02, SW-03 and SW-01 were 0.0086 mg/L, 0.0016 mg/L and 0.0071 mg/L, respectively. The elevated concentration of total arsenic at location SW-01 is irregular in that it is greater than the two upstream sources and may be related to localized remobilization of sediments.

The concentrations of dissolved arsenic in the 2001 suite of samples indicate that, at the time of sampling:

- the 1430 adit and, likely, runoff from the adit hillslope contribute arsenic into Cache Creek;
- arsenic is contributed into Cache Creek from an unidentified source upstream of the mill area that may be natural mineralization;
- the highest concentration of arsenic (0.016 mg/L) in Cache Creek was measured at two locations: upstream of the mill site and at the downstream end of the Cache reek diversion channel;
- concentrations of dissolved arsenic in Cache Creek were reduced with distance downstream of the tailings facility.

4.1.3 Proportional Contributions of Contaminants to Cache Creek

Because of the potential for contaminant contributions to Cache Creek from mining activities and natural exposures in the Peel Creek catchment, the 2001 surface water quality data was used to provide an indication of the proportional contributions of contaminants from Peel Creek versus the Cache Creek catchment upstream of Peel Creek.

For the 2001 suite of surface water samples, calculations of the proportional contributions of flow and contaminant loadings were made as a means of providing an indication of the most important sources of contaminants.

The calculations are based on a simple assumption of complete and simple mixing of two sources (say streams "A" and "B") into one stream (say stream "C") using the contaminant loading equation:

(flow A * concentration A) + (flow B * concentration B) = (flow C * concentration C)

In order to allow proportionate calculations in the absence of flow measurements, assume that flow at stream C is equal to 1 (i.e. the total flow being considered) so that:

[flow A * concentration A] + [(1 – flow A) * concentration B] = concentration C

In this way, the contaminant concentrations at the three locations under consideration can be used to provide the proportion of flow contributed from each source. The proportional flows can then be combined with the contaminant concentrations to provide the proportional contributions of contaminant loadings.

For example, the concentrations of dissolved arsenic at locations SW-02, SW-03 and SW-01 were 0.0086 mg/L, 0.0016 mg/L and 0.0071 mg/L, respectively. In terms of the calculations described above, location SW-02 is analogous to source stream A, location SW-03 is analogous to source stream B and location SW-01 is analogous to mixed stream C. The calculation for proportional flow contributions suggests that 78% of flow was contributed from location SW-02 (Cache Creek) and 22% of flow was contributed from location SW-03 (Peel Creek). That is,

$$[\%flow_{SW-02} * 0.0086] + [(1 - \%flow_{SW-02}) * 0.0016] = 0.0071$$

The calculation then suggest that the proportion of dissolved arsenic loading is 95% from location SW-02 (Cache Creek) and 5% from location SW-03 (Peel Creek). That is:

$$(0.78 * 0.0086) / 0.0071 = .95, \text{ and}$$
$$(0.22 * 0.0016) / 0.0071 = 0.05$$

Table 4.2 lists the results of the proportional flow and loading calculations for select parameters. Dissolved parameter concentrations and, particularly, sulphate are typically most useful in this regard.

Table 4.2: Proportional Flow and Loading Calculations for Cache Creek at Peel Creek

Parameter	**Concentration**		**(mg/L)**	**Flow From:**		**Loading From:**	
	SW-02	SW-03	SW-01	Cache Ck	Peel Ck	Cache Ck	Peel Ck
SO_4	108	309	158	75%	25%	51%	49%
As_d	0.0086	0.0016	0.0071	78%	22%	95%	5%
Ca_d	74	115	79.9	86%	14%	80%	20%
Cd_d	<0.00005	0.00042	0.00007	89%	11%	33%	67%
Mn_d	.00582	.326	.0651	81%	19%	7%	93%
Mo_d	0.00036	0.00009	0.00028	70%	30%	90%	10%
Ni_d	<0.0005	0.0324	0.0059	82%	18%	3%	97%
Zn_d	0.004	0.125	0.016	90%	10%	22%	78%

The calculations listed in Table 4.2 indicate that a large portion (70% to 90%) of the flow in Cache Creek originated (at the time of sampling) in the Cache Creek catchment upstream of Peel Creek and that only 10% to 30% of the flow originated in Peel Creek. This confirms general observations and expectations.

The calculations listed in Table 4.2 indicate that the dominant source of contaminants in Cache Creek varies between the two sources considered. The calculations suggest that the majority of the loadings of dissolved arsenic, dissolved calcium and dissolved molybdenum originated in the Cache Creek catchment upstream of Peel Creek whereas the majority of loadings of dissolved cadmium, dissolved manganese, dissolved nickel and dissolved zinc originated in Peel Creek. The loading of sulphate in Cache Creek is indicated to have originated equally from both sources.

Given that arsenic is considered to be the parameter of greatest environmental concern, the calculations above suggest that investigations and remedial efforts should be directed predominantly in the Cache Creek catchment upstream of Peel Creek and not in the Peel Creek catchment. Although this suggestion is based in only one set of data and should be conformed with additional sampling data, it agrees with general expectations and is considered, at this time, to be valid.

4.1.4 Historical Arsenic Concentrations

The available data regarding arsenic concentrations in surface water was compiled and summarized to provide a longer term context for interpretation of recent studies. The compilation includes background data collected in 1985/86 by or on behalf of DIAND, data collected during mine operations by the mine operator(s) and other agencies, and data collected post mine closure by DIAND or other agencies. The sample locations are listed with the various historical naming conventions in Table 4.3. The historical data has been listed in Table 4.4 according to the Water License names and then according to names used by DIAND for background studies and then by names used during the 2001 monitoring study.

Table 4.3: Surface Water Sampling Locations and Naming Conventions

Location	2001 Name (GLL)	1985/86 Name (DIAND)	License Name
Cache Ck u/s mill	SW-09	1	KR-01
1430 adit	SW-04	18	KR-03
North Dam Seep	SW-08		KR-04
South Dam Seep	SW-07		KR-05
Polishing Pond	SW-14		KR-07
Cache Ck u/s Peel Ck	SW-02		KR-08
Tailings Pond	SW-11		KR-09
Cach Ck u/s end diversion	SW-10		KR-13
Oxo Ck		9	KR-14
Peel Ck	SW-03	3	KR-15
Sue Ck		2	
Cache Ck d/s Peel Ck	SW-01	4	
Cache Ck mouth		5	
1510 adit		16	
Lower Subsidiary Ck	SW-12	20	
Cache Ck at Tarn Lk	SW-05		
Cach Ck u/s Oxo Ck	SW-06		
NW Int Ditch	SW-13		

Table 4.4: Historical Arsenic Concentrations in Surface Water

2001 Name (GLL)	SW-09	SW-09	SW-04	SW-04	SW-08	SW-08	SW-07	SW-07	SW-14	SW-14	SW-02	SW-02	SW-11	SW-11	SW-10	SW-10	-
1985/86 Name (DIAND)	1	1	18	18	-	-	-	-	-	-	-	-	-	-	-	-	9
License Name	KR-01	KR-01	KR-03	KR-03	KR-04	KR-04	KR-05	KR-05	KR-07	KR-07	KR-08	KR-08	KR-09	KR-09	KR-13	KR-13	KR-14
Parameter	As-t	As-d	As-t	As-d	As-t	As-d	As-t	As-d	As-t	As-d	As-t	As-d	As-t	As-d	As-t	As-d	As-t
Jul-85	0.011	0.011															
Aug-85	<0.05																<0.05
Sep-86	<0.05		3.380														<0.05
Sep-87	<0.05	<0.05	7.800	0.06	0.3	0.07	<0.05	<0.05			<0.05	<0.05	<0.05	<0.05			<0.05
Mar-88	0.014		10.000		0.014						0.0063		10.700	10.500			
Jun-88	0.0099		0.250		0.014		0.013				0.011		14.600	14.300			
Sep-88	0.039		2.170		0.035		0.036		0.30		0.026		11.400	10.900			
Dec-88	0.019				0.020		0.014				0.014		9.100	8.400			
Feb-89	0.021	0.021					0.034	0.014									
Mar-89					0.021	0.011					0.006	0.005					
Jun-89	0.014	0.014			0.014	0.014	0.011	0.011			0.009	0.008	14.600	14.300			
Sep-89	<0.010	<0.010	8.440	1.510			<0.010	<0.010	0.130	0.120	<0.010	<0.010	11.400	10.900			
Dec-89	0.013	0.013	5.360	1.270	0.015	0.010	0.009	0.008			0.006	0.005	9.100	8.400			
Mar-90	0.012	0.011	2.600	2.600	0.009	0.009	0.003	0.003			0.006	0.006	9.780	9.630			
Jun-90	0.014	0.014	3.970	2.490	0.014	0.013	0.014	0.013	0.034	0.016	0.008	0.008	10.700	10.100			0.010
Sep-90	0.015				0.013	0.009	0.025	0.017	0.020	0.020	0.050	0.003	1.800				
Oct-90			2.250	1.550													
Dec-90	0.020	0.020		1.100	0.014	0.012	0.007	0.007			0.009	0.009	2.510	1.560			
Mar-91	0.021	0.021	0.623	0.544	0.0110	0.0110	0.007	0.007			0.200	0.007	1.940	0.007			
Jun-91	0.003				0.0010	0.0010	<0.001				<0.001			0.542			
Sep-91	0.019	0.016	0.660	0.530	0.0120	0.0110	0.009	0.004			0.037	0.008	2.820	2.490			
Dec-91	0.017	0.016			0.0131	0.0121	0.005	0.005			0.018	0.016	3.020	3.020			
Mar-92	0.020	0.017			0.0100	0.0100	0.006	0.006			0.006	0.006	2.830	2.740			
Jun-92	0.018	0.016			0.0110	0.0100	0.015	0.014			0.010	0.009	0.857	0.346			
Sep-92	0.019	0.015			0.0091	0.0081	0.005	0.005			0.007	0.007	1.920	1.920			
Dec-92	0.016	0.015			0.0084	0.0069	0.005	0.005			0.005	0.005	1.280	1.210			
Mar-93	0.017	0.017			0.0085	0.0080	0.004	0.004			0.005	0.005	1.320	1.300			
Jun-93	0.012	0.012			0.0072	0.0071	0.008	0.008			0.008	0.007	0.758	0.758			
Sep-93	0.013	0.013			0.0079	0.0075	0.006	0.006			0.007	0.007	1.400	1.340			
Dec-93	0.017	0.015			0.0076	0.0068	0.006	0.006			0.006	0.006	1.570	1.350			
Mar-94	0.016	0.016			0.0070	0.0070	0.003	0.003			0.005	0.005	1.460	1.460			
Jun-94	0.019	0.012			0.0097	0.0081	0.010	0.009			0.007	0.007	1.330	1.230			
Sep-94	0.016	0.016			0.0086	0.0076	0.005	0.005			0.008	0.008	1.900	1.760			
Dec-94	0.014	0.014			0.0080	0.0070	0.003	0.003			0.017	0.006	1.660	1.490			
Mar-95	0.0169	0.0169			0.0080	0.0070	0.0024	0.0022			0.0055	0.0048	1.93	1.75			
Jun-95	0.0120	0.0120	0.777	0.214	0.0086	0.0086	0.0125	0.0125			0.0076	0.0076	1.41	1.33			
Aug-95																	0.0004
Sep-95	0.0131	0.0115	0.279	0.240	0.0110	0.0083	0.0089	0.0086			0.0095	0.0087	1.73	1.64			
Nov-95																	0.0008
Dec-95	0.0164	0.0148			0.0089	0.0076	0.0042	0.0042			0.0050	0.0050	1.76	1.70			
Mar-98	0.0164	0.0157					0.0036	0.0034					1.61	1.61			
Apr-98					0.0070	0.0071											
Jun-98	0.0131	0.0140			0.0076	0.0080	0.0138	0.0150					1.20	1.20			
Sep-98	0.0113	0.0112			0.0085	0.0075	0.0063	0.0058					1.30	1.30			
Nov-98	0.0133	0.0130			0.0106	0.0097	0.0068	0.0064					1.60	1.60			
Sep-99					0.0328	0.0306			0.0877				1.17	1.12			
Oct-99					<0.02	.	<0.02						0.86				
Oct-01	0.0161	0.0156	22.7000	0.2660	0.0081	0.0064	0.0495		0.1070		0.0077	0.0086	0.7060	0.6930	0.0132	0.0141	
Max	0.0390	0.0210	22.7000	2.6000	0.3000	0.0700	0.0495	0.0170	0.3000	0.1200	0.2000	0.0160	14.6000	14.3000	0.0132	0.0141	0.0100
Min	0.0030	0.0110	0.2500	0.0600	0.0010	0.0010	0.0024	0.0022	0.0200	0.0160	0.0050	0.0030	0.7060	0.0070	0.0132	0.0141	0.0004
Avg	0.0159	0.0148	4.7506	1.0312	0.0193	0.0111	0.0109	0.0074	0.1131	0.0520	0.0172	0.0070	3.9738	3.7749	0.0132	0.0141	0.0037
Number	37	31	15	12	38	34	34	30	6	3	31	27	37	36	1	1	3

2001 Name (GLL)	SW-03	SW-03	-	-	SW-01	SW-01	-	-	-	-	SW-12	SW-05	SW-05	SW-06	SW-06	SW-13	SW-13
1985/86 Name (DIAND)	3	3	2	2	4	4	5	5	16	16	20	-	-	-	-	-	-
License Name	KR-15	KR-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parameter	As-t	As-d	As-t	As-d	As-t	As-d	As-t	As-d	As-t	As-d	As-t	As-t	As-d	As-t	As-d	As-t	As-d
Jul-85	0.039	0.024	0.0006	0.0005	0.011	0.0090	0.010	0.0091									
Aug-85	0.050		<0.05		<0.05		<0.05										
Sep-86	0.070		<0.05		<0.05		<0.05		0.140		<0.05						
Sep-87	0.05	0.05	<0.05	<0.05			<0.05	<0.05	0.17	0.17							
Mar-88																	
Jun-88																	
Sep-88																	
Dec-88																	
Feb-89																	
Mar-89																	
Jun-89																	
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Nov-95																	
Dec-95																	
Mar-98																	
Apr-98																	
Jun-98																	
Sep-98																	
Nov-98																	
Sep-99	0.0623	0.0052															
Oct-99																	
Oct-01	0.0533	0.0016			0.1580	0.0071					0.0261	0.0024	0.0017	0.0160	0.0160	0.0385	0.0397
Max	0.0700	0.0500	0.0006	0.0005	0.1580	0.0090	0.0100	0.0091	0.1700	0.1700	0.0261	0.0024	0.0017	0.0160	0.0160	0.0385	0.0397
Min	0.0390	0.0016	0.0006	0.0005	0.0110	0.0071	0.0100	0.0091	0.1400	0.1700	0.0261	0.0024	0.0017	0.0160	0.0160	0.0385	0.0397
Avg	0.0541	0.0202	0.0006	0.0005	0.0845	0.0081	0.0100	0.0091	0.1550	0.1700	0.0261	0.0024	0.0017	0.0160	0.0160	0.0385	0.0397
Number	6	4	1	1	2	2	1	1	2	1	1	1	1	1	1	1	1

For some of the older data sets, arsenic concentrations are reported as below a method detection limit (MDL) that is relatively high by current standards. For example, some older data sets report concentrations of <0.05 mg/L where other studies provide data as low as 0.001 mg/L. In these cases, the older data reported using a high MDL is not included in statistical calculations or on graphs to avoid misrepresenting the data.

A review of the available historical information listed in Table 4.4 provides the following observations that are illustrated on Figure 4.1:

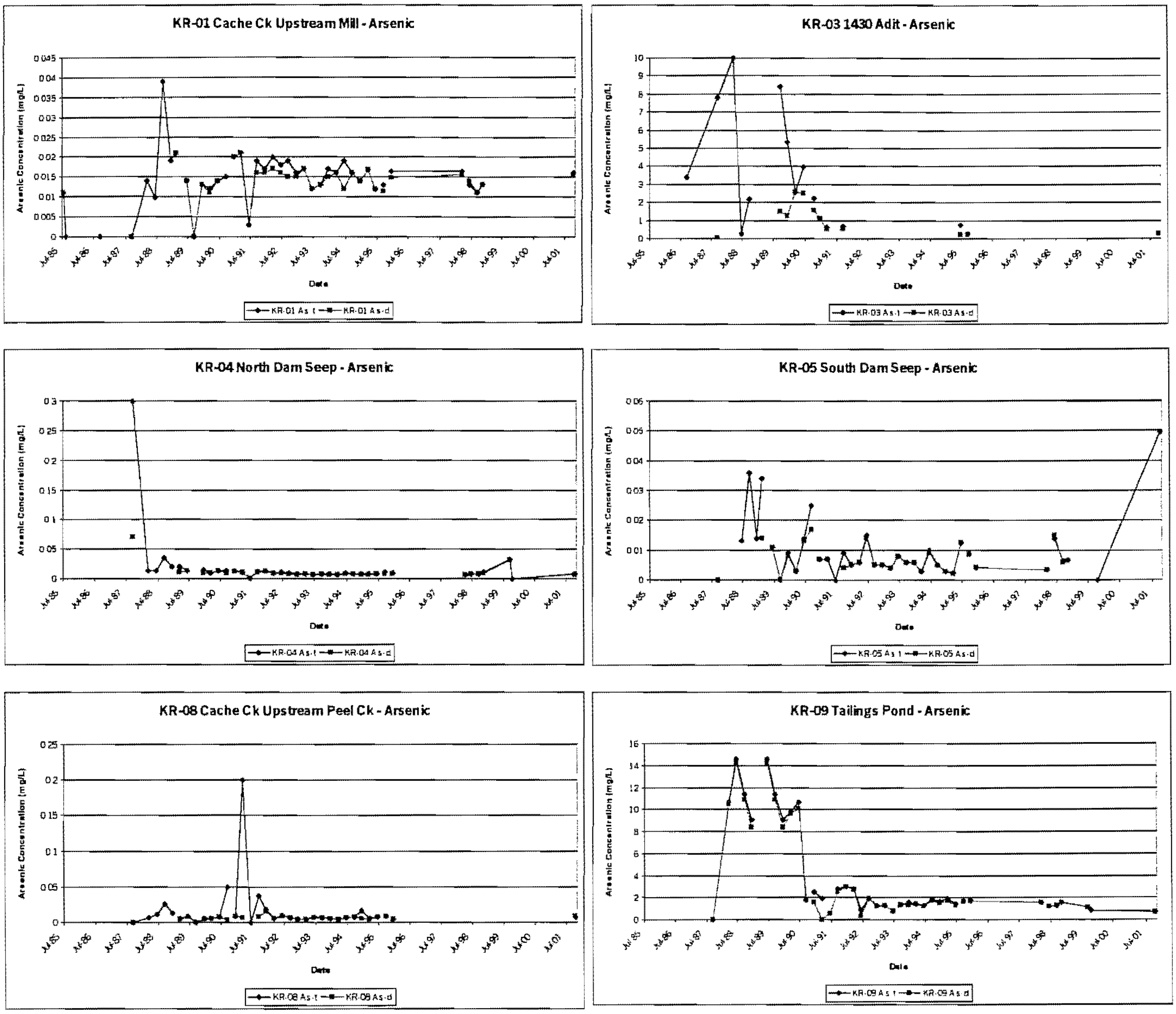
1. Arsenic concentrations at many locations have remained relatively stable since around 1992 which suggests that mine closure in 1990(?) had a beneficial effect on surface water quality.
2. Concentrations of total and dissolved arsenic are similar at most surface water quality monitoring locations and follow similar trends.
3. Arsenic concentrations at License location KR-01 (Cache Creek upstream of the mill site) have remained between 0.011 and 0.020 mg/L since 1992 and the greatest concentration of total arsenic recorded was 0.039 mg/L in September 1988.
4. Arsenic concentrations at License location KR-03 (drainage from the 1430 adit after the settlement pond, where applicable) have remained below 0.80 mg/L since 1991; a peak concentration of total arsenic of 10.0 mg/L was recorded in March 1988 and a peak concentration of dissolved arsenic of 2.60 mg/L was recorded in March 1990.
5. Arsenic concentrations at License locations KR-04 and KR-05 (North and South Dam Seeps) have generally remained below 0.015 mg/L since 1992 with the exception of one recent result at each location. Greater concentrations (up to 0.3 mg/L total arsenic) were recorded prior to 1992.
6. Arsenic concentrations at License location KR-08 (Cache Creek upstream of Peel Creek) have remained less than 0.018 mg/L (total) and less than 0.009 mg/L (dissolved) since 1992.
7. Arsenic concentrations at License location KR-08 (Cache Creek upstream of Peel Creek) have generally been greater than in Peel Creek.
8. Arsenic concentrations at License location KR-15 (Peel Creek) have remained less than 0.062 mg/L (total) and less than 0.0052 mg/l (dissolved) since 1992. The frequency of historical sampling at this location has been less than at most other locations.
9. Arsenic concentrations at License location KR-09 (tailings pond) have been less than 1.93 mg/L and have been generally decreasing since mid-1992. Arsenic concentrations at License location KR-09 were recorded as high as 14.6 mg/L (total) and 14.3 mg/L (dissolved) in June 1998 and June 1989.

4.2 Soil Quality

4.2.1 Overview of 2001 Investigation

Samples of surface and subsurface soil were collected in areas of known or suspected contamination during the October 2001 site visit. The sampling expands on the information collected during the 1999 Phase I site assessment that was conducted by Gartner Lee Limited. Test pits were excavated with a small hydraulic excavator that was mobilized to site from Ross River primarily for this purpose. Samples were collected into clean glass containers and shipped to an accredited laboratory (ALS Environmental) for analysis.

Figure 4.1: Historical Surface Water Arsenic Concentrations



The soil sample locations are illustrated on Figures 1.2 and 1.3 and can be grouped as follows:

1. Test Pit Nos. 1 to 4: along toe of mill site fill near Lower Subsidiary Creek.
2. Test Pit Nos. 5 and 25 to 29: small surface seep from mill area into Lower Subsidiary Creek.
3. Test Pit Nos. 6 to 18: mill area.
4. Test Pit Nos. 19 and 20: camp area.

Samples were analysed primarily for arsenic based on previous investigations that identified arsenic as the contaminant of primary concern (the Phase 1 ESA sampling also included several exceedances of the CCME and YCSR Guidelines for copper, nickel, vanadium and zinc). Some samples were analyzed for petroleum hydrocarbon content where visual and olfactory observations suggested that high concentrations might be present.

Analytical results are summarized in Table 4.5 and the raw data sheets, as received from the laboratory, are provided in Appendix C. Table 4.5 also provides the 1999 CCME Guidelines for the Soil Quality (CCME) and the Yukon Contaminated Sites Regulations (YCSR). These two guidelines have been included as a means of providing context for the interpretation of soil quality but are not considered to be objectives or requirements. The development of site-specific, risk-based remediation objectives, per the procedures provided in the Federal and Territorial Guidelines is considered to be appropriate for this site (Section 7).

4.2.2 2001 Arsenic Concentrations

Arsenic concentrations in the 66 soil samples analysed ranged from 92 mg/kg to 9,730 mg/kg, with an average of 1,348 mg/kg. All results were greater than the guidelines of 12 mg/kg (CCME) and 35 mg/kg (YCSR), which suggests that the level of natural mineralization in local soils may be greater than the guideline values and that the generic (Tier 1) guidelines may not provide a useful reference in this case.

Results for test pit no. TP01-20 located in the north area of the campsite may provide some additional insight into background arsenic concentrations. This test pit was excavated through 0.6 metes of gravel fill and then into 0.3 metres of organic (i.e. natural) soils and three samples were collected at 0.3 metre intervals. The arsenic concentrations were high relative to the guideline at 293 mg/kg, 226 mg/kg and 122 mg/kg for samples from surface to depth, respectively.

Test pit nos. 1 to 4 were sampled to investigate soil quality at the toe of the millsite fill material in the general drainage to Lower Subsidiary Creek. Arsenic concentrations in these test pits ranged from 92 mg/kg near surface in test pit no. 4 to 1,410 mg/kg at depth in test pit no. 1. The median concentration for this group of samples was 550 mg/kg. The two greatest concentrations in this group of samples (856 mg/kg and 1,410 mg/kg) were from test pit no. 1, which was located closest to Lower Subsidiary Creek and into which some water flowed at the approximate elevation of the creek.

Test pit nos. 5 and 25 to 29 were sampled to investigate a small surface seep from the millsite fill to Lower Subsidiary Creek. A hydrocarbon sheen was clearly visible in the surface seep when the saturated soils were disturbed. Arsenic concentrations in these samples ranged from 649 mg/kg to 2,340 mg/kg with an average concentration of 1,385 mg/kg.

Table 4.5: 2001 Soil Quality Data

Station	Guidelines		TP01-1 0-0.3	TP01-1 1.0-1.1	TP01-2 0-0.3	TP01-2 0.4-0.6	TP01-3 0-0.3	TP01-3 1.1-1.3	TP01-4 0-0.3	TP01-4 0.3-0.5	TP01-5 0-0.1	TP01-5 0.2-0.3	TP01-6 0-0.3	TP01-6 0.3-0.6	TP01-6 0.6-0.9
Date	CCME	YCSR	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001
Observations															
total depth, codes			1.3m, 1, 2	1.3m, 3	0.9m, 1	0.9m, 1	1.3m, 1, 5	1.3m, 1	1.1m, 4	1.1m, 1, 5	0.3m, 1, 4	0.3m, 1	1.3m, 1, 2	1.3m, 1, 2	1.3m, 1, 2, 5
Physical Tests															
Moisture %			10.9	44.9	8.6	8.5	17	9.9	64.4	29.8	26.4	49.1	12.1	7.2	8.3
Soil pH	6 - 8		-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals															
Arsenic	12	35	856	1410	511	544	449	267	92	273	1660	1010	1990	564	1580
Extractable Hydrocarbons															
EPH10-19	-	1000	-	-	-	-	-	-	-	-	-	-	-	-	-
EPH19-32	-	1000	-	-	-	-	-	-	-	-	-	-	-	-	-

Station	Guidelines		TP01-7 0-0.3	TP01-7 0.3-0.6	TP01-7 0.6-0.9	TP01-8 0-0.3	TP01-8 0.3-0.6	TP01-8 0.6-0.9	TP01-9 0-0.3	TP01-9 0.3-0.6	TP01-9 0.6-0.9	TP01-10 0-0.1	TP01-10 0.1-0.4	TP01-10 0.4-0.7	TP01-11 0-0.1
Date	CCME	YCSR	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001
Observations															
total depth, codes			1.3m, 1, 2	1.3m, 1, 2	1.3m, 1, 2, 5	1.2m, 1, 6	1.2m, 7	1.2m, 7	1.2m, 1, 6	1.2m, 7	1.2m, 7	1.3m, 1, 6	1.3m, 1	1.3m, 1, 5	0.9m, 1, 6
Physical Tests															
Moisture %			8.5	6.1	6.2	13.9	7.6	7.9	12.6	8.4	7.9	9.5	7.7	8.3	12.3
Soil pH	6 - 8		-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals															
Arsenic	12		634	190	279	6700	712	434	4090	351	260	1880	279	879	1390
Extractable Hydrocarbons															
EPH10-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPH19-32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Station	Guidelines		TP01-11 0.1-0.4	TP01-11 0.4-0.7	TP01-12 0-0.3	TP01-12 0.3-0.6	TP01-12 0.6-0.9	TP01-13 0-0.1	TP01-13 0.1-0.4	TP01-13 0.4-0.7	TP01-13 0.7-1.0	TP01-14 0-0.3	TP01-14 0.3-0.6	TP01-14 0.6-0.9	TP01-15 0-0.3
Date	CCME	YCSR	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001
Observations															
total depth, codes			0.9m, 1, 7	0.9m, 7, 1	1.3m, 1, 2, 5	1.3m, 1, 2, 5	1.3m, 1, 2, 5	1.2m, 1, 2, 6, 8	1.2m, 1, 2, 8	1.2m, 1, 2, 8	1.2m, 1, 2, 8	1.0m, 1, 6	1.0m, 1, 2	1.0m, 1, 2	1.2m, 1
Physical Tests															
Moisture %			7	8	8.8	6.9	7.9	11.7	9	8.6	9.3	14	7.8	9.2	8.8
Soil pH	6 - 8		-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals															
Arsenic	12		511	331	310	284	277	9480	1270	782	745	8270	1040	408	1200
Extractable Hydrocarbons															
EPH10-19	-	-	-	-	-	-	-	2220	428	1240	2270	-	-	-	-
EPH19-32	-	-	-	-	-	-	-	555	<200	<200	<200	-	-	-	-

Station	Guidelines		TP01-15 0.3-0.6	TP01-15 0.6-0.9	TP01-16 0-0.2	TP01-16 0.2-0.5	TP01-16 0.5-0.8	TP01-17 0-0.1	TP01-17 0.1-0.4	TP01-17 0.4-0.7	TP01-18 0.05-0.3	TP01-18 0.3-0.6	TP01-18 0.6-0.8	TP01-19 0.05-0.3	TP01-19 0.3-0.6	TP01-19 0-0.05
Date	CCME	YCSR	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/11/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001
Observations																
total depth, codes			1.2m, 1	1.2m, 1	0.8m, 1	0.8m, 1	0.8m, 1	0.8m, 1, 2, 6	0.8m, 1, 2, 5	0.8m, 1, 2, 7, 5	0.9m, 1, 2	0.9m, 1, 2	0.9m, 1, 2	0.8m, 1, 2, 5	0.8m, 1, 2, 5	0.8, 1, 2, 6
Physical Tests																
Moisture %			6.2	6.5	7.2	6.8	6.7	9.7	8	7.4	6.4	7.5	6.6	8	7.3	15
Soil pH	6 - 8		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals																
Arsenic	12		1260	247	2620	656	256	9730	880	377	571	257	274	582	1050	1450
Extractable Hydrocarbons																
EPH10-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPH19-32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Station	Guidelines		TP01-20 0-0.3	TP01-20 0.3-0.6	TP01-20 0.6-0.9	TP25 Surface	TP25 0.3m	TP26 Surface	TP26 0.3m	TP27 Surface	TP27 0.3m	TP28 Surface	TP28 0.3m	TP29 Surface	TP29 0.3m	Mill Assay
Date	CCME	YCSR	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001	10/12/2001
Observations																
total depth, codes			1.1m, 1, 2	1.1m, 1, 2	1.1m, 4	0.3m, 1, 4	0.3m, 1	0.3m, 1, 4	0.3m, 1	0.3m, 1, 4	0.3m, 1	0.3m, 1, 4	0.3m, 1	0.3m, 1, 4	0.3m, 1	9
Physical Tests																
Moisture %			11.6	23.3	11.3	45.6	62.6	19.2	21.1	53.2	43.9	13.7	53.9	34.7	41.7	4.1
Soil pH	6 - 8		-	-	-	-	-	-	-	-	-	-	-	-	-	8.27
Total Metals																
Arsenic	12		293	226	122	2100	1300	849	1260	1190	1370	841	1070	2340	1830	26000
Extractable Hydrocarbons																
EPH10-19	-	-	-	-	-	791	<400	<200	<200	<200	<200	<200	<200	341	<200	-
EPH19-32	-	-	-	-	-	556	<400	<200	<200	<200	<200	<200	<200	315	<200	-

Observation Codes: 1 = brown or grey sand/gravel possibly with minor soil; 2 = some cobbles; 3 = black gravel; 4 = organic soil; 5 = minor orange staining; 6 = strong orange staining; 7 = grey shale rock; 8 = strong hydrocarbon odour and visual; 9 = assay rejects composite

Test pit nos. 6 to 18 were sampled to investigate soil contamination in the mill area. Arsenic concentrations ranged from 190 mg/kg to 9,730 mg/kg with an average concentration of 1,606 mg/kg. To a large extent, arsenic concentrations were greatest in the near surface samples and were less at depth in these test pits. This corresponds to general expectations that the source of the contamination was surface activities. The concentrations at depth in some of the test pits may also relate to the natural mineralization in local soils and rocks.

Test pit nos. 19 and 20 were sampled to investigate the camp area. Test pit no. 19 was excavated on the west side of the camp area near the generator shed in a previous active working area. Arsenic concentrations ranged from 582 mg/kg to 1,450 mg/kg with the greatest concentration near surface. Test pit no. 20 was excavated in the northeast area in a less active work area. Arsenic concentrations ranged from 122 mg/kg to 293 mg/kg with the greatest concentration in the near surface sample.

4.2.3 2001 Hydrocarbon Concentrations

A select group of soil samples were analysed for light and heavy extractable petroleum hydrocarbons (EPH) based on evidence of either visible staining or a hydrocarbon odour. There were two areas of samples selected: in the vicinity of the tank farm at the millsite (test pit no. 13) and in the vicinity of the surface seep to Lower Subsidiary Creek (test pit nos. 25 to 29).

The reference used for hydrocarbon concentrations is the YCSR of 1,000 mg/L for each of light and heavy extractable petroleum hydrocarbons.

In test pit no. 13 near the tank farm, four samples were analysed to the full depth of the test pit (1.0 metres). Three of the four samples exceeded the YCSR guideline for light EPH (EPH_{10-19}) but none of the samples exceeded the YCSR for heavy EPH (EPH_{19-32}). There was a strong hydrocarbon odour in this test pit.

In test pit nos. 25 to 29, none of the 10 samples analysed exceeded the YCSR for either light or heavy EPH. The greatest concentration measured was 791 mg/L for EPH_{10-19}.

4.2.4 1999 Investigation

Surface soil samples (to 0.1 m depth) were collected from various areas of the mine site during the 1999 Phase 1 ESA (Gartner Lee Limited, 2001). The samples were intended to provide a broad indication of the extent and degree of surface contamination. A summary of the analytical results is as follows:

1. All samples (23) exceeded the generic Federal and Territorial guidelines for arsenic.
2. Some samples at the toe of the landfill contained zinc above the generic guidelines.
3. Hydrocarbons in soil near the "grease ramp" (exploration camp area) did not exceed the guidelines.
4. One sample from the boneyard contained zinc, copper, nickel and hydrocarbons in excess of the generic guidelines.

5. One sample near the storage tank at the 1510 portal contained copper and hydrocarbons in excess of the generic guidelines.
6. Some samples from the camp area contained zinc and hydrocarbons in excess of the generic guidelines.
7. Some samples from the mill area contained copper, total sulphur, and hydrocarbons.
8. One sample of the sediments in the polishing pond contained zinc, copper, vanadium, and nickel in excess of the generic guidelines.
9. One sample collected from the used oil storage area near the tailings impoundment contained hydrocarbons in excess of the generic guidelines.

4.2.5 Historical Fuel and Oil Spills

The Phase 1 ESA (Gartner Lee Limited, 2001) identified that a significant spill of diesel fuel had occurred in 1992 in the area of Lower Subsidiary Creek. The spill was described as follows:

"A 40,000 litre spill of diesel occurred in the spring of 1992 from one of the bulk storage tanks. A pipe elbow failed west of the mill building (behind the mill dry), allowing the tank contents to flow down slope to Lower Subsidiary Creek. Canamax estimated that approximately 26,000 l of fuel was recovered in a series of check dams and snow pits. The fuel was burned off in these collection pits daily. Follow-up site investigation consisting of a test pitting program was conducted by Seacor Environmental in the summer of 1992. No reports detailing the results of this work were found."

Although a substantial clean up effort is reported, it is likely that some residual contamination of shallow soil is present from this spill in the area downslope from the mill to Lower Subsidiary Creek, given the extent and nature of the spill.

The Phase 1 ESA also indicated that a spill of used oil had occurred from used oil storage drums in an area downstream of the tailings impoundment previously used for refueling and storage. The spill was described as follows:

"Used oil was stored just off the mine access road downstream of the mine site west of Peel Creek at the former refueling station. An inspection on April 25th, 1989 revealed that several of the 45-gallon drums of waste oils were leaking due to loose bungs. Visible staining of surficial soils and snow was observed. The drums were relocated to the tailings pond storage areas and it is reported that contaminated soils were also hauled to this area. No further documentation was found with respect to the extent of this clean-up or if any follow-up investigations were conducted."

It is possible that some residual contamination of surface soil is present in this area since the spill report makes no mention of a clean up of the visibly contaminated soil.

4.3 Tailings Dam Physical Stability Assessment

4.3.1 Assessment Objectives and Limitations

As noted in Section 10.4 of Gartner Lee Ltd. *et. al.* (2001), it was recommended that stability analyses be undertaken on the existing tailings dams at the Ketza River Mine site. Analyses were recommended since previous work by SRK (1994) and Brodie (1998) provided differing opinions on the stability of these dams. Geo-Engineering (1998) also provided stability analyses for both of the dams and their results are summarized below:

- The South Dam appears to meet required Factors of Safety against failure for both the static (Fs_{min} = 2.1) and pseudo-static (Fs_{min} = 1.7) conditions, assuming a design acceleration value of 0.078 g.
- For deep seated failures, the North Dam appears to meet required Factors of Safety against failure for both the static (Fs_{min} = ~1.5) and pseudo-static (Fs_{min} = 1.2) conditions. Marginal Factor of Safety values were derived though regarding local stability of the toe area.
- If a toe berm were installed at the North Dam, the Factors of Safety increased for both the static (Fs_{min} = 2.0) and pseudo-static (Fs_{min} = 1.5) conditions.

Although SRK (1994) noted that the South Dam was likely more critical for its potential greater susceptibility for deep-seated failure, analyses provided herein are focused on the North Dam due to the observed soft area at its toe. As such, this section provides an assessment of the physical stability of the North Dam, based on stability analyses undertaken for the currently-configured dam.

The evaluation provided herein is a physical stability assessment of the North Dam, based only on geotechnical stability analyses for the currently-configured dam. It does not address all aspects of physical stability such as piping and internal erosion or surface sloughing and erosion. Nor does this current assessment address any of the hydrotechnical issues (basin hydrology, flood routing capability, spillway sizing, etc.) related to this dam, which are likely to be as important as the geotechnical issues. For instance, an improperly designed spillway can lead to overtopping of the dam, which can lead to failure of the entire dam embankment. Additionally, the physical stability assessment provided herein is not a detailed assessment of the liquefaction potential of these dams. As such, the proper instrument for a complete assessment of the safety of either the North Dam or the South Dam is a Dam Safety Review (DSR), compliant with the requirements of Section 2.0 of CDA (1999). Within that document, a DSR is required for all dams based on a time period varying from 5 years for Very High Consequence dams to 10 years for Very Low Consequence dams. No DSR has been undertaken for these dams, based on BGC's current understanding of the site background. The results of the physical stability assessment provided herein would form but one component of an overall DSR.

The physical stability results provided in this report need to be evaluated in the overall context of dam safety that includes additional issues such as any piping potential, the potential overtopping of the dam and the potential liquefaction deformation of the dams. In addition, any stability analyses also need to consider the future role of these two dams in terms of water retention or not. It has been suggested that water retention is required to control arsenic levels within the seepage water, but not for control of potential acidic drainage. As such, the dams may be required to retain water for some intermediate term period until the arsenic levels drop to discharge limits. Then, the dams could be breached and soil cover placed over top of the tailings to control dusting and other environmental issues. However, a DSR is recommended if the dams are required to retain water on a short term, or longer, basis.

4.3.2 Information Sources Available

For the stability assessment work, several sources of data and information specific to the Ketza River Mine dams were obtained and reviewed, as summarized below:

- Report on the Preliminary Site Selection and Geotechnical Evaluation, Ketza River Project by Golder Associates, September 1985.
- Report on Geotechnical Design of Tailings Disposal Facilities, Camp Site and Mill Site Evaluation Ketza River Project by Golder Associates, December 1986.
- Hydrology Study and tailings Pond Mass Balance report by Kerr, Priestman & Associates Ltd. Consulting Engineers, November 1986.
- Report on Tailings Dam Construction, Ketza River Project by Golder Associates, November 1987.
- Various letters from Golder Associates to and from Canamax Resources Inc. between May and December 1987 on tendering and construction issues.
- Geotechnical inspection report, including stability analyses undertaken on both dams, by Geo-Engineering (M.S.T.) Ltd. 1998.
- Ketza River Mine Site – Phase 1 Environmental Site Investigation by Gartner Lee Ltd., Mehling Environmental Management Inc., BGC Engineering Inc. and Sheila C. Greer, March 2001.

Complete references for these information sources are provided in the Reference section.

In addition, Gartner Lee Ltd. also forwarded portions of the following reports to BGC for review:

- Groundwater Characterization Study by T.W. Higgs Associates, November 1989.
- Groundwater Well Installation report by SRK, February 1997.
- Report summarizing tailings area groundwater data by Environment Canada, January 1999.

In addition to the reports noted, BGC visited the site in October 2001 as outlined in Section 3.3.1. Additional site-specific data was collected at that time for input to the analyses provided herein.

4.3.3 Dam Configuration, Geometry and Materials

Two dams, the North Dam and the South Dam, provide tailings and water retention for the Ketza River Mine tailings area. Sections 3.3.2 and 3.3.3 provide a summary of the inspection conditions of the North and South Dams, respectively. The 1987 as-built report and drawings by Golder (1987a) indicates that the North Dam has three material zones while the South Dam has four, as summarized below:

- Zone 1 or Type A Fill (talus based)– Six inch minus gravel and sand with less than 10% silt and clay for the outer shell.

- Zone 2 or Type B Fill (colluvium based) – Six inch minus gravel and sand with 10 to 25% silt and clay for the outer core.
- Zone 3 or Type C Fill (till based) – Four inch minus gravely sand and silt with 20 to 50% passing the No. 200 sieve for the inner core. The silt content generally exceeded 30% with an average silt content of about 35% (Golder, 1987a). The in-situ permeability of the material was estimated at $1x10^{-6}$ cm/s utilising falling head permeability tests and gradation analyses (Golder, 1986).
- Zone 4 or Type B Fill – as for Zone 2 material noted above.

At the North Dam, the vertically-oriented inner core connects to a cut-off trench and ranges from 4 m to 7 m wide. The outer core zone is 3 m wide at the top, 18 m high, and slopes upstream and downstream at ratios of 1.5H:1V and 2H:1V, respectively. A downstream drainage blanket is present beneath the downstream outer core material with filter cloth placed between the materials.

Foundation conditions for the North Dam vary across the length of the dam. In the middle portion of the dam, the dam rests on alluvium material. The abutments of the dam rest on a sloping surface blanketed by colluvium and glacial till beneath the left (looking downstream) abutment and granular outwash and glacial till deposits beneath the right abutment.

Considerable seepage was noted in the vicinity where the North Dam is now located during the preliminary site selection and geotechnical evaluation for the dams (Golder, 1985). This reference also notes that the natural soils on the valley floor were generally saturated.

4.3.4 Dam Safety Guidelines

CDA (1999) defines slope stability Factor of Safety as the factor required to reduce the mobilized shear strength parameters (of the soil or rock) of a potential sliding mass into a state of limiting equilibrium. A simpler definition notes the Factor of Safety as the ratio of the resisting forces in a sliding block (e.g. shear strength of the soil) to the driving forces (e.g. soil weight). As such, for a block to be considered "stable", the resisting forces must exceed the driving forces. If the resisting forces are just equal to the driving forces, then the Factor of Safety is equal to 1.0 and the slope is marginally stable.

CDA (1999) provides design criteria for the required Factors of Safety for static analysis of embankment dams, as summarized in Table 4.6:

Table 4.6: Factors of Safety, Static Assessment (after CDA, 1999)

Loading Conditions	Minimum Factor of Safety
Steady state seepage with maximum pond height	1.5
End of construction before impoundment filling	1.3

As such, the downstream face of any retention dam needs to achieve a Factor of Safety of at least 1.5, in order to meet these generally accepted guidelines for dam design.

CDA (1999) also provides guidance on the design criteria for earthquake resistance of embankment dams. Section 5.0 of that reference states that dams (and associated components) shall be designed to resist the ground movements associated the Maximum Design Earthquake (MDE). The selection of the MDE is based on the consequences of failure that is defined in Table 5-1 of CDA (1999). For a "Very High" consequence category dam, the MDE shall be either of the Maximum Credible Earthquake (MCE), if determined deterministically or a return period event of 10,000 years for a probabilistically derived earthquake. For a High Consequence dam, the MDE is either 50 to 100% of the MCE or a seismic event in the range of 1:1,000 to 1:10,000 year return periods.

The Pacific Geoscience Centre (PGC, a division of the Geological Survey of Canada) was contacted and they provided the following assessment of the potential seismic hazards at the Ketza River Mine site:

- 0.042g for a 200 year return period.
- 0.056g for a 476 year return period.
- 0.071g for a 1,000 year return period.

PGC does not provide values for more extreme events, such as the 1:10,000 year event. It should be noted that SRK (1994), in their stability review of the dams, used an acceleration value of 0.062g multiplied by an amplification factor of 1.25 for a pseudo-static acceleration value of 0.078g. This was the same value as used by Geo-Engineering (1998) in their assessment of the dam stability.

Faro Mine, located approximately 125 km northeast of the Ketza River Mine site, was subject to a detailed seismic hazard assessment in Appendix A of Robertson (1996). Dr. Scott Dunbar, P.Eng., provided an assessment of seismic ground motion estimates for the Faro area. Within that assessment, and allowing for the assumptions made therein, the following peak ground acceleration (PGA) values for rock sites were determined:

- 0.05g for a 475 year return period and
- 0.13g for a 10,000 year return period event.

Based on that assessment, the MCE for the Faro site may be as high as 0.13g.

Given the information reviewed, and the lack of site-specific seismic data, it was decided that the PGA values for pseudo-static seismic analyses of the North Dam would be varied between 0.07g (roughly equivalent to a 1,000 year return period event) and 0.13g (roughly equivalent to a 10,000 year return period event). In Section 4.3.7, a recommendation will be provided to undertake a site specific seismic hazard assessment.

CDA (1999) does not provide any specific factors of safety required for pseudo-static analyses, but refers to some other published work for guidance. Mitchell (1983) does provide typical seismic safety factors for impoundment dams, as summarized in Table 4.7:

Table 4.7: Typical Safety Factors for Impoundment Dams (after Mitchell, 1983)

Case	High Risk Dam	Low Risk Dam
[a] end of construction	1.3	1.3
[b] normal operation	1.5	1.3
[c] rapid drawdown	1.3	1.1
[d] earthquake loadings	1.2	1.1
[e] earthquake loadings in combination with [a], [b] or [c]	1.1	1.0

From this reference, safety factors between 1.1 and 1.2 would be recommended for seismic analysis of embankment dams. Based on Australian experience with embankment dam design, Fell *et. al.* (1992) notes that a minimum Factor of Safety of 1.1 is required for seismic analysis.

In summary, the following Factors of Safety were used as design criteria for the stability analyses of the North Dam:

- Full pond level, steady state seepage, static conditions – 1.5.
- Full pond level, steady state seepage, seismic condition, pseudo-static analyses – 1.1.

It should be noted that full pond level refers to a water elevation situated 2 m below the physical crest of the dam.

It should be noted that no rapid draw down analyses were undertaken within the work scope provided herein. Rapid draw down conditions occur in embankment dams when the upstream reservoir level is quickly dropped. If the embankment materials cannot drain rapidly, then excess pore pressures will be generated. Instability of the upstream face may then result. If any future operation of the tailings pond requires that the water level be rapidly dropped, then a draw down analyses should be undertaken.

4.3.5 Current Piezometric Conditions

The tailings dams contain a number of standpipe piezometers installed for the purpose of monitoring subsurface water pressures. It appears that piezometers were installed during the site investigations carried out in 1986 (Golder, 1986), while some of the piezometers were installed more recently in 1989, 1990 and 1996, subsequent to dam construction (SRK, 1997). The piezometers installed by Golder appear to have been lost during dam construction. Only the piezometers installed since 1989 are currently accessible. Table 4.1 of SRK (1997) provides a summary of the installation depths and elevations of the various piezometers in the dams.

Standpipe piezometers (that were measured in October, 2001) in the crest of the North Dam were numbered P90-8, P90-9, P90-10A and -10B and P96-11A, -11B and –11C. Table 4.8 provides a summary of the important installation information for these instruments, based on the Table 4.1 of SRK (1997):

Table 4.8: North Dam Piezometer Information (after SRK, 1997)

Piezometer Number	Constructed Depth of Casing Below Ground Surface (m)	Material at Well Screen Interval	Elevation (m) of Water Table on 1996/09/14	Elevation (m) of Water Table on 2001/10/10
P90-8	9.9	Glacial till – native material	1307.32	1306.82
P90-9	7.6	Glacial till – native material	1307.18	1308.18
P90-10A	32.2	Fractured phyllite bedrock	1301.14	1299.32
P90-10B	15.2	Glacial till – dam fill	1299.19	N/a (dry to bottom)
P96-11A	25.8	Phyllite - bedrock	1296.07	1295.26
P96-11B	20.3	Outwash gravel	1294.03	N/a (dry to bottom)
P96-11C	17.0	Sandy silty dam fill	N/a (dry to bottom)	1299.25

Recent data collected from piezometers P90-10A and P96-11C by BGC indicate that the piezometric level in the dam fill and in the fractured phylite bedrock foundation, near the deepest fill section of the dam, is approximately 1299.2 m. This piezometric level is utilised in the stability analyses denoted Case 1 - Measured Piezometric Conditions, along with the pond level assumed to be at 1312 m that is two metres below the physical crest. Figure 4.2 provides a graphical representation of this piezometric surface.

In addition to the Case 1 piezometric conditions, two other cases were formulated for this assessment and these are explained as follows:

- Case 2 – Intermediate Piezometric Conditions: From the upstream pond level at 1312 m, the phreatic surface decreases as a straight line until the mid-point of the granular toe drain.
- Case 3 – Long Term Worst Case Piezometric Conditions: From the upstream pond level at 1312 m, the phreatic surface decreases as a straight line directly to the toe of the North Dam. This surface would be reflective of blockage and/or failure of the granular toe drain that may be possible over the long term (closure phase).

As such, three potential piezometric cases, as shown on Figure 4.2, are reviewed within the following stability analyses.

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Figure 4.2
North Dam Piezometric Cases

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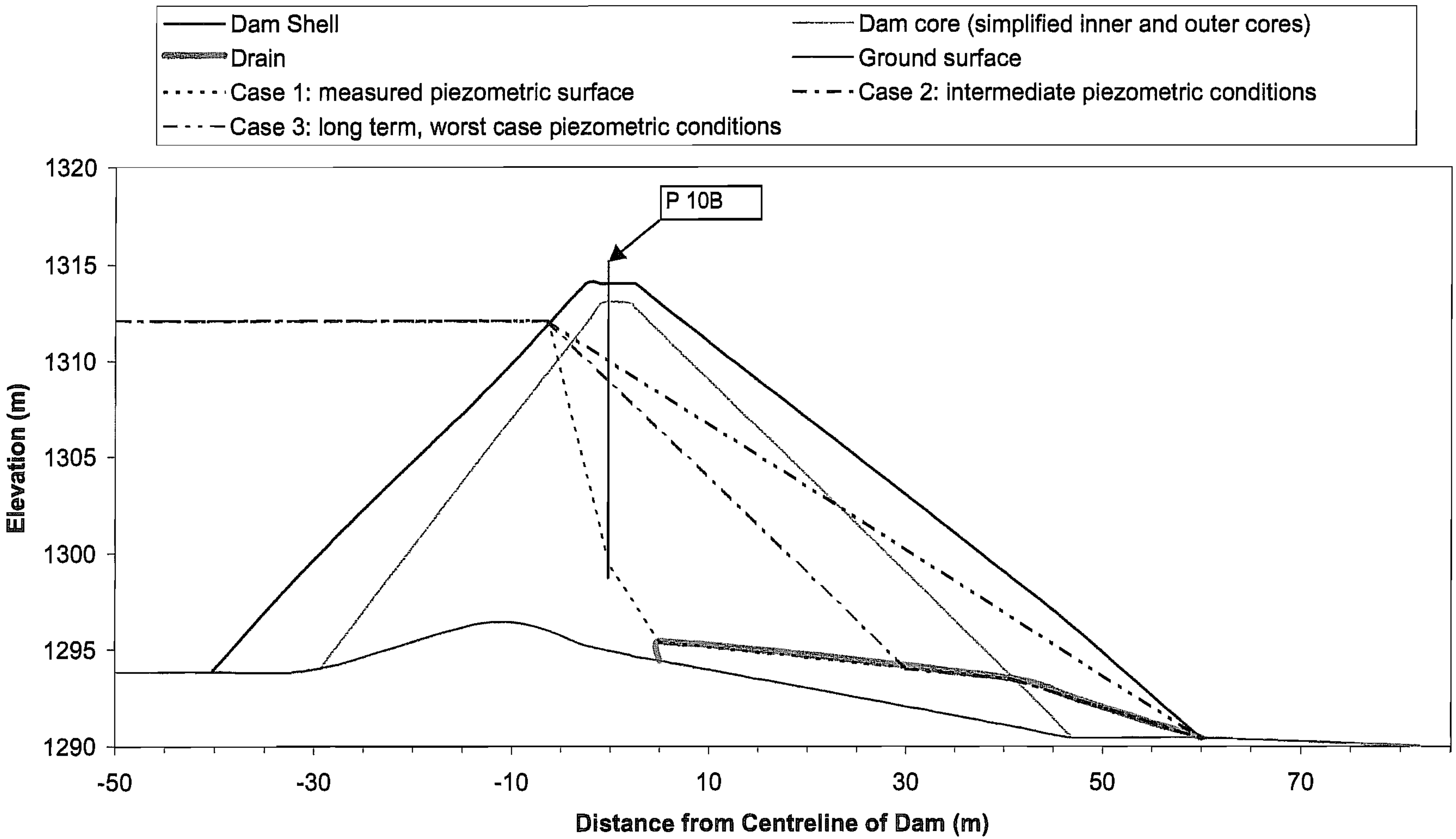


21950-D1-Figure 4.2.xls

4.3.6 Stability Analyses of the North Dam

Numerous analytical methods exist for the determination of the Factor of Safety in slope stability analyses. All slope stability analyses undertaken in this study were done with the commercial software, SLOPE/W and used the General Limit Equilibrium (GLE) method of analysis. The GLE method calculates the Factor of Safety by satisfying both moment and force equilibrium.

Given the previous placement of tailings on the upstream side of the dam (and the uncertainty with the beach extent), analyses within this current study were limited to the exposed downstream face. Analyses of the downstream face of the dam were conducted under both static and seismic loading (PGA =0.07g and 0.13g) conditions.

Parametric analyses were carried out to determine the slip surfaces with the minimum Factor of Safety. The geometry of a representative slip surface determined during the parametric analyses is illustrated in Figure 4.3. In some cases, the slip surface with the minimum Factor of Safety did not include the dam crest. In general, the minimum Factors of Safety for slip surfaces that did not include the dam crest were 0.01 to 0.09 less than the Factors of Safety for slip surfaces that did include the dam crest.

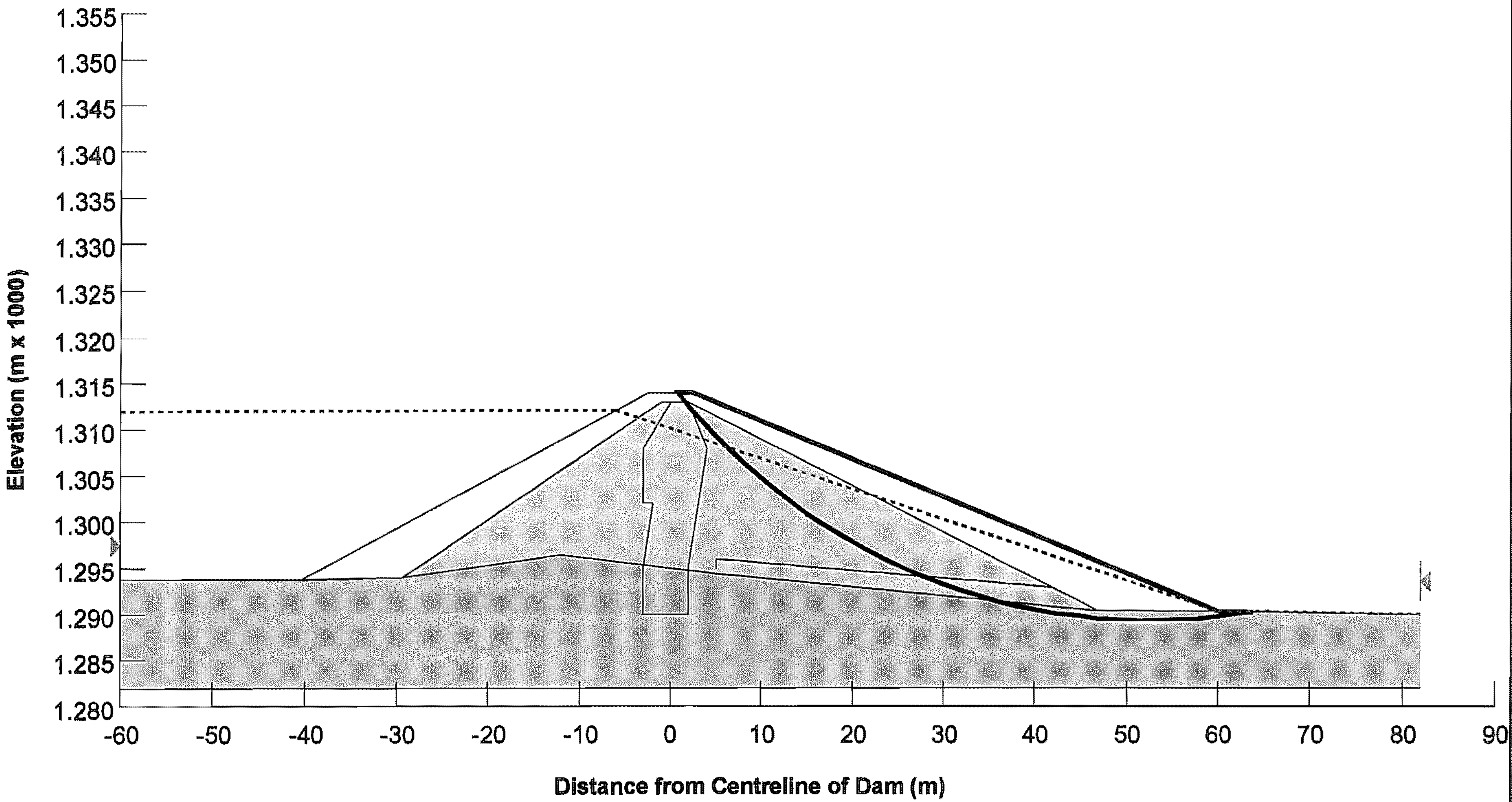
Information on materials used during construction of the tailings dam was discussed in Golder (1997a). That information, along with correlations from published geotechnical information, were used to estimate the range of probable soil properties used for the stability analyses. Those properties are presented in Table 4.9.

Table 4.9: Material Properties Used for BGC Stability Analysis

Material	Range of Effective Friction Angles	Effective Cohesion (kPa)	Unit Weight (kN/m^3)
Inner and Outer Core Zones	28° – 34°	0	20
Shell	34°	0	20
Foundation	30° - 36°	0	20

It should be noted that the friction angle values from Table 4.9 are slightly lower or equivalent to those used in SRK (1994) and roughly equivalent to those used in Geo-Engineering (1998).

The 1987 as-built drawing produced by Golder indicated that three zones exist within the North Dam; Zone 1 – the shell, Zone 2 – the outer core and Zone 3 – the control (inner) core. Grain size analyses (Golder, 1987a) indicated that the silt content of the Zone 2 and Zone 3 material ranged from 10% to 49%. The range of effective friction angles that can be expected for materials with those fines contents are encompassed by the values presented in Table 4.9. As a result, parametric analyses were conducted considering both Zones 2 and 3 materials to have the same frictional values.



SCALE: As shown	DATE: MAY 30, 2002	DRAWN: BN
File: 21950-D1-FIG4.3.CDR	CHECKED: JWC	APPROVED: JWC

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Gartner Lee Limited

CLIENT: DIAND Contaminants

PROJECT: Ketza River Mine Liability Assessment

TITLE: North Dam Representative Failure Surface

PROJECT No.	DWG. No.	REV.
21-950	Figure 4.3	0

For the Case 1 piezometric conditions, the results of the static and pseudo-static analyses for the North Dam are summarized graphically on Figures 4.4 and 4.5. For static conditions, the dam meets the required Factor of Safety of 1.5 when the dam core material is a minimum value of 30° and the foundation material is at least 34°. As the frictional value of the dam core material rises from 30°, then the majority of the Factor of Safety curves are above the required Factor of Safety of 1.5. Figure 4.5 provides the results of the seismic loading analyses, for the suggested range of PGA values. All of the Factor of Safety curves are higher than 1.1 required for a PGA of 0.07g. When the PGA increases to the extreme value of 0.13g, frictional values of at least 32° for both the core and the foundation materials are required to meet the Factor of Safety criteria.

The results for the Case 2 static and pseudo-static analyses are summarized on Figures 4.6 and 4.7. Case 2 represents intermediate piezometric conditions in the dam section. For the static assessment, the dam meets the required factor of 1.5 when the either foundation material is 34° or higher and when the dam core frictional value is 30° or higher. In comparison to the results for Case 1, the Factor of Safety results for Case 2 conditions are lower and more varied. For the pseudo-static assessment, the majority of the results for a PGA value of 0.07g are equal or greater than the required 1.1. When the PGA value is increased to 0.13g, then the dam core needs a frictional value of at least 32° along with a foundation value greater than 34°.

Case 3 (worst case long-term piezometric conditions) static and pseudo-static analyses are provide in Figures 4.8 and 4.9. The results indicate that the dam will not meet either of the required design criteria of 1.5 for static conditions or 1.1 for seismic conditions for any of the friction angles for the foundation materials and the dam core considered by BGC. Therefore, if the phreatic surface within the North Dam ever developed to such a severe condition, a toe berm would be required to increase the minimum Factor of Safety to those required under long-term closure conditions. A toe berm would be recommended as a stabilizing element rather than attempting to guarantee drainage measures in the long term.

BGC carried out parametric analyses for the lowest effective angle of friction of the foundation materials (30°) considered in the analyses to determine the approximate size of a toe berm. Based on those analyses, an approximately 10 m high berm would be required to achieve the minimum Factors of Safety for static and pseudo-static (PGA=0.13g) conditions. The results of the static and pseudo-static analyses for Case 3 piezometric conditions with a 10 m high toe berm are summarized on Figures 4.10 and 4.11. The Case 3 piezometric conditions with a 10 m high toe berm results indicate that the dam could meet the recommended criteria of 1.5 for static conditions and 1.1 for pseudo-static conditions (PGA=0.13g). Those Factors of Safety are achieved when the effective friction angle of the foundation and the dam core are greater than or equal to 30° and 32°, respectively.

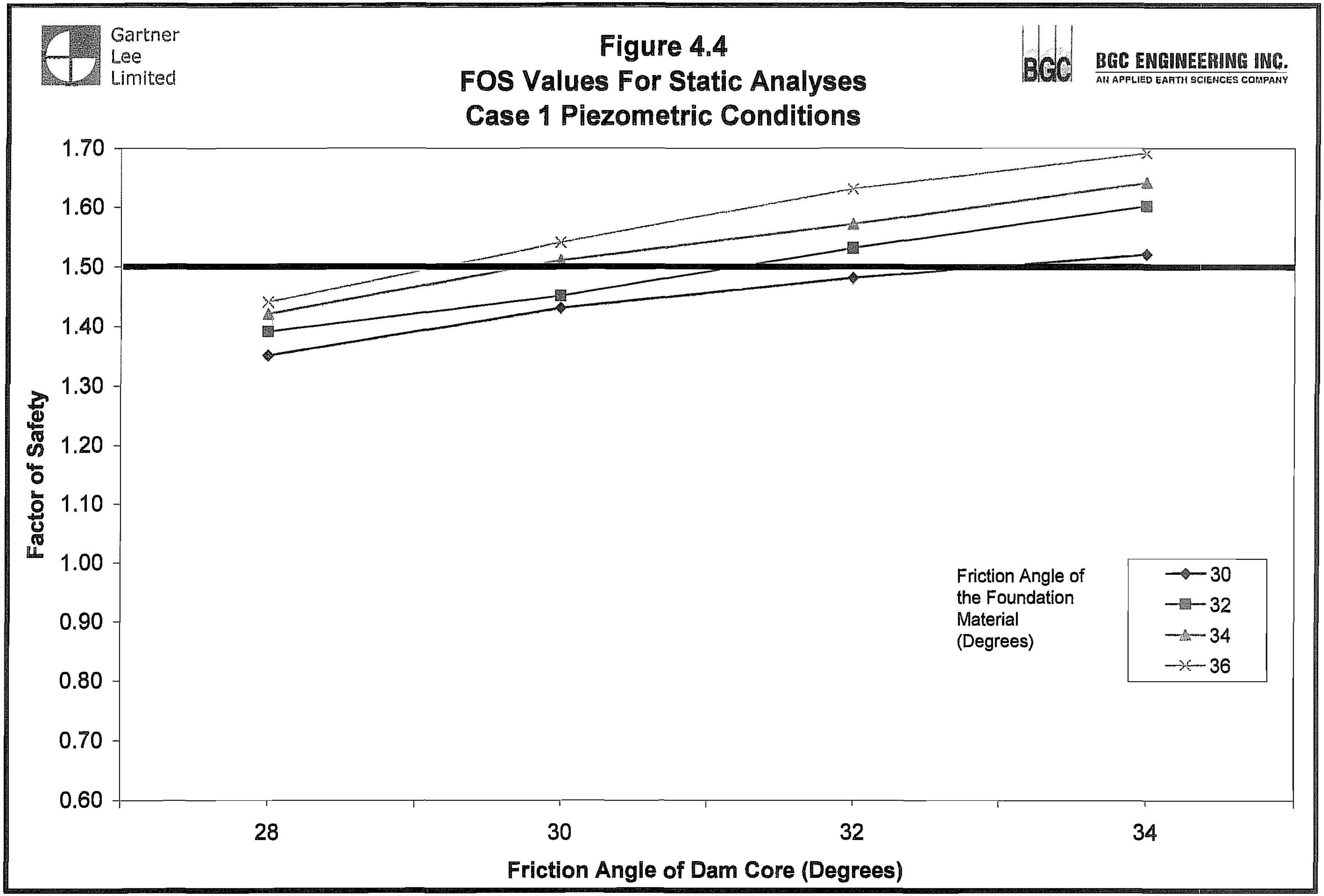
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Figure 4.4
FOS Values For Static Analyses
Case 1 Piezometric Conditions
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
Factor of Safety
28
30
32
34
Friction Angle of Dam Core (Degrees)
Friction Angle of the Foundation Material (Degrees)
30
32
34
36

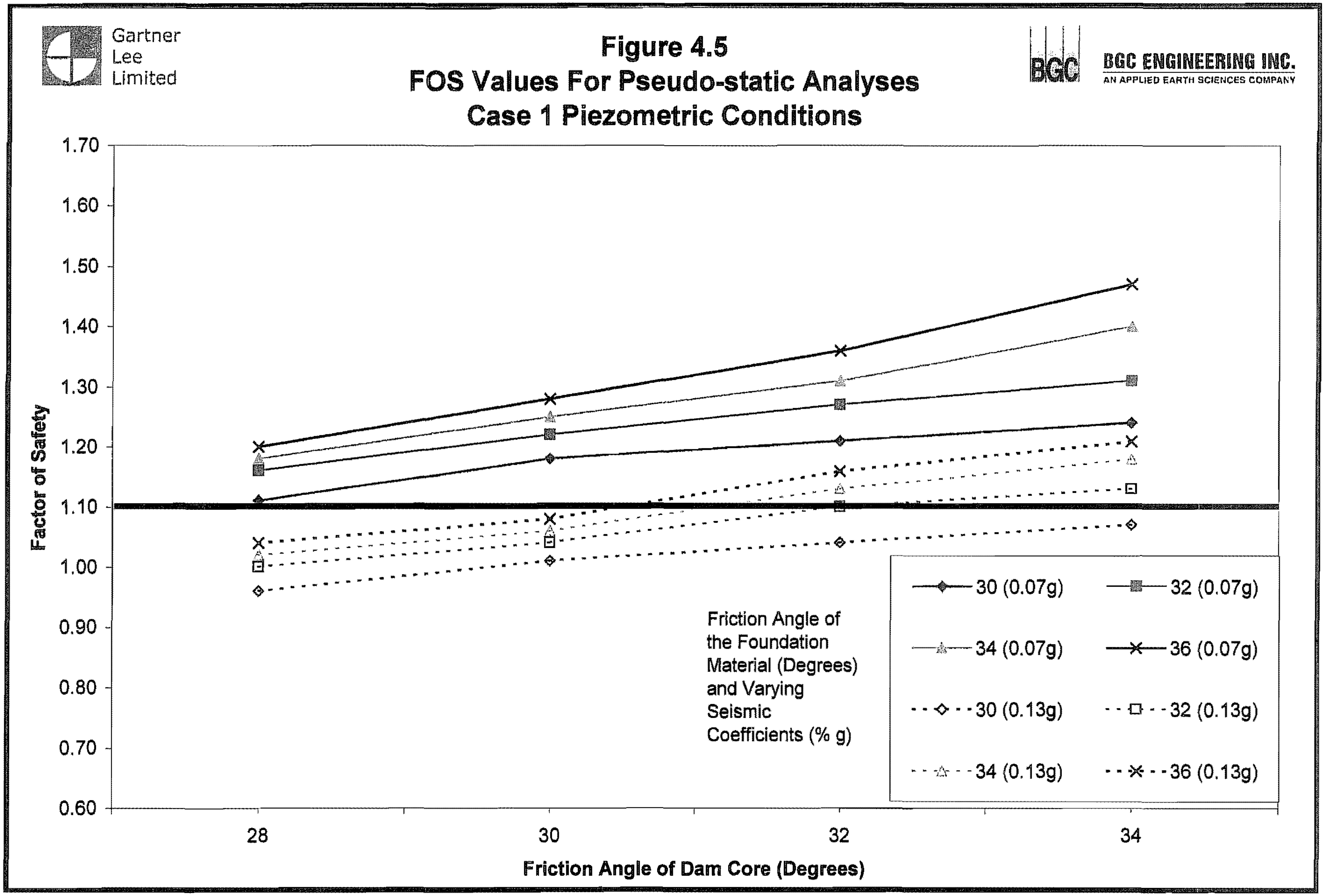

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Figure 4.5
FOS Values For Pseudo-static Analyses
Case 1 Piezometric Conditions
BGC
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1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
Factor of Safety
28
30
32
34
Friction Angle of Dam Core (Degrees)
Friction Angle of the Foundation Material (Degrees) and Varying Seismic Coefficients (% g)
30 (0.07g)
32 (0.07g)
34 (0.07g)
36 (0.07g)
30 (0.13g)
32 (0.13g)
34 (0.13g)
36 (0.13g)

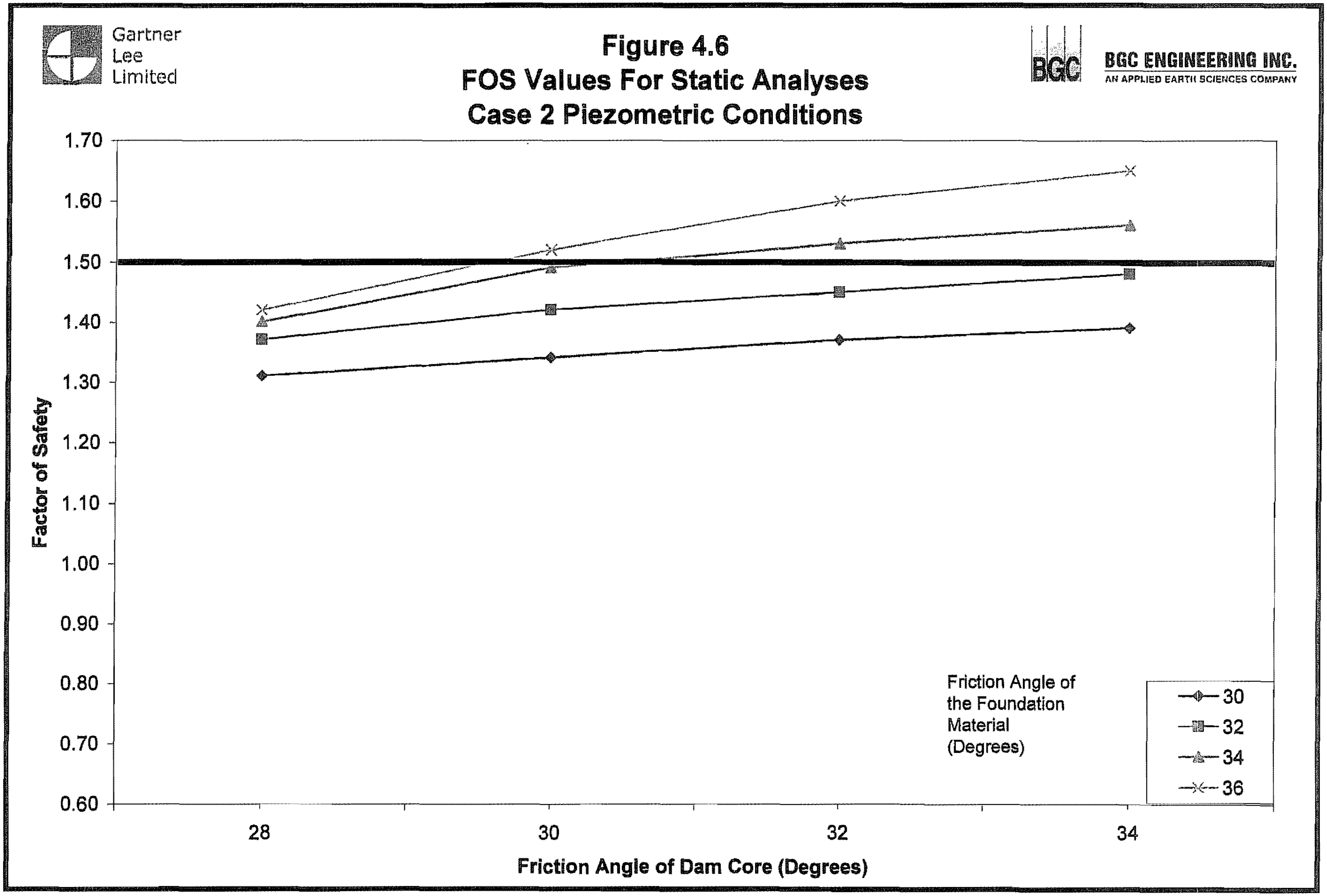
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Figure 4.6
FOS Values For Static Analyses
Case 2 Piezometric Conditions
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
Factor of Safety
28
30
32
34
Friction Angle of Dam Core (Degrees)
Friction Angle of the Foundation Material (Degrees)
30
32
34
36

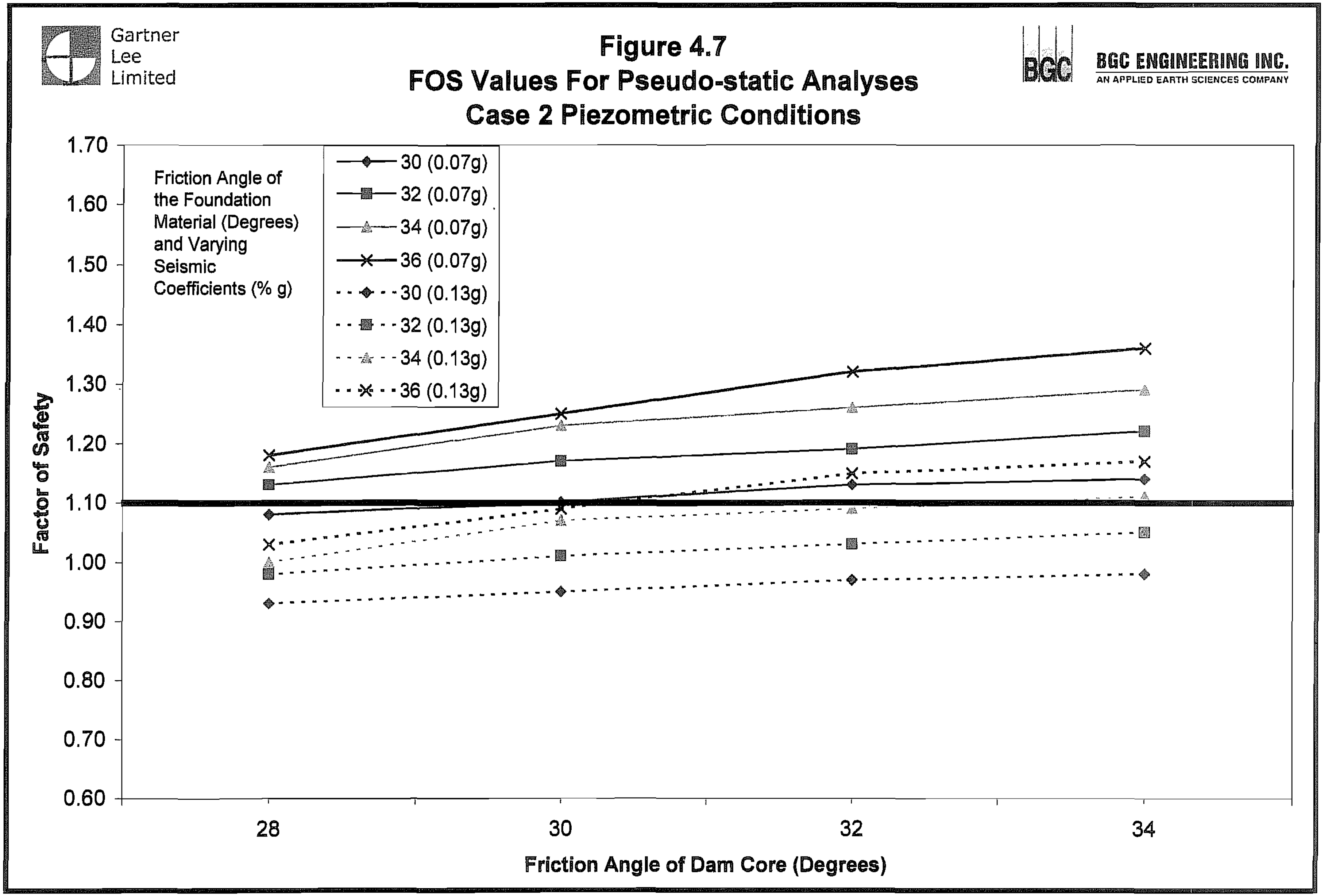
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Figure 4.7
FOS Values For Pseudo-static Analyses
Case 2 Piezometric Conditions
BGC
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Friction Angle of the Foundation Material (Degrees) and Varying Seismic Coefficients (% g)
30 (0.07g)
32 (0.07g)
34 (0.07g)
36 (0.07g)
30 (0.13g)
32 (0.13g)
34 (0.13g)
36 (0.13g)
Factor of Safety
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
28
30
32
34
Friction Angle of Dam Core (Degrees)

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Figure 4.8
FOS Values For Static Analyses
Case 3 Piezometric Conditions

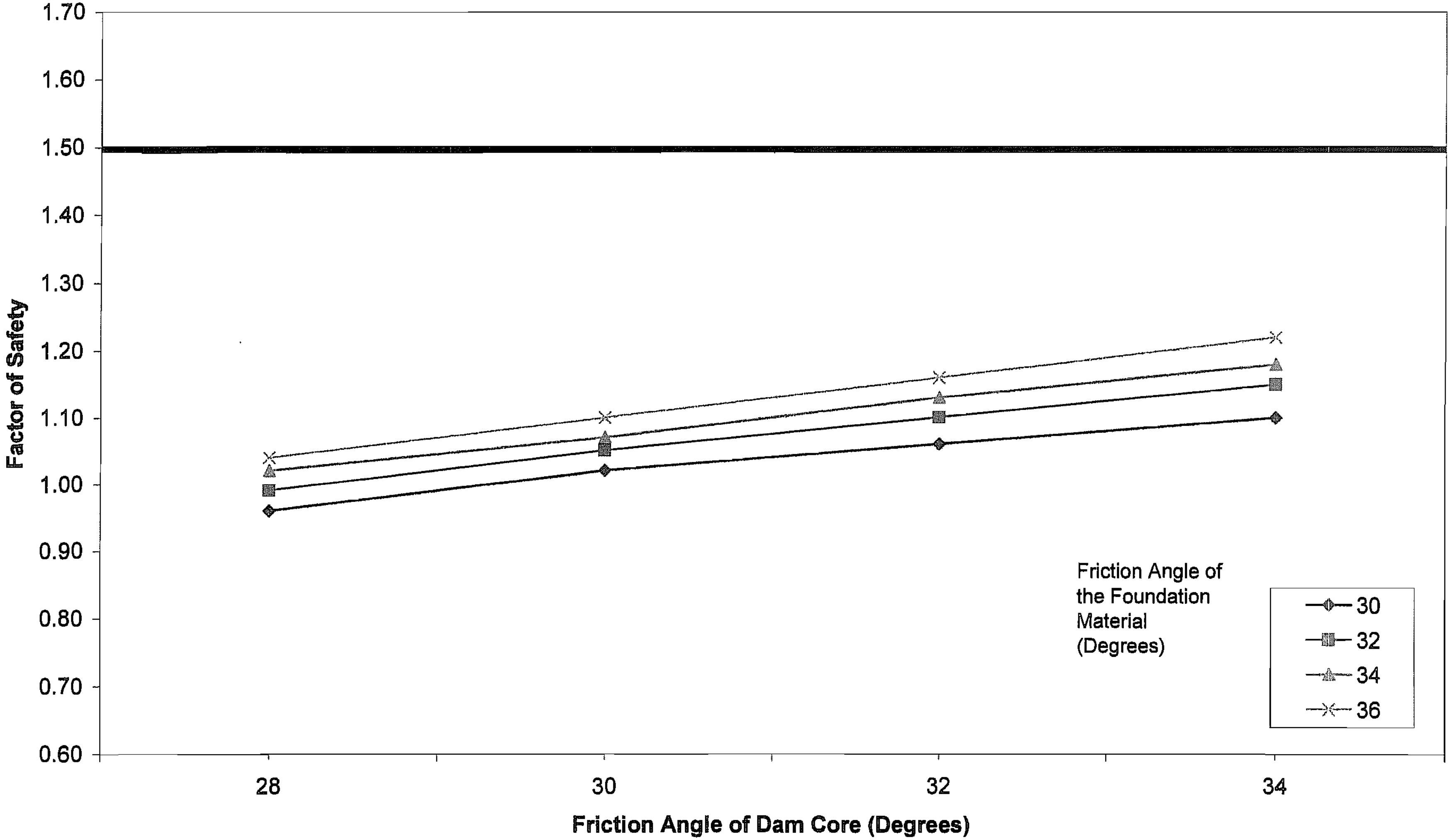

Figure 4.9
FOS Values For Pseudo-static Analyses
Case 3 Piezometric Conditions

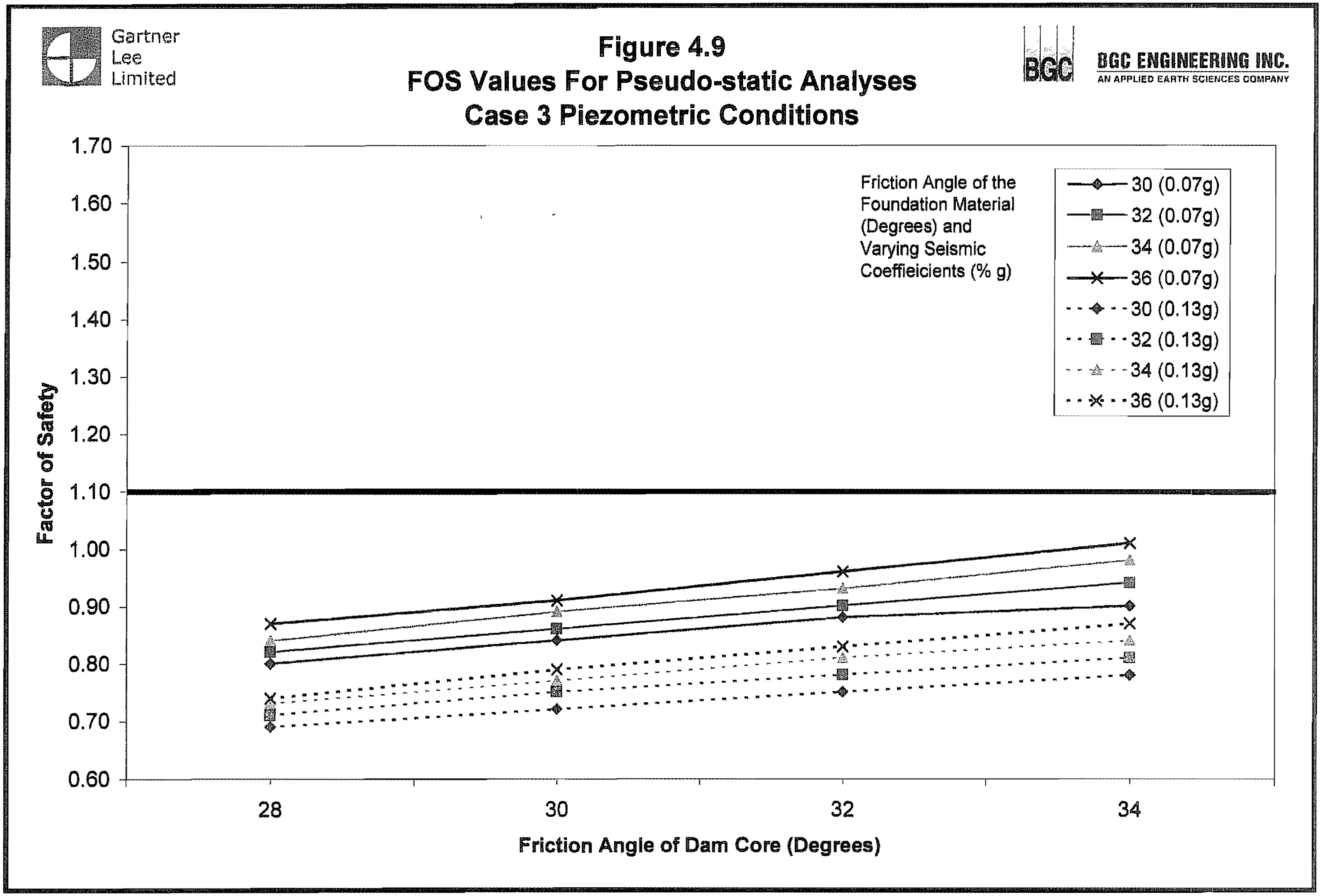

Figure 4.10
FOS Values For Static Analyses
Case 3 Piezometric Conditions
Toe Berm Evaluation

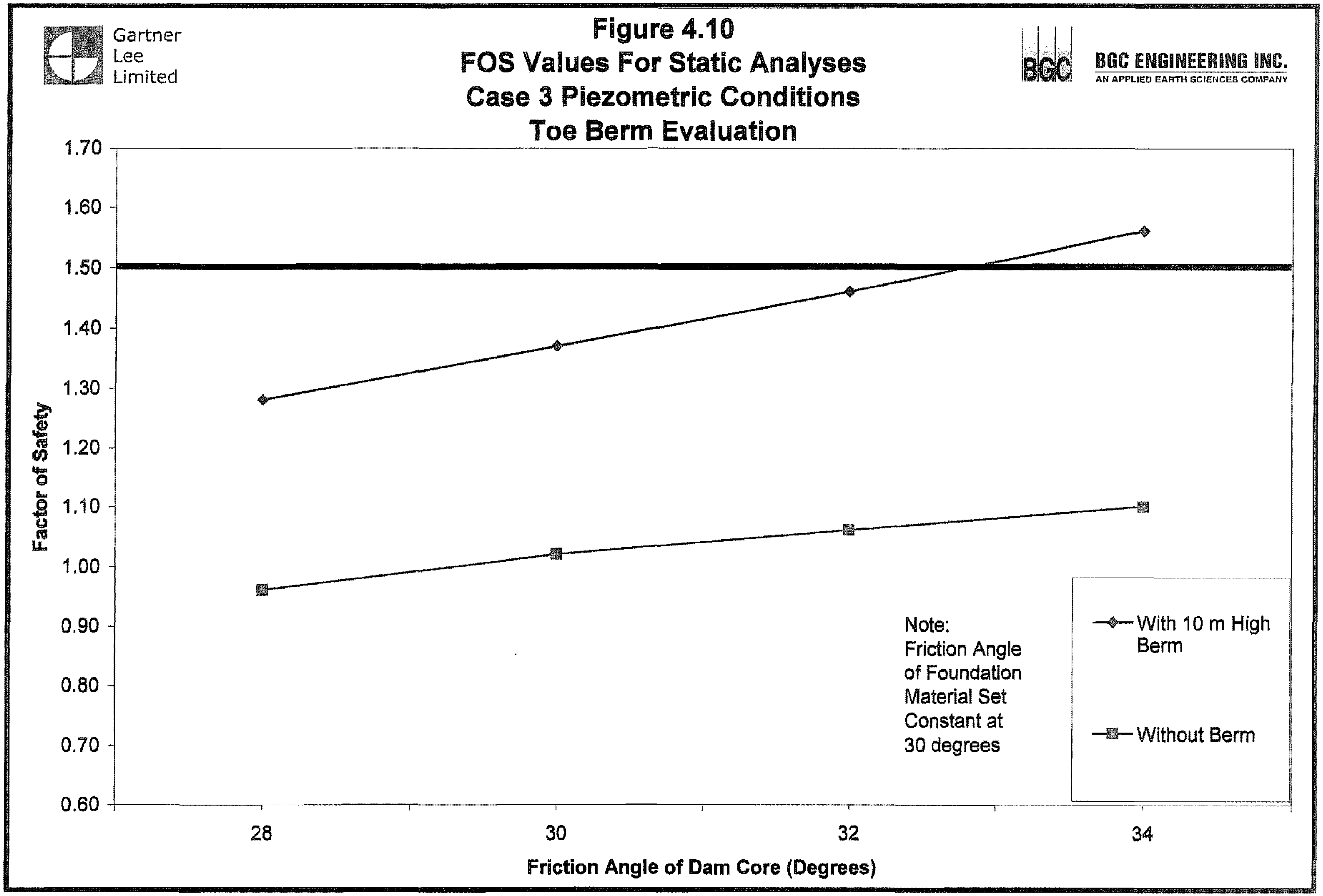

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Figure 4.11
FOS Values For Psuedo-static Analyses
Case 3 Piezometric Conditions
Toe Berm Evaluation

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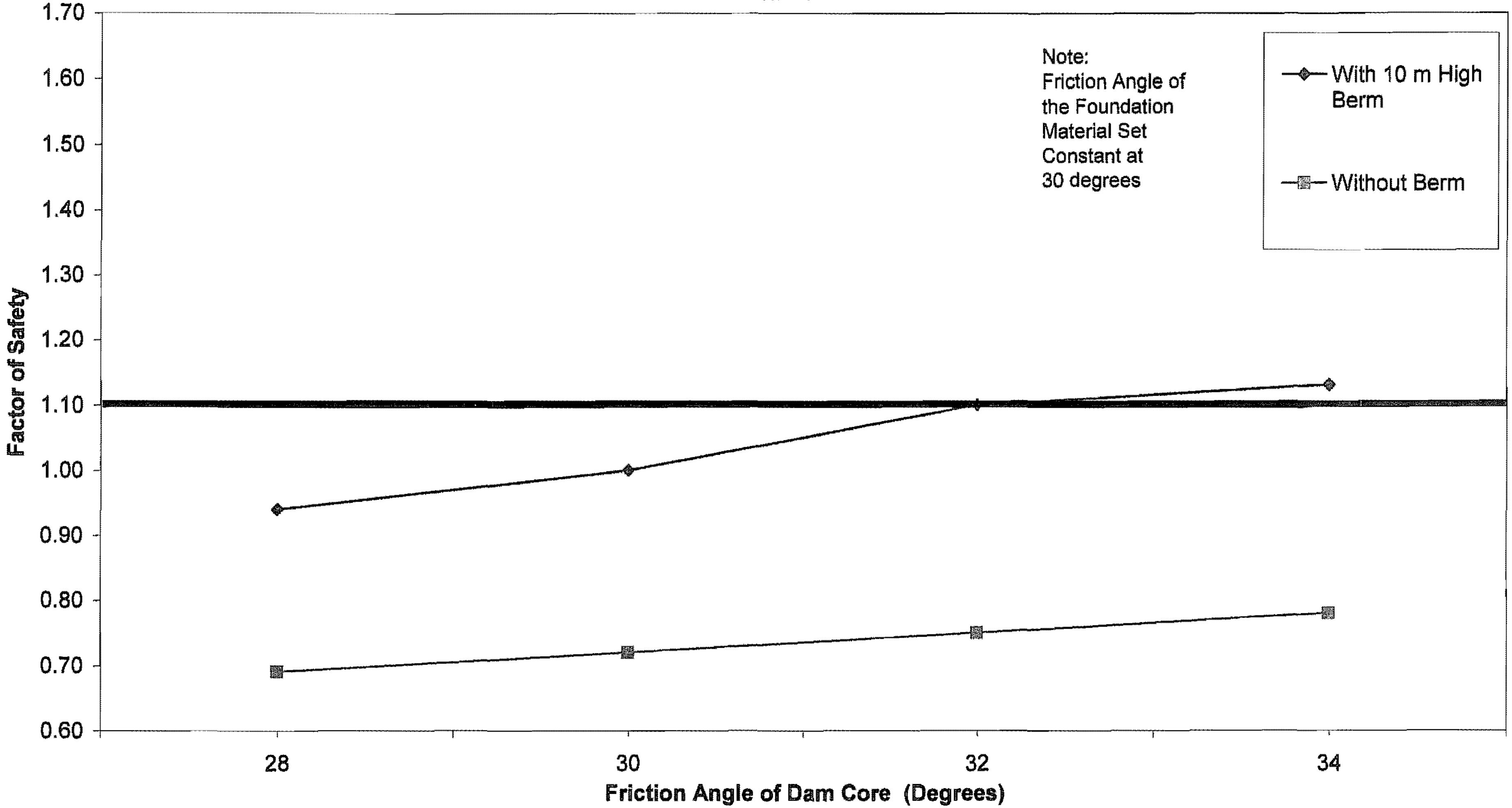

4.3.7 Stability Conclusions And Recommendations

BGC carried out a series of stability analyses for the Ketza River Mine tailings dam, based on internal geometry and material information provided by other parties and on current and estimated intermediate to long-term piezometric conditions. In addition, seismic acceleration values, based on both site specific and proximal information, were assumed for the analyses. Based on the these assumptions, the following conclusions are made by BGC:

1. The downstream slope of the North Dam meets the static and pseudo-static Factor of Safety requirements, under the currently-measured piezometric conditions, if the effective angle of friction of the foundation and dam core materials are equal to, or greater than 32°. The stability assessment by Geo-Engineering (1998) assumed frictional values of 30° to 35° for the dam core materials and 33° to 35° for the foundation materials.
2. Some potential concerns exists with regards to the soft spot observed at the toe of the North Dam. Analyses by Geo-Engineering (1998) illustrate the low Factor of Safety possible regarding local stability of the toe portion of the dam. Liquefaction of the foundation and/or the embankment is still a concern and a drilling program should be undertaken to assess the soft spot at the toe. Coupled with this investigative component, an assessment of the relevant seismic acceleration criteria should also be undertaken.
3. The downstream slope of the North Dam meets the static and pseudo-static Factor of Safety requirements under intermediate piezometric conditions (reflective of potentially deteriorating conditions in the drainage blanket) if the effective angle of friction of the foundation and dam core materials are equal to or greater than 34° and 32°, respectively.
4. If internal drainage conditions worsened until the Case 3 conditions occurred (that may occur over the longer term during the closure phase), then the North Dam would not be able to meet either of the required static or pseudo-static Factors of Safety.
5. A 10 m high toe berm is required for the dam to meets the static and pseudo-static requirements under long term piezometric conditions if the effective angle of friction of the foundation and dam core materials are equal to or greater than 30° and 32°, respectively. The approximate volume of a required toe berm amounts to approximately 8,500 bank m^3, based on certain assumed dimensions.

Based on those conclusions, BGC makes the following recommendations relative to the stability of the tailings dams at site:

1. A drilling program should be undertaken to investigate the extent and the causes of the soft spot at the toe of the North Dam. Piezometers should be installed within this area in assess groundwater seepage direction. In addition, it may be relevant to collect other site-specific information relative to the liquefaction assessment of the two dams and to the frictional values of the material placed in the dam.
2. A detailed topographic survey of the main structures within the tailings area should be carried out. This should include locations and elevations for all relevant monitoring instruments, a bathymetric survey of the tailings beach and pond depth on the upstream side of the dams,

centerline profile and typical cross-sections for the spillway and all ditches and diversion channels and locations and elevations for all culverts around the area.

3. A seismic hazard assessment should be carried out specifically for the Ketza River Mine site such that the Maximum Design Earthquake (MDE) can be evaluated. This assessment should be accordance with the requirements of Section 5.0 of CDA (1999). As such, each dam should be classified in terms of its potential consequences of failure. The consequence categories vary from Very Low upwards to Very High, based on both life safety and socioeconomic, financial and environmental aspects.
4. Additional static and pseudo-static stability analyses, along with a liquefaction assessment, should be carried out using the parameters determined from the above investigations and assessments and from the proposed closure configuration of the two dams.
5. If either of the two dams will be required to retain water in the future (on a temporary or longer-term basis), a Dam Safety Review should be undertaken.

Several other recommendations regarding associated aspects such as monitoring, surface water drainage and hydrotechnical concerns are also reviewed within Section 6.0 of this report.

4.4 Hazardous Materials

A representative of Hazco Environmental Services Ltd. ("Hazco") visited the site in October 2001 while other site activities were being conducted. Hazco specializes in the management, handling, transportation and disposal of waste materials. The purpose of the visit was to enable Hazco to provide an informed and professional assessment of the requirements and costs for removal and disposal of hazardous materials from the mine site.

While on-site, Hazco and Gartner Lee reviewed the inventory of waste materials and selected those that were appropriate for transport and disposal off-site. A summary report and cost estimate was subsequently prepared by Hazco and is provided in Appendix D.

A summary of the assessment provided by Hazco is as follows:

1. The poor condition of the access road would necessitate repairs to several areas such that flat deck trucks could access the site.
2. Even in light of some repairs to the access road, access would be restricted to small (3-tonne) trucks, which would be used to "ferry" materials from the site to highway transport trucks.
3. Two secure material handling areas would be required: one at the mine site and one at the Robert Campbell Highway.
4. The "ferry" trucks would require on-board secondary containment as would the highway transport trucks.
5. Spill containment kits would be located at strategic locations around the mine site and along the access road.
6. Some waste materials would require re-packaging prior to transport.

7. Labeling would be required for all transported materials.
8. Local contractors could be used for some tasks but would require on-site training.

The cost for removal and disposal of waste materials was estimated to be in the order of $200,000. This cost estimate included the provision of a temporary "bridge" to cross a washout in the access road, the completion of minor road repairs and the provision of some local heavy equipment and labour.

5. Assessment of Environmental Liability

5.1 Objective and Approach

The need for an assessment of the environmental liability at the mine site stems from a requirement for the Federal government to account for future costs (equivalent to a liability) in its accounting practices. As such, it is understood that Treasury Board has requested that DIAND provide an estimate of future costs relative to the assessment, closure and monitoring of abandoned mine sites, including the Ketza River mine site.

The following approach was taken relative to assessing the environmental liability at the Ketza River mine site:

1. Review available environmental and tailings design information (Sections 2 and 3).
2. Collect additional field information to fill information gaps (Sections 3 and 4).
3. Assess all available environmental information and dam stability (Section 4).
4. Review previous mine closure plans and cost estimates (Section 5).
5. Compile an updated liability cost estimate utilizing all available information (Section 5).

5.2 Previous Mine Closure Plans and Cost Estimates

Three previous closure plans and cost estimates, noted below, were available for review. These plans are briefly described in the subsequent sections:

1. Canamax Resources 1987.
2. Wheaton River Minerals and Steffen Robertson Kirsten Inc. 1994/96.
3. Brodie Consulting Ltd. 1998.

5.2.1 Canamax Resources 1987

This closure plan and cost estimate was conceptual in nature and was developed prior to development of the actual mine. The mine design was in-place during its development and the mine was developed largely as envisioned in the conceptual closure plan. The major components of the closure plan included the following:

1. Maintain all clean water diversions around the tailings impoundment in perpetuity.
2. Flood tailings under water cover behind the North and South Dams.
3. Remove buildings for salvage value (i.e. no net cost).
4. Seal underground openings.
5. Conduct post reclamation monitoring for 3 years.

The total cost for this plan was estimated to be between $400,000 and $650,000, inclusive of the post reclamation monitoring.

5.2.2 Wheaton River Minerals and Steffen Robertson Kirsten 1994/96

This closure plan and cost estimate was developed in two components. The owner, Wheaton River Minerals (WRM), developed the closure plan for all facilities excluding the tailings impoundment and Steffen Robertson Kirsten Inc. (SRK) developed the closure plan for the tailings impoundment. The closure plan for the tailings impoundment was modified by SRK in 1996 as an addendum to the 1994 plan and the 1996 addendum has been used for this comparison.

The 1996 addendum presented two alternative closure plans for the tailings impoundment. The primary plan was based on the conceptual (1987) plan that involved upgrading and maintaining all clean water diversions around the tailings impoundment in perpetuity. A contingency plan was also presented that consisted of relocating and covering tailings with soil within the impoundment and breaching one dam such that the clean water diversions were not required for closure. The contingency plan was to be implemented if aqueous arsenic concentrations in the tailings pond were "high". The contingency plan was used in this comparison because it is deemed more appropriate to the current conditions at the mine site.

The other primary components of that plan included:

1. Remove buildings for net financial gain.
2. Treat tailings pond water and discharge.
3. Relocate tailings to north side of impoundment and cover with soil.
4. Remove South Dam and route Cache Creek and other diversions through a new constructed channel.
5. Seal underground openings.
6. Conduct post reclamation monitoring for 3 years.

The total cost was estimated to be $1,010,000, inclusive of the post reclamation monitoring and 20% contingency.

5.2.3 Brodie Consulting Ltd. 1998

This closure plan and estimate was based largely on the work described in the 1994/96 closure plan using the 1996 contingency plan for the tailings impoundment. Updated and, in some cases, more detailed costs were provided.

The total cost was estimated at $1,207,000, inclusive of a 5-year post reclamation monitoring program and 25% contingency.

5.3 Updated Liability Cost Assessment

5.3.1 Overview

As noted previously, DIAND has requested that an updated environmental liability assessment for the site be prepared. For this assessment, it has been determined that an estimate of the costs required to close this mine site is required. Within a mine closure cost estimate, there are several different components that can be summed up into a total cost item as follows:

1. Direct consulting and engineering costs relative to technical studies required for planning and the development of an "approved" closure plan.
2. Direct capital cost of construction works required for closure of the site.
3. Indirect costs related to closure plan development (stakeholder consultation, permitting, etc.) and construction implementation (construction road access, camp accommodations for workers, etc.).
4. On-going monitoring and surveillance costs (sometimes referred to as post-closure costs).
5. Project management and cost control related to the entire closure process.

Cost estimates can typically be provided for components #1, #2 and #4 (above) to a level of confidence appropriate to the amount and quality of information that is available. Cost estimates for components #3 and #4 (above) can be more difficult to estimate as they are often influenced by events beyond the control of the owner/operator. For the Ketza River mine site, the indirect costs referred to in components #3 and #5 (above) may be significant, given the remote location and the community concerns.

The common approach to estimating closure costs is a deterministic approach that provides a single value cost estimate. This is the approach that was taken for the previous closure cost estimates described above and for the current cost estimate. An estimated deterministic cost should be interpreted in light of the limitations and assumptions inherent in the method. Even if an extensive amount of site investigation, characterization and design was undertaken (which is not the case for the current liability estimate), it is likely that the actual closure cost will be significantly different due to unforeseen changes in quantities and complexities of scheduling inter-related activities and measures. This is typically recognized by the application of a general contingency factor, as has been done for the previous and the current cost estimates for the Ketza River mine. A more sophisticated approach to cost estimation (a probabilistic approach) is being adopted by the industry that can consider a range of estimated costs on a probabilistic basis and provide a best estimate value with upper and lower confidence bounds. The probabilistic approach would be recommended for future estimation of closure costs for the Ketza River mine site when additional detailed site characterization information and required design standards are available.

The design criteria used for design of the various structures and for clean-up of the various facilities is a critical component of closure cost estimates. For the current liability assessment, assumptions have been made in this regard (described in subsequent sections) that would be evaluated and finalized using a risk-based approach prior to a detailed cost estimating process. A partial list of some of design criteria that will be required are as follows:

1. Seismic loading for earth structures (extreme criteria referred to as the Maximum Credible Earthquake or MCE).
2. Hydrological event sizing of design of water diversion/retention structures (extreme criteria referred to as Probable Maximum Flood or PMF).
3. Site-specific water quality criteria used for effluent discharge and/or receiving water.
4. Site-specific soil remediation criteria used for the clean-up of hydrocarbon and metals at contaminated areas of the mine.

The current liability cost assessment provided herein should be considered to be conceptual in nature. The selection of the appropriate closure measures is based on the extension of previously developed measures, generally vetted against the appropriateness and cost-effectiveness of each measure. For example, flooding of the tailings and retention of a pond over the tailings in the long term is not deemed to be an appropriate closure measure due to the high environmental and cost risks associated with maintenance of a water retaining dam as compared to draining the tailings pond and breaching the dam. For each of the primary closure activities, a preliminary estimate of quantities was developed based on the available information. Except for the proposed toe berm on the North Dam where some preliminary work has been done, no engineering analyses have been undertaken to design the structures or activities. Estimated unit rates were then applied to the estimated quantities and extended in order to derive the total estimated cost for each of the primary closure activities.

In addition to these considerations, the following limitations on the cost estimate should be noted:

1. No linking of construction activities or consideration for temporary measures has been undertaken.
2. No assessment of the appropriate construction equipment sizing, and their compatibility with one another has been undertaken.
3. No detailed assessment of site access and construction requirements (camp accommodations, fuel supplies, etc.) has been undertaken.

5.3.2 Unit Costs

The unit costs used for the current liability assessment were determined based on the following principles:

1. Recent and direct local (Yukon and other northern mines) experience of the project team.
2. Consideration of previous estimates.
3. Conservative approach intended to provide "high-end" estimates.

A comparison of unit costs for the primary work items for the three previous closure plans and the current liability assessment are listed in Table 5.1 for corresponding work tasks.

Table 5.1: Comparison of Unit Costs for Closure Work

ITEM	WRM/SRK, 1994/96	Brodie 1998	GLL/BGC 2002	Comment re. 2002 useage
geotextile, placed	$2/m2	-	-	
rip rap, placed	$20/m3	$10.92/m3	$30/m3	drill/blast/screen/haul
bulk soil excavation	$5/m3	$2.74/m3	$5/m3	short haul/dump
bulk rock excavation	$10/m3	-	$10/m3	no drill/blast req'd
granular fill	$5/m3	$8.45/m3	-	
soil fill	-	$6.54/m3	$10/m3	limited compaction
dam fill	-	$4.15/m3	-	
pipeline	$5/m	-	-	
dozer/excavator	$1,500/day	-	-	
cement cap, b.f. raise	$2,100 L.S.	$25,000 L.S.	$25,000 L.S.	
crane	$20,000/mo	-	-	
analysis (water?)	$200 each	-	see cost detail	
post closure inspection	$5,000 each	$100 each	see cost detail	
contouring	-	$2.67/m3	-	
relocation of tailings	-	$2.50/m3	$3.00/m3	within tailings impoundment
teardown and slabs, mill	-	$60/m2	$60/m2	
teardown and slabs, tanks/dry	-	$30/m2	$30/m2	
teardown, small	-	$5/m2	-	
revegetation	-	$1,100/ha	$1,100/ha	
chemicals	-	$8,000 L.S.	$250,000 L.S.	based on 2001 Hazco quote
water treatment plant	-	$50,000 L.S.	$100,000 L.S.	temporary or in-pond system
water treatment	-	$1.09/m3	$1.50/m3	
mob/contractor infrastructure	$79,000 L.S.	$51,000 L.S.	$100,000 L.S.	incl. accomm.

Table 5.1 shows significant variation among the previous and current unit costs, that is most pronounced for the following items:

1. Production and placement of rip rap (current unit rate based on current local experience).
2. Relocation of tailings (current unit rate based on estimates used for other local mines and general industry experience).
3. Relocation of hazardous materials off the site (current estimate based on 2001 site-specific quote from a specialist contractor).
4. Operating cost for the treatment of water (current unit rate is intended to be a conservative estimate based on general experience and consideration of the remote location and uncertainties regarding water treatability).

In addition to the above items, these unit costs for material movement and placement were used to develop costs per lineal metre of upgrading of diversion ditches as per the design drawings provided in the 1996 contingency plan for the tailings impoundment. The rates per lineal metre are based on an estimated channel width (for larger sized hydrological events), along with the placement of filter and rip rap layers as follows:

1. Subsidiary Creek diversion $100/m
2. Cache Creek diversion $500/m

5.3.3 Assessment of Closure Measures

The closure measures described in previous closure plans were reviewed and used to form the basis for the current assessment. Additional closure measures were also introduced into the assessment, where necessary, to ensure that the current assessment includes all relevant areas of environmental liability.

Assumptions

The current assessment is based on the following primary assumptions:

1. Piling and covering tailings with a simple soil cover will provide acceptable seepage water quality.
   This assumption is the basis of the 1996 contingency closure plan for the tailings impoundment (SRK) that was adopted for the current assessment. Brodie 1998 suggested that additional research was necessary to verify this assumption and such environmental studies have been incorporated into the current assessment.
2. An adequate supply of natural construction and covering materials are present on the mine site.
   The local availability of various natural materials of appropriate physical characteristics for the prescribed closure work has not been verified. This assumption is also implicit in the previous closure plans and such engineering studies are incorporated into the current assessment.
3. Treatment of pond water can be accomplished with conventional lime treatment.
   Reduction of aqueous arsenic and possibly other contaminants to the license discharge limits is assumed ,based on past performance of the treatment system. Treatability testing would be recommended prior to treatment as part of the environmental studies incorporated into the current assessment.
4. Camp trailers can be removed for re-use at no cost.
   The remaining bunkhouse trailers are assumed to be sold for re-use.
5. A new landfill can be permitted for construction debris.
   The current assessment assumes that on-site disposal of non-hazardous solid wastes will be allowed and permitted.
6. Project management, licensing and permitting work will be provided by DIAND (i.e. not costed herein).
   If these management functions cannot be performed directly by DIAND, then additional funding would be required for outsourcing.
7. Seepage from 1430 adit can be allowed to drain to Cache Creek.
   This assumption is also implicit in the previous closure plans. Some previous plans suggested routing seepage through a limestone trench, which is not considered to provide meaningful long-term benefit.

Closure Measures

The current assessment is based on the following primary closure measures:

1. Seal all openings to the underground mine at surface.
2. Backfill and cover open pits to minimize ponding of water.
3. Pull back the crests of some rock dumps to top where practical to reduce oversteepening.

4. Relocate scrap from the boneyard to the existing or new landfill.
5. Close the existing and new landfills (assumed 1.5 m soil cover).
6. Tear down all buildings and dispose of on-site (new landfill) except the bunkhouse trailers sold for re-use) and break concrete slabs to allow revegetation.
7. Remediate areas of contaminated soil by covering (1.5 m assumed) in-place.
8. Relocate tailings to north side of impoundment per the 1996 contingency plan.
9. Upgrade Subsidiary Creek diversion channel to pass water around the tailings pile.
10. Remove the Northwest diversion channel and allow runoff over the tailings pile.
11. Upgrade and relocate the Cache Creek diversion channel per the 1996 contingency plan.
12. Breach the South Dam and use the excavated soil to cover the tailings pile.
13. Construct a toe berm at the North Dam.
14. Treat the tailings pond water prior to or during pumping from the pond.
15. Remove residual chemicals and other wastes for disposal.
16. Reclaim roadways by removing culverts and contouring.
17. Upgrade and repair the mine access road to allow heavy equipment access.
18. Conduct environmental and engineering studies to support the closure activities.
19. Conduct a 7-year post-reclamation monitoring and monitoring program to include environmental and engineering functions.

5.3.4 Cost Estimate

The current assessment of liability cost is listed in Table 5.2 and totals $5,089,200, inclusive of a 7-year post reclamation monitoring program and a 20% contingency. Within that total, the largest single component cost relates to the closure plan for the tailings area. The next largest single cost item relates to the estimated costs for monitoring and maintenance over an expected period of seven years.

Table 5.3 lists the cost estimates for the previous closure plans and the current assessment. The current assessment is approximately five times greater than the next greatest estimate, which is due primarily to the following reasons:

1. Inclusion of an actual quotation cost for removal and disposal of hazardous chemicals and materials at site.
2. Inclusion of soil testing information and an estimate for remediation of contaminated soils.
3. Inclusion of updated unit costs (based, in part, on local Yukon experience) for material movement regarding the tailings impoundment.
4. Inclusion of substantial environmental and engineering studies in support of the closure activities.
5. Inclusion of updated costs for post reclamation monitoring (based, in part, on local Yukon experience).
6. Extension of the post reclamation monitoring period from 3 or 5 years to 7 years.

The largest increases in cost components relate to the tailings area and to the requirement for monitoring and maintenance in the seven-year post-closure period. The contingency amount has also increased significantly.

Table 5.2: Current Assessed Costs

Item	Description	Unit Cost		Quantity	Cost
Mine					
raise	cap	$25,000	L.S.	1	$25,000
portals	block with rockfill	$10	m^3	1000	$10,000
open pits	backfill and cover to prevent ponding	$10	m^3	2500	$25,000
buildings, tanks	tear down and slabs, scrap to landfill	$30	m^2	1000	$30,000
contaminated soil	see mill/camp				$0
rock dumps	pull back crests	$5	m^3	2000	$10,000
boneyard	scrap to landfill	$10	m^3	1000	$10,000
old landfill closure	contour and cover	$10	m^3	1000	$10,000
other	estimate	$10,000	L.S.	1	$10,000
sub total Mine					$130,000
Mill/Camp					
buildings (excl. camp), tanks	tear down and slabs, scrap to landfill	$60	m^2	8500	$510,000
contaminated soil	cover	$10	m^3	10000	$100,000
low grade stockpile	contour and cover	$10	m^3	6000	$60,000
camp trailers	salvage at no cost				$0
sewage lagoon	contour and cover	$10	m^3	500	$5,000
sub total Mill/Camp					$670,000
Tailings					
Subsidiary Creek	upgrade	$100	m	300	$30,000
Northwest Ditch	remove	$10,000	L.S.	1	$10,000
Cache Creek	upgrade	$500	m	400	$200,000
Relocate Tailings		$3.00	m^3	80000	$240,000
Cover Tailings		$10	m^3	75000	$750,000
Toe Buttress		$10	m^3	8500	$85,000
Breach S. Dam	costed under covering				
Water Treatment	pond water and porewater	$1.50	m^3	300000	$450,000
sub total Tailings					$1,765,000
Infrastructure					
access road	repair for heavy equipment access	$20,000	L.S.	1	$20,000
Roads/Culverts	remove culverts and reslope	$1,000	km	5	$5,000
Revegetation		$1,100	ha	10	$11,000
Chemicals/Reagents	removal and disposal	$250,000	L.S.	1	$250,000
Construct Water Treatment System		$100,000	L.S.	1	$100,000
New Landfill Closure	contour and cover	$10	m^3	1000	$10,000
sub total Infrastructure					$396,000
Other					
mob/contractor infrastructure		$100,000	L.S.	1	$100,000
Engineering and Env. Studies	arsenic mobility, hydrology, construction designs, risk assessment, stability investigations	$500,000	L.S.	1	$500,000
sub total Other					$600,000
Monitoring & Maintenance					
Install Monitoring Instrumentation	flow metres, piezometers, etc.	$50,000	L.S.	1	$50,000
Long Term Monitoring & Reporting	water qty and physical stability, data analysis and reporting	$75,000	yr	7	$525,000
Long Term Maintenance	repair ditches, covers, etc.	$15,000	yr	7	$105,000
Sub Total Monitoring & Maintenance					$680,000
Sub Total Capital Cost					**$4,241,000**
Contingency (20%)					$848,200
Total					**$5,089,200**

Table 5.3: Comparison of Previous Closure Costs ($'000's) with Current Assessed Cost

ITEM	Canamax 1987	WRM/SRK 1994/96	Brodie 1998	GLL/BGC 2002	Comments re. Significant Increases in 2002
Mine		18	56	130	incl. contour pits to prevent ponding
Mill/Camp		346	158	670	incl. cost for remediation of contaminated soil
Tailings		319	551	1765	updated costs and quantities
Infrastructure		44	8	396	incl. cost for removal of chemicals
Mob/Contractor Infrastructure		79	51	100	incl. accomm/camp requirement
Engineering and Env. Studies			30	500	delineate studies and eng. design requirements
Monitoring and Maintenance	3 yrs 150	3 yrs 44	5 yrs 90	7 yrs 680	increase to 7 yrs, higher annual cost
Contingency		20% 160	25% 263	20% 848	
Total Cost	**est. 400-650 $525**	**$1,010**	**$1,207**	**$5,089**	

6. Conclusions

The following conclusions can be drawn from the observations and information provided in this report.

Access

1. Public access to the mine facilities, into the interior of the mill building, the mine office and waste storage sites is unrestricted.
2. Several locations on the access road from the Robert Campbell Highway to the mine site are largely impassable to any but 4-wheel drive light vehicles.
3. It would not be possible to mobilize heavy equipment that might be required to respond to an environmental event directly to the mine site in the absence of substantial repairs to several locations (including a bridge crossing and several washouts) on the road.

Mine Openings

4. Public access to the underground workings is effectively prevented by timber bulkheads except for the 1510 ventilation adit, which appears to be blocked only by loose plywood.
5. The bulkeads are typically located approximately 5 to 10 m into the access drifts and public access into these entry areas is unrestricted.
6. Safety screening and rock bolting has resulted in loose rock and hanging blocks at the brows above each adit.
7. The 1510 backfill raise appears to have been filled to surface although no details regarding the method or extent of filling were identified.

Tailings Area

8. Several open holes on the crest of the North Dam were temporarily filled in October 2001 on an interim basis but will require further assessment and rehabilitation.
9. Water levels have not been recorded in recent years in piezometers (located in the dams) or in the tailings pond.
10. The Northwest Interceptor Ditch is in poor physical condition and is not achieving its design function.
11. The Cache Creek Diversion Ditch shows signs of creep failure and may not be able to achieve its design function without remediation.
12. The Lower Subsidiary Creek Diversion Ditch has been breached in the past and some remediation work is required.
13. The site visits of October 2001 and March 2002 indicate that the North and South Dams appear to be generally stable. However, the soft ground at the toe of the North Dam and the settlement troughs adjacent to two piezometers on the crest of the North Dam are areas of concern and should be further investigated.
14. A current stability analyses of the downstream slope of the North Dam indicates that this dam likely meets the required Factors of Safety for static and assumed seismic conditions but does not comment

on its liquefaction potential. Additional investigative and analytical work is required to confirm the parameters assumed for the stability analyses.

Waste Materials

15. Waste and hazardous materials are stored in various unsecured locations around the mine site that are publicly accessible.
16. The current cost for removal and off-site disposal of waste and hazardous materials is estimated to be in the order of $200,000.

Soil Quality

17. Surface soils throughout the mine facilities contain elevated concentrations of metals (especially arsenic) and hydrocarbons relative to generic guidelines.
18. Elevated contaminant concentrations are considered to be restricted to the near surface zone.
19. The development of Tier 2 or Tier 3 site-specific soil quality remediation objectives would be appropriate for this site.

Surface Water Quality

20. Surface water quality data during freshet is largely absent from the database in recent years.
21. The concentration of arsenic in the tailings pond has continued a decreasing trend since mine shut down in 1992.
22. In October 2001, a calculated 90% of the arsenic load in Cache Creek originated from the Cache Creek catchment upstream of Peel Creek and only 10% from Peel Creek.
23. In October 2001, a calculated 80% of the zinc load in Cache Creek originated from Peel Creek and only 20% from the Cache Creek catchment upstream of Peel Creek.

Community Involvement

24. The mine site has been identified as a traditional land use area for the Ross River Dena.
25. Community members utilize the area for hunting and have a continuing interest in environmental conditions at the mine site.

Liability Cost Estimate

26. The current liability cost estimate is $5.1 million, inclusive of a 7-year post reclamation monitoring and maintenance program and 20% contingency.
27. The current assessment is approximately five times greater than previous estimates due to the inclusion or expansion of work activities and the use of update unit costs.
28. The current assessment is conceptual in nature and is based variously on previously developed closure measures, assumed reclamation design parameters and assumed water and soil quality remediation objectives.

7. Recommendations

Recommendations specific to the tailings area and the stability assessment of the tailings dams are listed in Section 4.3.7 and are not repeated here in their entirety. In addition, the following recommendations are provided as potential means of reducing the short term, medium term and long term environmental risks at the mine site:

Short Term Reduction of Risk

1. Install a vehicle gate on the access road at the entrance to the mine site, install barricades at all entrances into the mill building and post safety signage.
   Unrestricted public access to waste materials has created a risk of their unauthorized distribution or disposal.
2. Perform repairs to the mine access road that would allow access to the mine site by heavy equipment that will be required to undertake recommended maintenance/monitoring and might be required to respond to a potential environmental event.
   Given the current condition of the road, delays in the mobilization of heavy equipment would result in delays to undertaking the recommended work and in reaction to environmental events.
3. Several settlement troughs, adjacent to piezometers on the dam crest, were backfilled on an interim basis in October 2001 and these settled areas need to be monitored and rehabilitated.
   Any additional settlement adjacent to dam instrumentation, or any other observed signs of deformation, may be indicative of deteriorating performance and assessment and remedial measures would need to be implemented as soon as possible. The temporary backfill should be supplemented with a more appropriate mix of sand and bentonite to prevent downward migration of surface water.
4. Conduct a site visit before the spring run-off of 2002 to conduct an inspection of the dam spillway and all diversion ditches and to collect surface water quality information.
   Accumulated snow, ice and frost-mobilized surface materials all have the potential to partially or completely block drainage diversion structures. In addition, freshet is a critical time period when maximum stress is placed on water retention dams and diversion ditches and when a large portion of the annual contaminant load is mobilized in surface water. Proactive assessment of potential blockages will significantly reduce the associated risks.
5. Repair work is required on the Northwest Interceptor Ditch and related channels and culverts proximal to the tailings area to maintain the design objective of the channel designs.
   The ditches (and associated culverts) have been identified as deficient and in need of maintenance and repair. Numerous erosional gullies below the Lower Subsidiary Creek should be backfilled and graded over.
6. Design and implement a schedule for routine site visits, including an annual inspection by a qualified professional geotechnical engineer, to observe the general condition of the mine facilities and to collect required instrumentation data, as well as to perform other maintenance activities.
   The documented deficiencies and risks regarding water control structures require routine inspection and instrumentation monitoring to determine their level of performance and to identify potential deteriorating conditions on these structures. It must be noted that any personnel tasked with

observing, monitoring and maintaining these facilities should be suitably trained and/or experienced to do so.

7. Install data recorders to record piezometric levels in both dams, seepage flows below both dams and the tailings pond water level.
   Detailed records and trends in piezometric levels, seepage quantities and pond water level are critical components of assessing the performance of the two dams at site. In addition, the information needs to be assessed within the context of an overall site water balance. This data can either be collected by personnel visiting the site on a regular basis or by remote data acquisition techniques and the results should be reviewed by a professional geotechnical engineer.
8. Involve the community of Ross River in the program of routine site visits in order to provide training and employment benefits to the local community and to provide a cost-effective program.
   Use of local equipment contractors and employees would require some training but would ultimately provide an efficient means of conducting site visits.
9. Develop an Emergency Response Plan (ERP) that would describe the procedures to be implemented on an emergency basis, should an environmental event occur.
   Given the remote nature of the site and the various possible events that could occur, an emergency response plan that would be distributed to all affected parties and agencies would be of benefit in ensuring a timely response to environmental events.

Medium Term Reduction of Risk

10. Conduct an Ecological and Human Health Risk Assessment.
    This standardized procedure would identify key environmental receptors and would provide site specific remediation objectives according to the procedures described in Federal Guidelines.
11. Install and monitor some thermistor cables proximal to the Cache Creek diversion channel.
    The backslope of this diversion channel is located in permafrost that is moving in response to thermal disturbance of the area. Installation of appropriate instrumentation and interpretation of the thermal regime will be required to determine an appropriate design for the long term closure of the channel.
12. Conduct a hydrological assessment of surface flows to re-assess the ability of the diversion ditches to achieve design objectives and to re-evaluate the site water balance.
    Additional site data (flows, water levels, precipitation, etc.) will be required to update the water balance to allow an assessment of current structures and to allow future remedial planning to proceed. In addition, this work will be required to determine the Inflow Design Flood (IDF) for the tailings area.
13. Conduct a Comprehensive Qualitative Risk Assessment ("QRA") of the mine facilities to document and prioritize possible failure modes according to likelihood and consequences.
    This methodology has been effectively applied for other local mine sites and represents a standardized and methodical approach to identifying and categorizing risks that can subsequently be utilized to develop action plans for risk reduction. This risk assessment could also quantify potential environmental costs and effects that may occur.
14. Maintain community involvement by including the community in planning meetings and distribution of information.

Community involvement will maintain access to local knowledge and information and will provide some benefit to the local community.

Long Term Reduction of Risk

15. Prepare a more detailed Abandonment and Restoration Plan complete with an Implementation Schedule and Cost Estimate.
    This should utilize previous work as a basis and may require research or additional on-site studies.
16. Implement the Abandonment and Restoration Plan.
    Remedial work would be approached on a priority basis focussing initially on the highest risk elements.

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Appendices

Appendix A

Listing of Waste and Hazardous Materials (from Gartner Lee Limited 2001)

Gartner Lee

Ketza River Mine Site – Phase 1 Environmental Site Investigation

Prepared For:
Ross River Dena Council and
DIAND Contaminants/Waste Program

Prepared By:
Gartner Lee Limited
Mehling Environmental Management Inc.
BGC Engineering Inc.
Sheila C. Greer

GLL 99-914

March, 2001

Distribution

2 *Ross River Dena Council*
10 *DIAND*
5 *Gartner Lee & Team*

Table 7.1: Summary of Hazardous and Non-Hazardous Wastes at Ketza River Mine Site

Location	Hazardous and Non-Hazardous Wastes
Mill Building	
Vehicle Repair Bays	• 4 industrial/vehicle batteries • 3 45-gallon drums of used oil • 1 45-gallon drum for gasoline (with hand pump)
Assay Labs	• 20 10L pails of Fire Assay Flux, containing: • 30% lead monoxide, 11.3% sodium carbonate, 3.8% sodium tetraborate, 5.6% silica, 1.9% florospar • 1 box soda ash • 1 box borax • 1 box nitre (potassium nitrate) • 1 small drum sodium tetraborate • sodium bicarbonate solution (for HF burns) • ½ bottle calcium sulfate • 2 pails ethyl alcohol Ganulite bicardium (Super R Grit) • Silica sand
Lower Level Mill Area/Powerhouse	• 2 empty(?) day-tanks for generators • 2 empty wooden crates for sodium cyanide
Upper Level Mill Area	• Empty HCl tank • Ferric sulphate tank with bottom sludge • 1 pallet of Percol flocculent bags (approx. 15 bags) • 2 45-gallon drums of caustic soda • small drum of lead nitrate • small drum of potassium permanganate • 1 oil drum near ore feed bin • 3 cans of Nordback (mill hardening)
Mill Yard	
South Mill Yard/Mill Boneyard	• Sulphur Dioxide Railcar Tank – Leaking • 5 electrical transformers – marked < 50 ppm PCBs • 1 unlabeled full 45-gallon drum in laydown area • 1 horizontal 45-gallon drum between repair bay doors • 2 unlabelled full 45-gallon drums beside bay doors • numerous drums of used mill balls
Assay Office Shed	• 6(?) 20 gallon pails of borax • 2 pails florospar • 1 pail soda ash • 1 amber bottled labeled waste pyridine • 2 tins of lead monoxide (Aarco) • 1 large carboy of "new standard flux"

Location	Hazardous and Non-Hazardous Wastes
Tank farm	• All 4 diesel storage tanks appear empty • ½ full 45-gallon fuel drum
Enclosed Mill Storage Shed	• 8 4L jugs of muriatic acid • 4 glass jugs of nitric acid in styrofoam crate • 1 partially full 20L pail of "Frostfree" compressed air line deicing fluid
Open Shed	• 4 55-gallon drums of potassium permanganate • 1 partially full 45-gallon drum labeled "Gas" • 1 horizontal 45-gallon diesel drum • 7 pallets of 25 kg bags of hydrated lime • 1 Caterpillar generator • 2 20L pails of engine oil • 1 partially full 45-gallon drum of gasoline or Jet B
Lubricant Storage Area	• 1 unmarked horizontal 45-gallon drum in "Antifreeze" area • 3 full 55kg drums of grease • 1 unlabelled 45-gallon drum • 2 empty modified household style ASTs • 24 sealed unmarked 45-gallon drums on pallets – from Imperial Oil, Esso, & PetroCanada • 1 20L pail of Varsol on cable spool platform • puddle of hardened grease under ball mill housing/guard
Tailings Pond	
Tailings Pond Storage Area	• 100 (approx.) empty or partially empty blue plastic 45-gallon sulphuric acid drums; • waste pile of coconut fiber; • 1 unopened crate of sodium cyanide; • 100 (approx.) drums of waste oil; • 1 pallet (12 5-gallon pails) of black plastic pails of hydrochloric acid; • 1 pallet of industrial (caterpillar) batteries; • 4 45-gallon drums of caustic soda (NaOH)

Appendix B

Analytical Data: Surface Water

ALS Environmental

Water

CHEMICAL ANALYSIS REPORT

Date: October 31, 2001

ALS File No. N6869

Report On: 21950 Water Analysis
Ketza River Mine

Report To: **Gartner Lee Ltd.**
4908 - 50th Ave
PO Box 98
Yellowknife, NWT
X1A 2N1

Attention: **Mr. Eric Denholm**

Received: October 16, 2001

ALS ENVIRONMENTAL
per:

Amber Springer

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REMARKS

The detection limits for some total and dissolved metals were increased for the samples reported due to interferences encountered during analysis.

For some of the submitted water samples, the measured concentration of specific dissolved parameters is greater than the corresponding total parameters concentration. The explanation for these findings is one or a combination of the following:

- laboratory method variability;
- field sampling method variability;
- bias introduced during general handling, storage, transportation and/or analysis of the sample;
- field sample grab bias - where separate grab samples are processed to produce total and dissolved samples;
- field sample split bias - where total and dissolved parameters samples are produced from the same grab sample.

For further clarification on any of the above information, please contact your ALS representative.

File No. N6869

RESULTS OF ANALYSIS - Water

Sample ID			SW01	SW02	SW03
Sample Date			01 10 10	01 10 10	01 10 10
ALS ID			*1*	*2*	*3*
Physical Tests					
Hardness	CaCO3		293	277	-
Total Suspended Solids			<3	<3	16
Dissolved Anions					
Sulphate	SO4		158	108	309
Nutrients					
Ammonia Nitrogen		N	0.010	0.009	0.005

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.

File No. N6869

RESULTS OF ANALYSIS - Water

ALS

Sample ID		SW01	SW02	SW03	SW04	SW05
Sample Date		01 10 10	01 10 10	01 10 10	01 10 11	01 10 11
ALS ID		*1*	*2*	*3*	*4*	*5*
Total Metals						
Aluminum	T-Al	0.542	0.001	1.30	10.8	0.185
Antimony	T-Sb	0.0010	0.0002	0.0002	0.042	<0.0001
Arsenic	T-As	0.158	0.0077	0.0533	22.7	0.0024
Barium	T-Ba	0.0290	0.0125	0.0115	0.120	0.00277
Beryllium	T-Be	<0.0005	<0.0005	<0.0005	<0.005	<0.0005
Bismuth	T-Bi	0.0007	<0.0005	<0.0005	0.134	<0.0005
Boron	T-B	<0.01	<0.01	<0.01	<0.1	<0.01
Cadmium	T-Cd	0.00023	<0.00005	0.00059	0.0167	0.00029
Calcium	T-Ca	86.2	73.1	115	778	37.3
Chromium	T-Cr	0.0064	<0.0005	<0.0005	0.015	<0.0005
Cobalt	T-Co	0.0098	<0.0001	0.0485	0.026	0.0064
Copper	T-Cu	0.0042	0.0002	0.0046	0.394	0.0013
Iron	T-Fe	1.99	<0.03	5.56	124	0.20
Lead	T-Pb	0.00654	<0.00005	0.00035	0.912	0.00016
Lithium	T-Li	<0.005	<0.005	<0.005	<0.05	<0.005
Magnesium	T-Mg	23.5	22.1	26.9	29.1	15.6
Manganese	T-Mn	0.0985	0.00575	0.319	2.33	0.108
Molybdenum	T-Mo	0.00029	0.00035	0.00010	0.0029	0.00012
Nickel	T-Ni	0.0081	<0.0005	0.0322	0.054	0.0277
Phosphorus	T-P	<0.3	<0.3	<0.3	0.4	<0.3
Potassium	T-K	<2	<2	<2	3	<2
Selenium	T-Se	<0.001	<0.001	<0.001	<0.01	<0.001
Silicon	T-Si	3.26	2.18	4.73	19.7	1.05
Silver	T-Ag	0.00004	<0.00001	<0.00001	0.0030	<0.00001
Sodium	T-Na	<2	<2	<2	<2	<2
Strontium	T-Sr	0.194	0.185	0.270	1.92	0.0954
Thallium	T-Tl	<0.0001	<0.0001	<0.0001	<0.001	<0.0001
Tin	T-Sn	0.0003	<0.0001	<0.0001	0.003	<0.0001
Titanium	T-Ti	0.02	<0.01	<0.01	0.23	<0.01
Uranium	T-U	0.00206	0.00229	0.00110	0.0114	0.00116
Vanadium	T-V	<0.001	<0.001	<0.001	0.01	<0.001
Zinc	T-Zn	0.073	<0.001	0.185	1.03	0.022

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File No. N6869

RESULTS OF ANALYSIS - Water

Sample ID		SW01	SW02	SW03	SW04	SW05
Sample Date		01 10 10	01 10 10	01 10 10	01 10 11	01 10 11
ALS ID		*1*	*2*	*3*	*4*	*5*
Dissolved Metals						
Aluminum	D-Al	0.113	0.002	0.018	<0.01	0.129
Antimony	D-Sb	0.0002	0.0002	0.0002	<0.001	<0.0001
Arsenic	D-As	0.0071	0.0086	0.0016	0.266	0.0017
Barium	D-Ba	0.0112	0.0136	0.0106	0.0033	0.00266
Beryllium	D-Be	<0.0005	<0.0005	<0.0005	<0.005	<0.0005
Bismuth	D-Bi	<0.0005	<0.0005	<0.0005	<0.005	<0.0005
Boron	D-B	<0.01	<0.01	<0.01	<0.1	<0.01
Cadmium	D-Cd	0.00007	<0.00005	0.00042	<0.0005	0.00027
Calcium	D-Ca	79.9	74.0	115	125	37.3
Chromium	D-Cr	<0.0005	<0.0005	<0.0005	<0.005	<0.0005
Cobalt	D-Co	0.0086	<0.0001	0.0487	<0.001	0.0064
Copper	D-Cu	0.0045	0.0003	0.0003	<0.001	0.0012
Iron	D-Fe	0.15	<0.03	<0.03	<0.03	0.09
Lead	D-Pb	0.00019	0.00007	<0.00005	<0.0005	0.00011
Lithium	D-Li	<0.005	<0.005	<0.005	<0.05	<0.005
Magnesium	D-Mg	22.6	22.4	27.3	17.1	15.6
Manganese	D-Mn	0.0651	0.00582	0.326	0.0267	0.109
Molybdenum	D-Mo	0.00028	0.00036	0.00009	<0.0005	0.00013
Nickel	D-Ni	0.0059	<0.0005	0.0324	<0.005	0.0281
Phosphorus	D-P	<0.3	<0.3	<0.3	<0.3	<0.3
Potassium	D-K	<2	<2	<2	<2	<2
Selenium	D-Se	<0.001	0.001	<0.001	<0.01	<0.001
Silicon	D-Si	2.55	2.22	3.99	4.70	1.02
Silver	D-Ag	<0.00001	<0.00001	<0.00001	<0.0001	<0.00001
Sodium	D-Na	<2	<2	<2	<2	<2
Strontium	D-Sr	0.188	0.192	0.276	0.255	0.0957
Thallium	D-Tl	<0.0001	<0.0001	<0.0001	<0.001	<0.0001
Tin	D-Sn	<0.0001	<0.0001	<0.0001	<0.001	<0.0001
Titanium	D-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	D-U	0.00194	0.00231	0.00085	0.0034	0.00109
Vanadium	D-V	<0.001	<0.001	<0.001	<0.01	<0.001
Zinc	D-Zn	0.016	0.004	0.125	<0.01	0.020

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File No. N6869

RESULTS OF ANALYSIS - Water

Sample ID			SW06	SW08	SW09
Sample Date			01 10 11	01 10 11	01 10 11
ALS ID			*6*	*8*	*9*
Physical Tests					
Hardness	CaCO3		277	-	245
Total Suspended Solids			-	5	<3
Dissolved Anions					
Sulphate	SO4		110	176	92
Nutrients					
Ammonia Nitrogen		N	-	0.007	<0.005

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File No. N6869

RESULTS OF ANALYSIS - Water

Sample ID		SW06	SW07	SW08	SW09	SW10
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*6*	*7*	*8*	*9*	*10*
Total Metals						
Aluminum	T-Al	0.018	<0.005	0.023	<0.005	<0.005
Antimony	T-Sb	0.0003	<0.0005	<0.0005	<0.0005	<0.0005
Arsenic	T-As	0.0160	0.0495	0.0081	0.0161	0.0132
Barium	T-Ba	0.00766	0.0062	0.0122	0.0085	0.0077
Beryllium	T-Be	<0.0005	<0.003	<0.003	<0.003	<0.003
Bismuth	T-Bi	<0.0005	<0.003	<0.003	<0.003	<0.003
Boron	T-B	<0.01	<0.05	<0.05	<0.05	<0.05
Cadmium	T-Cd	<0.00005	<0.0003	<0.0003	<0.0003	<0.0003
Calcium	T-Ca	81.2	88.8	129	65.5	73.3
Chromium	T-Cr	<0.0005	<0.003	<0.003	<0.003	<0.003
Cobalt	T-Co	<0.0001	0.0018	0.0006	<0.0005	<0.0005
Copper	T-Cu	0.0002	0.0010	<0.0005	<0.0005	<0.0005
Iron	T-Fe	<0.03	<0.03	0.05	<0.03	<0.03
Lead	T-Pb	0.00012	<0.0003	0.0003	0.0003	<0.0003
Lithium	T-Li	<0.005	<0.03	<0.03	<0.03	<0.03
Magnesium	T-Mg	17.1	13.7	15.8	17.3	16.4
Manganese	T-Mn	0.0230	0.386	0.0047	0.0006	0.0005
Molybdenum	T-Mo	0.00027	0.0014	0.0005	0.0003	<0.0003
Nickel	T-Ni	<0.0005	<0.003	<0.003	<0.003	<0.003
Phosphorus	T-P	<0.3	<0.3	<0.3	<0.3	<0.3
Potassium	T-K	<2	<2	2	<2	<2
Selenium	T-Se	<0.001	<0.005	<0.005	<0.005	<0.005
Silicon	T-Si	2.21	2.37	3.30	1.83	1.87
Silver	T-Ag	<0.00001	0.00006	<0.00005	<0.00005	<0.00005
Sodium	T-Na	<2	5	3	<2	<2
Strontium	T-Sr	0.168	0.203	0.262	0.160	0.180
Thallium	T-Tl	<0.0001	<0.0005	<0.0005	<0.0005	<0.0005
Tin	T-Sn	<0.0001	<0.0005	<0.0005	<0.0005	<0.0005
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.00163	0.00143	0.00105	0.00216	0.00182
Vanadium	T-V	<0.001	<0.005	<0.005	<0.005	<0.005
Zinc	T-Zn	<0.001	<0.005	<0.005	<0.005	<0.005

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File No. N6869

RESULTS OF ANALYSIS - Water

Sample ID		SW06	SW08	SW09	SW10
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*6*	*8*	*9*	*10*
Dissolved Metals					
Aluminum	D-Al	0.003	<0.005	<0.005	<0.005
Antimony	D-Sb	0.0003	<0.0005	<0.0005	<0.0005
Arsenic	D-As	0.0160	0.0064	0.0156	0.0141
Barium	D-Ba	0.00714	0.0120	0.0082	0.0072
Beryllium	D-Be	<0.0005	<0.003	<0.003	<0.003
Bismuth	D-Bi	<0.0005	<0.003	<0.003	<0.003
Boron	D-B	<0.01	<0.05	<0.05	<0.05
Cadmium	D-Cd	<0.00005	<0.0003	<0.0003	<0.0003
Calcium	D-Ca	82.2	125	68.1	74.6
Chromium	D-Cr	<0.0005	<0.003	<0.003	<0.003
Cobalt	D-Co	<0.0001	0.0005	<0.0005	<0.0005
Copper	D-Cu	0.0002	<0.0005	<0.0005	<0.0005
Iron	D-Fe	<0.03	<0.03	<0.03	<0.03
Lead	D-Pb	<0.00005	<0.0003	<0.0003	<0.0003
Lithium	D-Li	<0.005	<0.03	<0.03	<0.03
Magnesium	D-Mg	17.4	16.2	18.1	16.7
Manganese	D-Mn	0.0215	0.0024	<0.0003	<0.0003
Molybdenum	D-Mo	0.00027	0.0006	<0.0003	<0.0003
Nickel	D-Ni	<0.0005	<0.003	<0.003	<0.003
Phosphorus	D-P	<0.3	<0.3	<0.3	<0.3
Potassium	D-K	<2	<2	<2	<2
Selenium	D-Se	<0.001	<0.005	<0.005	<0.005
Silicon	D-Si	2.21	3.31	1.91	1.92
Silver	D-Ag	<0.00001	<0.00005	<0.00005	<0.00005
Sodium	D-Na	<2	3	<2	<2
Strontium	D-Sr	0.169	0.244	0.152	0.176
Thallium	D-Tl	<0.0001	<0.0005	<0.0005	<0.0005
Tin	D-Sn	<0.0001	<0.0005	<0.0005	<0.0005
Titanium	D-Ti	<0.01	<0.01	<0.01	<0.01
Uranium	D-U	0.00159	0.00095	0.00203	0.00176
Vanadium	D-V	<0.001	<0.005	<0.005	<0.005
Zinc	D-Zn	<0.001	<0.005	<0.005	<0.005

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EPH10-19 is equivalent to EHw10-19.

File No. N6869

RESULTS OF ANALYSIS - Water

Sample ID			SW11	SW14
Sample Date			01 10 11	01 10 11
ALS ID			*11*	*14*
Physical Tests				
Hardness	CaCO3		-	-
Total Suspended Solids			<3	5
Dissolved Anions				
Sulphate	SO4		130	7
Nutrients				
Ammonia Nitrogen		N	0.013	0.055
Cyanides				
Total Cyanide	CN		<0.005	-

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File No. N6869

RESULTS OF ANALYSIS - Water

Sample ID		SW11	SW12	SW13	SW14	SEEP-5
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 12
ALS ID		*11*	*12*	*13*	*14*	*15*
Total Metals						
Aluminum	T-Al	0.005	<0.005	0.018	0.061	0.652
Antimony	T-Sb	0.0014	<0.0005	<0.0005	0.0006	<0.0005
Arsenic	T-As	0.706	0.0261	0.0385	0.107	0.0112
Barium	T-Ba	0.0055	0.0071	0.0078	0.0304	0.0169
Beryllium	T-Be	<0.003	<0.003	<0.003	<0.003	<0.003
Bismuth	T-Bi	<0.003	<0.003	<0.003	<0.003	<0.003
Boron	T-B	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	T-Cd	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Calcium	T-Ca	75.8	89.7	108	25.3	170
Chromium	T-Cr	<0.003	<0.003	<0.003	<0.003	<0.003
Cobalt	T-Co	<0.0005	<0.0005	<0.0005	0.0006	<0.0005
Copper	T-Cu	0.0011	<0.0005	<0.0005	0.0302	0.0010
Iron	T-Fe	0.04	<0.03	0.03	0.17	<0.03
Lead	T-Pb	<0.0003	<0.0003	<0.0003	0.0009	<0.0003
Lithium	T-Li	<0.03	<0.03	<0.03	<0.03	<0.03
Magnesium	T-Mg	12.9	10.1	11.3	1.0	15.5
Manganese	T-Mn	0.0102	0.0040	0.0017	0.0061	0.0347
Molybdenum	T-Mo	0.0005	<0.0003	<0.0003	0.0014	<0.0003
Nickel	T-Ni	<0.003	<0.003	<0.003	0.003	0.004
Phosphorus	T-P	<0.3	<0.3	<0.3	<0.3	<0.3
Potassium	T-K	<2	<2	<2	<2	<2
Selenium	T-Se	<0.005	<0.005	<0.005	<0.005	<0.005
Silicon	T-Si	2.06	3.12	3.37	2.14	3.95
Silver	T-Ag	<0.00005	<0.00005	<0.00005	0.00012	<0.00005
Sodium	T-Na	3	3	<2	<2	5
Strontium	T-Sr	0.213	0.226	0.186	0.0762	0.502
Thallium	T-Tl	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Tin	T-Sn	<0.0005	<0.0005	<0.0005	<0.0005	<0.005
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.00134	0.00099	0.00119	0.00081	0.00119
Vanadium	T-V	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	T-Zn	<0.005	<0.005	<0.005	0.012	0.010

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File No. N6869

RESULTS OF ANALYSIS - Water

Sample ID		SW11	SW13	SEEP-5
Sample Date		01 10 11	01 10 11	01 10 12
ALS ID		*11*	*13*	*15*
Dissolved Metals				
Aluminum	D-Al	<0.005	<0.005	-
Antimony	D-Sb	0.0014	<0.0005	-
Arsenic	D-As	0.693	0.0397	-
Barium	D-Ba	0.0057	0.0073	-
Beryllium	D-Be	<0.003	<0.003	-
Bismuth	D-Bi	<0.003	<0.003	-
Boron	D-B	<0.05	<0.05	-
Cadmium	D-Cd	<0.0003	<0.0003	-
Calcium	D-Ca	78.9	108	-
Chromium	D-Cr	<0.003	<0.003	-
Cobalt	D-Co	<0.0005	<0.0005	-
Copper	D-Cu	0.0011	<0.0005	-
Iron	D-Fe	<0.03	<0.03	-
Lead	D-Pb	<0.0003	<0.0003	-
Lithium	D-Li	<0.03	<0.03	-
Magnesium	D-Mg	13.3	11.4	-
Manganese	D-Mn	0.0061	0.0006	-
Molybdenum	D-Mo	0.0005	<0.0003	-
Nickel	D-Ni	<0.003	<0.003	-
Phosphorus	D-P	<0.3	<0.3	-
Potassium	D-K	<2	<2	-
Selenium	D-Se	<0.005	<0.005	-
Silicon	D-Si	2.13	3.38	-
Silver	D-Ag	<0.00005	<0.00005	-
Sodium	D-Na	3	<2	-
Strontium	D-Sr	0.207	0.187	-
Thallium	D-Tl	<0.0005	<0.0005	-
Tin	D-Sn	<0.0005	<0.0005	-
Titanium	D-Ti	<0.01	<0.01	-
Uranium	D-U	0.00131	0.00117	-
Vanadium	D-V	<0.005	<0.005	-
Zinc	D-Zn	<0.005	<0.005	-
Extractable Hydrocarbons				
EPH10-19		-	-	<0.3
EPH19-32		-	-	<1

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Appendix 1 - METHODOLOGY

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

Solids in Water

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total dissolved solids (TDS) and total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius, TSS is determined by drying the filter at 104 degrees celsius. Total solids are determined by evaporating a sample to dryness at 104 degrees celsius. Fixed and volatile solids are determined by igniting a dried sample residue at 550 degrees celsius.

Recommended Holding Time:

Sample: 7 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Sulphate In Water

This analysis is carried out using procedures adapted from APHA Method 4500-SO4 "Sulphate". Sulphate is determined using the turbidimetric method.

Recommended Holding Time:

Sample: 28 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Ammonia in Water by Colourimetry

This analysis is carried out, on unpreserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using the phenate colourimetric method.

Recommended Holding Time:

Sample: 1 day
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Appendix 1 - METHODOLOGY - Continued

Metals In Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:

Sample:	6 months
Reference:	EPA
For more detail see:	ALS "Collection & Sampling Guide"

Cyanide Species in Water

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide and weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method. Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode. Thiocyanate is determined by the ferric nitrate colourimetric method.

Recommended Holding Time:

Sample: 14 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Extractable Hydrocarbons In Water

This analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Water by GC/FID" (Version 2.1, July 1999). The procedure involves extraction of the entire water sample with dichloromethane. The extract is then solvent exchanged to toluene and analysed by capillary column gas chromatography with flame ionization detection (GC/FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

Recommended Holding Time:

Sample: 7 days   Extract: 40 days
Reference: BCMELP
For more detail see ALS Environmental "Collection & Sampling Guide"

End Of Report

CLIENT: ~~GLL~~ Gartner Lee Limited
ADDRESS: PO Box 98, 4908-50th Ave.
CITY: Yellowknife PROV.: NT POSTAL CODE: X1A 2N1
CONTACT: Eric Denholm SAMPLER: E. Denholm / Di Li
TELEPHONE: 867-873-5808 FAX: 867-873-4453
PROJECT NAME/NO.: Ketza River Mine
P.O. NO.: 21950 QUOTE NO.: —
DATE SUBMITTED: ALS CONTACT:

ALS

ALS Environmental

1988 Triumph Street
Vancouver, BC
Canada V5L 1K5
TEL: 604-253-4188
TOLL FREE: 1-800-665-0243
FAX: 604-253-6700
www.alsenviro.com

LAB USE ONLY: N6869

FOR LAB USE ONLY

SAMPLE IDENTIFICATION	Y	M	D	TIME	MATRIX	NOTES
SW 01	01	10	10	__:__ AM/PM	Water	
SW 02	01	10	10	__:__ AM/PM		
SW 03	01	10	10	__:__ AM/PM		
SW 04	01	10	11	__:__ AM/PM		
SW 05	01	10	11	__:__ AM/PM		
SW 06	01	10	11	__:__ AM/PM		
SW 07	01	10	11	__:__ AM/PM		
SW 08	01	10	11	__:__ AM/PM		
SW 09	01	10	11	__:__ AM/PM		
SW 10	01	10	11	__:__ AM/PM		
SW 11	01	10	11	__:__ AM/PM		
SW 12	01	10	11	__:__ AM/PM		
SW 13	01	10	11	__:__ AM/PM		
SW 14	01	10	11	__:__ AM/PM		
SEEP-5	01	10	12	__:__ AM/PM		
				__:__ AM/PM		

T.B.A.

TURN AROUND REQUIRED:
☑ ROUTINE (7 - 10 WORKING DAYS) ☐ RUSH (SPECIFY DATE): ______
SPECIAL INSTRUCTIONS (BILLING DETAILS, QC REPORTING, ETC.):

RELIQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME
	DATE: TIME:		DATE: TIME:
	DATE: TIME:	CP	DATE: 01/10/16 TIME: 1035

FOR LAB USE ONLY

COOLER SEAL INTACT UPON RECEIPT? ☐ YES ☐ NO ☐ N/A

SAMPLE TEMPERATURE UPON RECEIPT: 7 °C
FROZEN? ☐ YES ☐ NO

ALS COPY

SEE WHITE PAPER OC SOURCE VERSI

TSS/02

Appendix C

Analytical Data: Soil

ALS Environmental

CHEMICAL ANALYSIS REPORT

Soil

Date: November 20, 2001

ALS File No. N7040

Report On: 21950 Soil Analysis

Report To: **Gartner Lee Ltd.**
4908 - 50th Ave
PO Box 98
Yellowknife, NWT
X1A 2N1

Attention: **Mr. Eric Denholm**

Received: October 16, 2001

ALS ENVIRONMENTAL
per:

Amber Springer, B.Sc. - Project Chemist
Brent C. Mack, B.Sc. - Project Chemist

AURORA LABORATORY SERVICES LTD.
1988 Triumph Street, Vancouver, BC Canada V5L 1K5
Phone: 604-253-4188 Fax: 604-253-6700 Website: www.alsenviro.com

File No. N7040

REMARKS

Please note the detection limits for certain Total Metals have been increased for the sample identified as 'Mill Assay' due to the high level of Total Arsenic in the sample. As well, the detection limits for Extractable Hydrocarbons have been increased for the sample identified as 'TP25 0.3m' due to the high moisture content of the sample.

File No. N7040

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-1 0-0.3	TP01-1 1.0-1.1	TP01-2 0-0.3	TP01-2 0.4-0.6	TP01-3 0-0.3
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*1*	*2*	*3*	*4*	*5*
Physical Tests						
Moisture	%	10.9	44.9	8.6	8.5	17.0
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	856	1410	511	544	449
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

File No. N7040

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-3 1.1-1.3	TP01-4 0-0.3	TP01-4 0.3-0.5	TP01-5 0-0.1	TP01-5 0.2-0.3
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*6*	*7*	*8*	*9*	*10*
Physical Tests						
Moisture	%	9.9	64.4	29.8	26.4	49.1
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	267	92	273	1660	1010
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

File No. N7040

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-6 0-0.3	TP01-6 0.3-0.6	TP01-6 0.6-0.9	TP01-7 0-0.3	TP01-7 0.3-0.6
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*11*	*12*	*13*	*14*	*15*
Physical Tests						
Moisture	%	12.1	7.2	8.3	8.5	6.1
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	1990	564	1580	634	190
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

File No. N7040

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-7 0.6-0.9	TP01-8 0-0.3	TP01-8 0.3-0.6	TP01-8 0.6-0.9	TP01-9 0-0.3
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*16*	*17*	*18*	*19*	*20*
Physical Tests						
Moisture	%	6.2	12.9	7.6	7.9	12.6
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	279	6700	712	434	4090
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

File No. N7040

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-9 0.3-0.6	TP01-9 0.6-0.9	TP01-10 0-0.1	TP01-10 0.1-0.4	TP01-10 0.4-0.7
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*21*	*22*	*23*	*24*	*25*
Physical Tests						
Moisture	%	8.4	7.9	9.5	7.7	8.3
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	351	260	1880	279	879
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

File No. N7040

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-11 0-0.1	TP01-11 0.1-0.4	TP01-11 0.4-0.7	TP01-12 0-0.3	TP01-12 0.3-0.6
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*26*	*27*	*28*	*29*	*30*
Physical Tests						
Moisture	%	12.3	7.0	8.0	8.6	6.9
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	1390	511	331	310	284
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-12 0.6-0.9	TP01-13 0-0.1	TP01-13 0.1-0.4	TP01-13 0.4-0.7	TP01-13 0.7-1.0
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*31*	*32*	*33*	*34*	*35*
Physical Tests						
Moisture	%	7.9	11.7	9.0	8.6	9.3
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	277	9480	1270	782	745
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-
Extractable Hydrocarbons						
EPH10-19		-	2220	428	1240	2270
EPH19-32		-	555	<200	<200	<200

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

File No. N7040

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-14 0-0.3	TP01-14 0.3-0.6	TP01-14 0.6-0.9	TP01-15 0-0.3	TP01-15 0.3-0.6
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 11
ALS ID		*36*	*37*	*38*	*39*	*40*
Physical Tests						
Moisture	%	14.0	7.8	9.2	8.8	6.2
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	8270	1040	408	1200	1260
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

File No. N7040

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-15 0.6-0.9	TP01-16 0-0.2	TP01-16 0.2-0.5	TP01-16 0.5-0.8	TP01-17 0-0.1
Sample Date		01 10 11	01 10 11	01 10 11	01 10 11	01 10 12
ALS ID		*41*	*42*	*43*	*44*	*45*
Physical Tests						
Moisture	%	6.5	7.2	6.8	8.7	9.7
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	247	2620	656	256	9730
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		TP01-17 0.1-0.4	TP01-17 0.4-0.7	TP01-18 0.05-0.3	TP01-18 0.3-0.6	TP01-18 0.6-0.85
Sample Date		01 10 12	01 10 12	01 10 12	01 10 12	01 10 12
ALS ID		*46*	*47*	*48*	*49*	*50*
Physical Tests						
Moisture	%	8.0	7.4	6.4	7.5	6.8
pH		-	-	-	-	-
Total Metals						
Antimony	T-Sb	-	-	-	-	-
Arsenic	T-As	880	377	571	257	274
Barium	T-Ba	-	-	-	-	-
Beryllium	T-Be	-	-	-	-	-
Cadmium	T-Cd	-	-	-	-	-
Chromium	T-Cr	-	-	-	-	-
Cobalt	T-Co	-	-	-	-	-
Copper	T-Cu	-	-	-	-	-
Lead	T-Pb	-	-	-	-	-
Mercury	T-Hg	-	-	-	-	-
Molybdenum	T-Mo	-	-	-	-	-
Nickel	T-Ni	-	-	-	-	-
Selenium	T-Se	-	-	-	-	-
Silver	T-Ag	-	-	-	-	-
Tin	T-Sn	-	-	-	-	-
Vanadium	T-V	-	-	-	-	-
Zinc	T-Zn	-	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

Gartner Lee Limited

Environmental Services for Industry & Government

Vancouver • Toronto • Whitehorse Yellowknife • St. Catharines

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

Tel: (867) 873-5808 • Email: edenholm@gartnerlee.com • Website: www.gartnerlee.com

# Pages	~~30~~ (total)	**Date:**	June 1, 2002
To:	Pam Vust	**To Fax:**	GLL – Whitehorse
From:	Eric Denholm	**From Fax:**	(867) 873-4453

~~Hi,~~ Pam

Remainder of ~~Attached is~~ Appendix C for the Ketza River Report "Analytical Results: Soil"

Eric D.

For more detail see ALS Environmental "Collection & Sampling Guide"

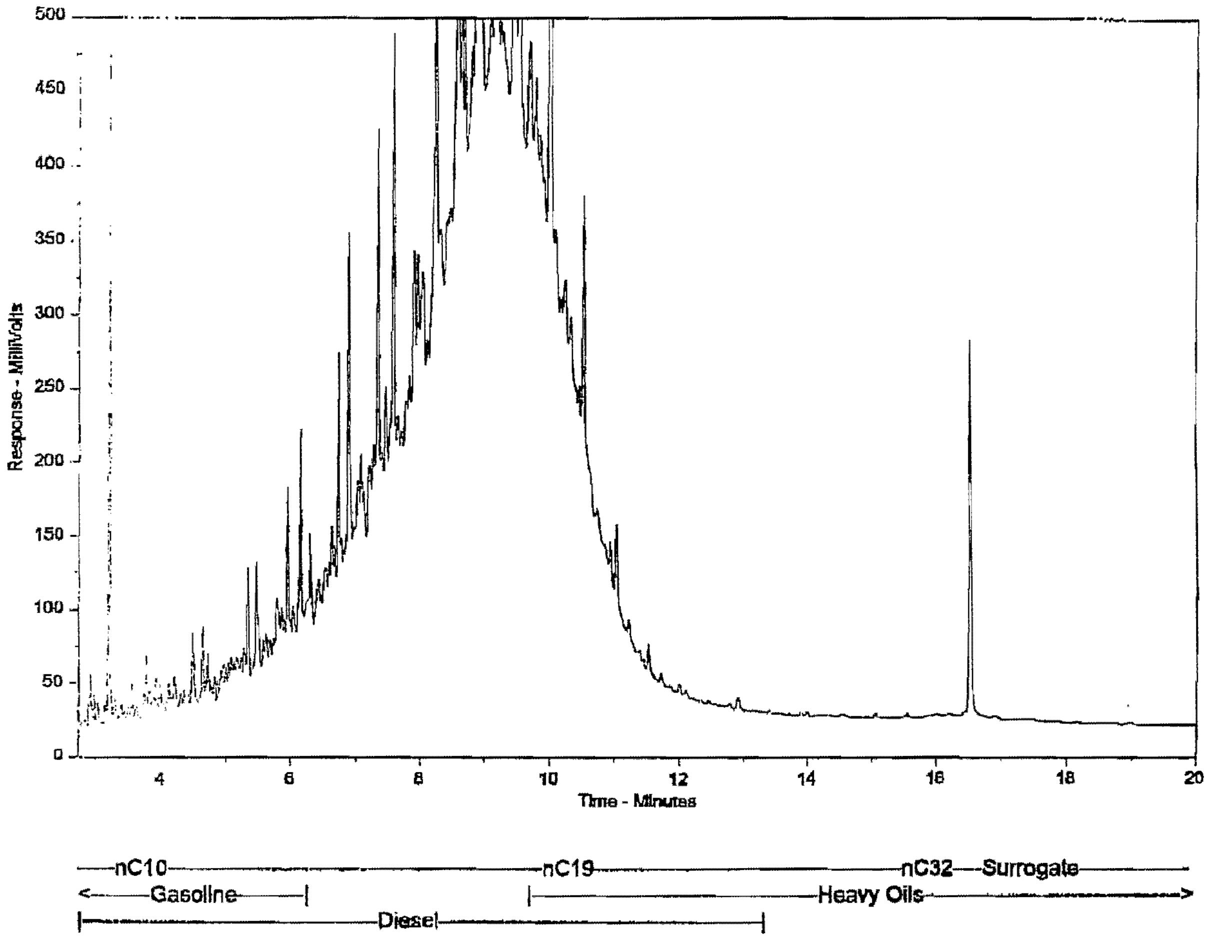
pH in Soil

This analysis is carried out in accordance with procedures described in "Soil Sampling and Methods of Analysis" (CSSS). The procedure involves mixing the air-dried sample with deionized/distilled water. The pH of the solution is then measured using a standard pH probe. A one to two ratio of sediment to water is used for mineral soils and a one to ten ratio is used for highly organic soils.

End Of Report

ALS Environmental - Hydrocarbon Distribution Report

Client Sample ID:
ALS Sample ID: **N7040-T--32**
File Name: i:\Chrom\gc18\data\gc18_24octB.0023.RAW
Run Information: Acquired on GC18, 10/24/01 11:15:50 PM



Sample Amount = 10.2 (g or mL) Dilution Factor = 10.0

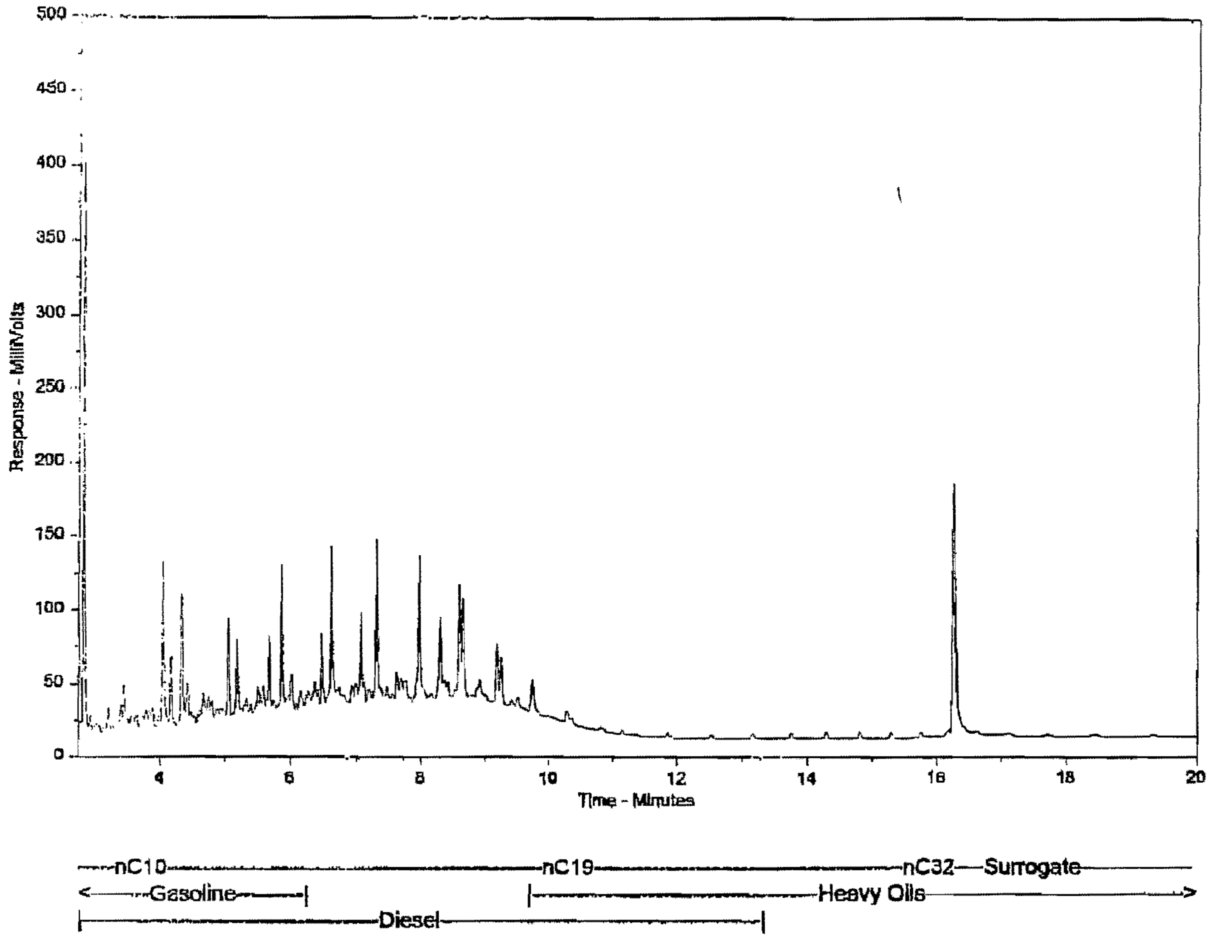
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample. A current library of reference products is available upon request.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A C35 surrogate compound is added to all samples by the laboratory as a component of quality control. Depending on the amount of heavy hydrocarbons present in the sample, this peak may or may not be visible near the end of the chromomatogram where indicated.

ALS Environmental - Hydrocarbon Distribution Report

Client Sample ID:
ALS Sample ID: **N7040-T--33**
File Name: i:\Chrom\gc18\data\gc18_24octA.0024.RAW
Run Information: Acquired on GC18, 10/24/01 11:47:03 PM



Sample Amount = 9.4 (g or mL) Dilution Factor = 10.0

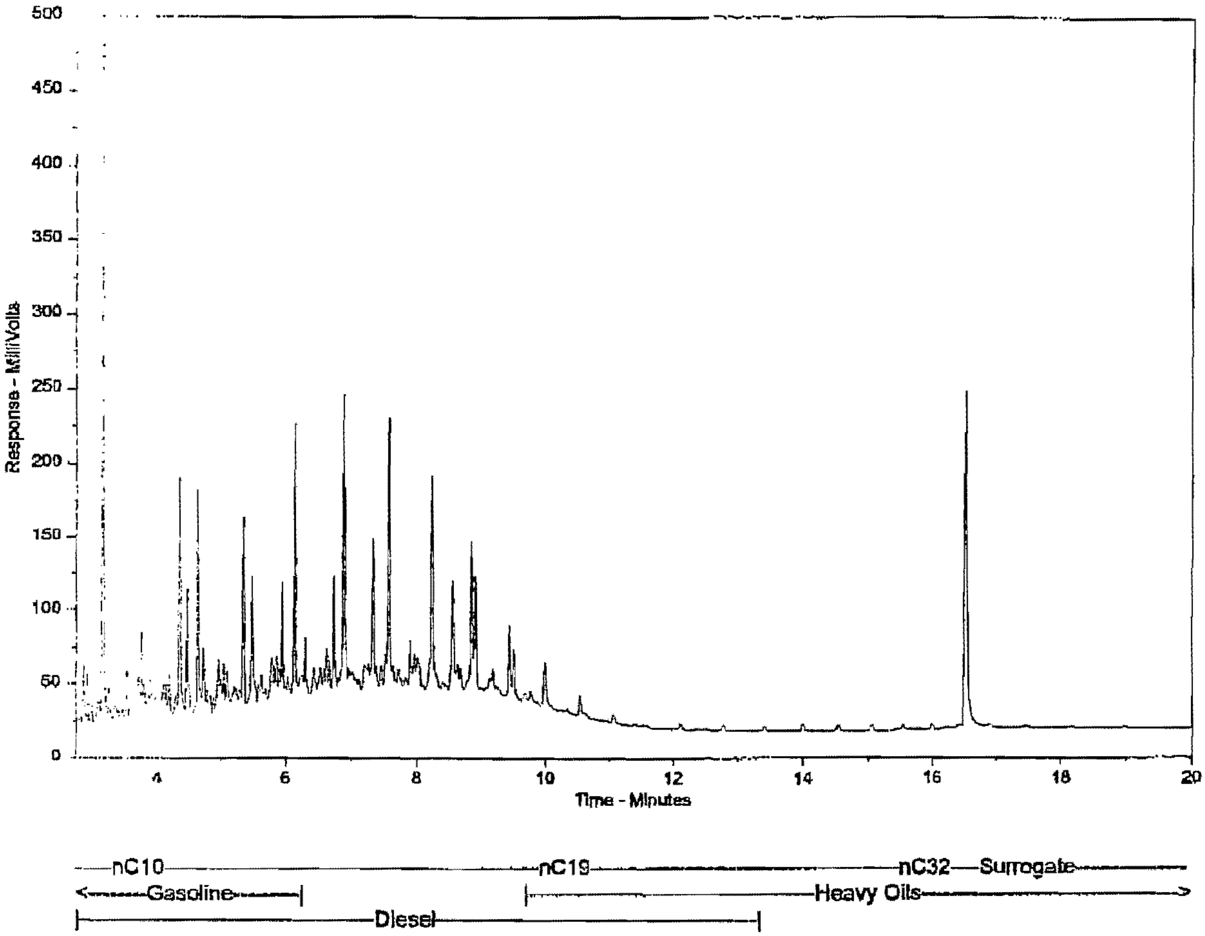
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample. A current library of reference products is available upon request.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A C35 surrogate compound is added to all samples by the laboratory as a component of quality control. Depending on the amount of heavy hydrocarbons present in the sample, this peak may or may not be visible near the end of the chromomatogram where indicated.

ALS Environmental - Hydrocarbon Distribution Report

Client Sample ID:
ALS Sample ID: **QC-T--262461#N7040-33 DUP**
File Name: i:\Chrom\gc18\data\gc18_24octB.0024.RAW
Run Information: Acquired on GC18, 10/24/01 11:47:03 PM



Sample Amount = 9.6 (g or mL) Dilution Factor = 10.0

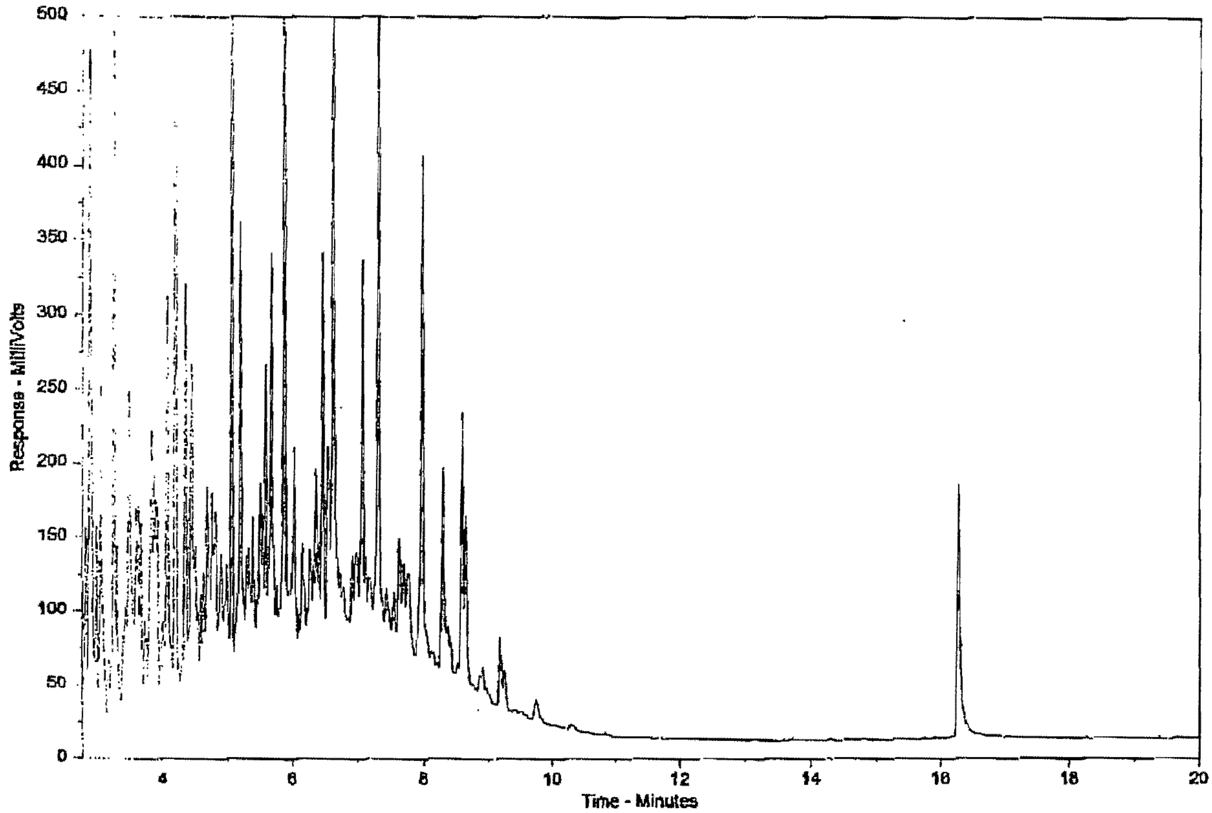
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample. A current library of reference products is available upon request.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A C35 surrogate compound is added to all samples by the laboratory as a component of quality control. Depending on the amount of heavy hydrocarbons present in the sample, this peak may or may not be visible near the end of the chromomatogram where indicated.

ALS Environmental - Hydrocarbon Distribution Report

Client Sample ID:
ALS Sample ID: **N7040-T--34**
File Name: i:\Chrom\gc18\data\gc18_24octA.0026.RAW
Run Information: Acquired on GC18, 10/25/01 12:49:44 AM



----nC10------------------------------------nC19------------------------------nC32---Surrogate--------
<--------Gasoline--------| |-------------------------Heavy Oils------------------------->
|-----------------------------Diesel-----------------------------|

Sample Amount = 10.3 (g or mL) Dilution Factor = 10.0

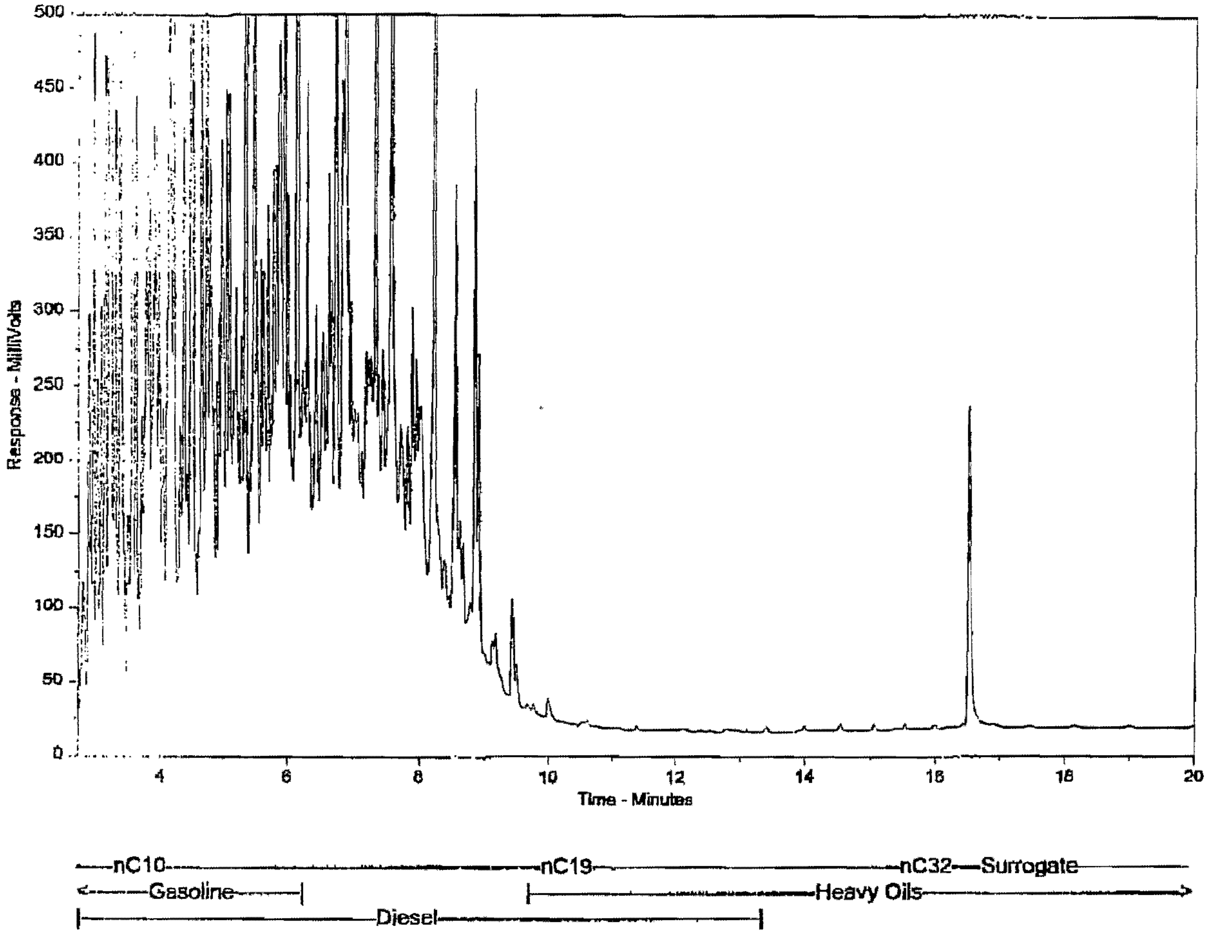
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample. A current library of reference products is available upon request.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A C35 surrogate compound is added to all samples by the laboratory as a component of quality control. Depending on the amount of heavy hydrocarbons present in the sample, this peak may or may not be visible near the end of the chromomatogram where indicated.

ALS Environmental - Hydrocarbon Distribution Report

Client Sample ID:
ALS Sample ID: **N7040-T--35**
File Name: i:\Chrom\gc18\data\gc18_24octB.0026.RAW
Run Information: Acquired on GC18, 10/25/01 12:49:45 AM



Sample Amount = 10.9 (g or mL)

Dilution Factor = 10.0

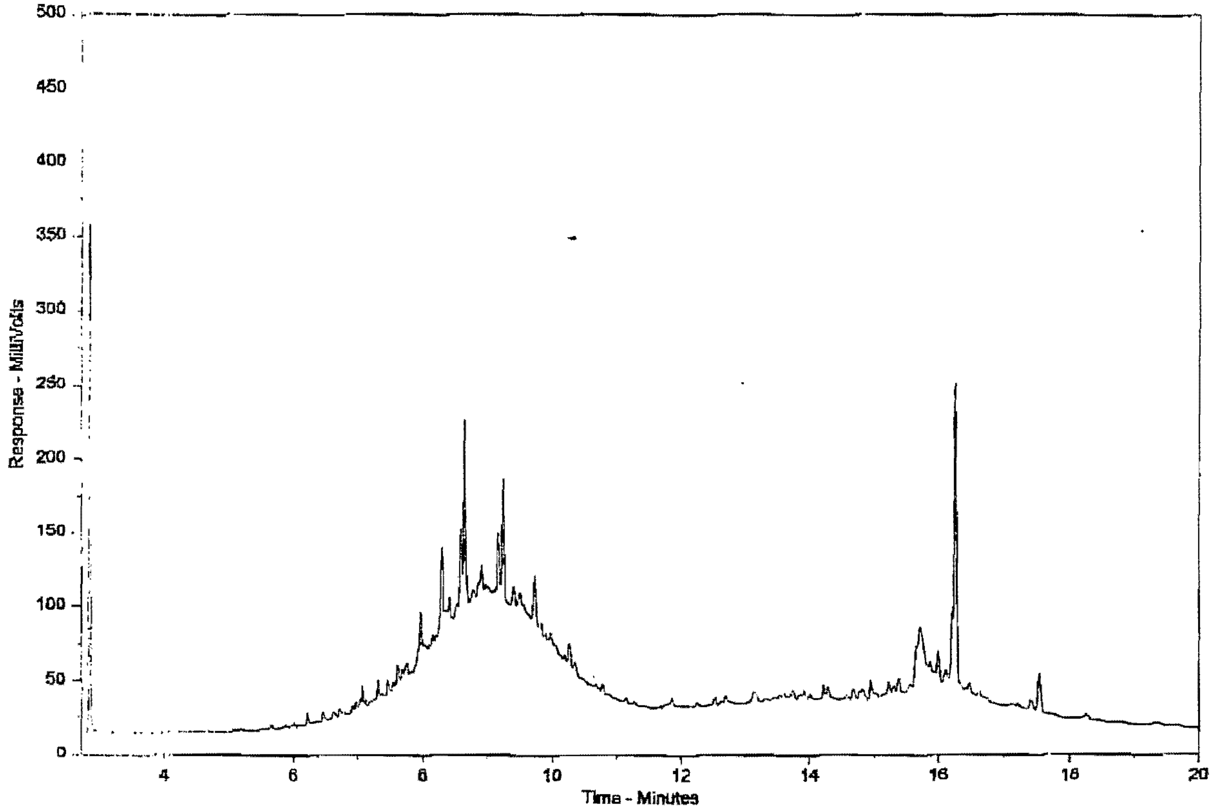
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample. A current library of reference products is available upon request.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A C35 surrogate compound is added to all samples by the laboratory as a component of quality control. Depending on the amount of heavy hydrocarbons present in the sample, this peak may or may not be visible near the end of the chromomatogram where indicated.

ALS Environmental - Hydrocarbon Distribution Report

Client Sample ID:
ALS Sample ID: **N7040-T--57**
File Name: i:\Chrom\gc18\data\gc18_24octA.0027.RAW
Run Information: Acquired on GC18, 10/25/01 1:21:05 AM



—nC10—————————nC19—————————nC32—Surrogate——
<——Gasoline——| |——————Heavy Oils——————>
|——————Diesel——————|

Sample Amount = 5.7 (g or mL) Dilution Factor = 10.0

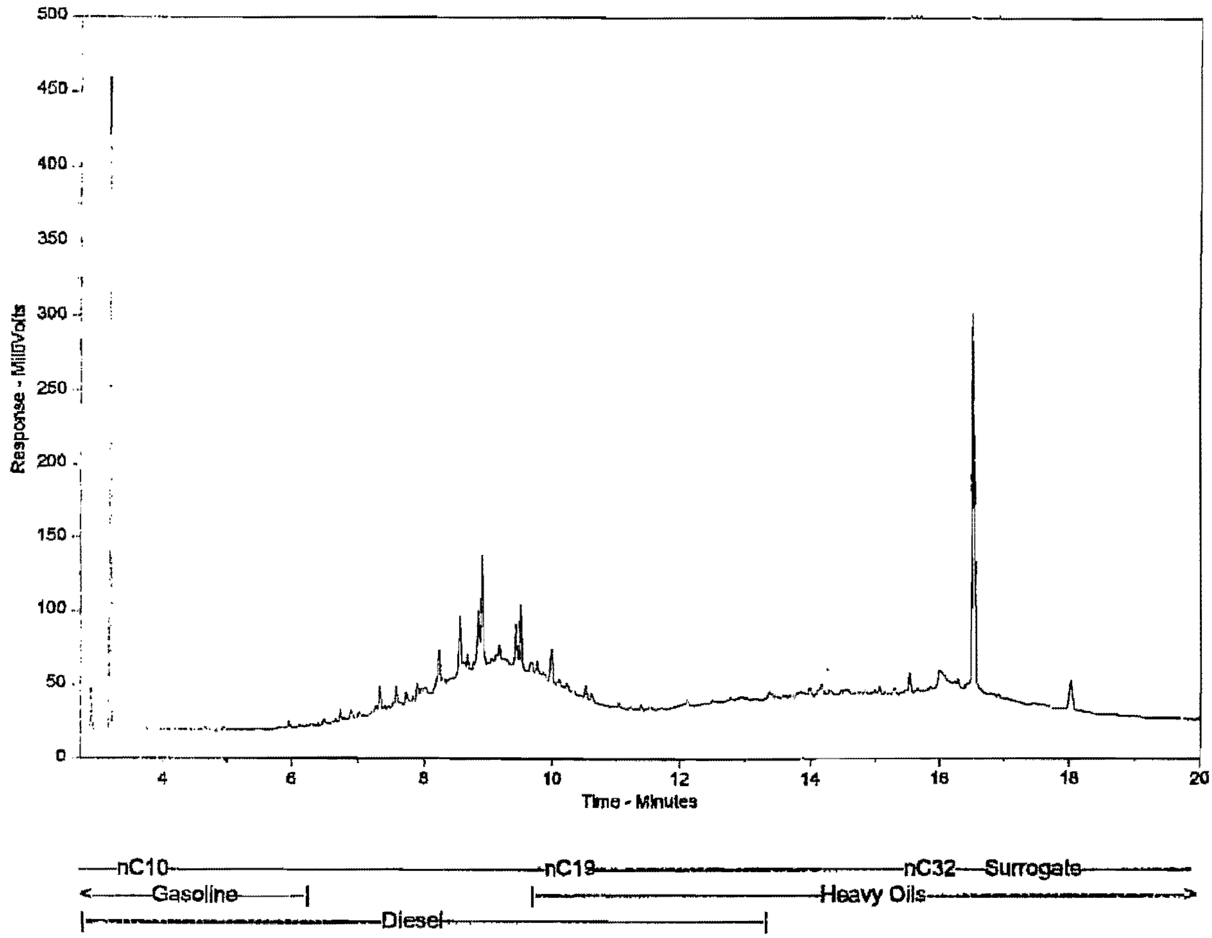
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample. A current library of reference products is available upon request.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A C35 surrogate compound is added to all samples by the laboratory as a component of quality control. Depending on the amount of heavy hydrocarbons present in the sample, this peak may or may not be visible near the end of the chromomatogram where indicated.

ALS Environmental - Hydrocarbon Distribution Report

Client Sample ID:
ALS Sample ID: **N7040-T--65**
File Name: i:\Chrom\gc18\data\gc18_24octB.0031.RAW
Run Information: Acquired on GC18, 10/25/01 3:26:14 AM



Sample Amount = 7.0 (g or mL) Dilution Factor = 10.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample. A current library of reference products is available upon request.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

A C35 surrogate compound is added to all samples by the laboratory as a component of quality control. Depending on the amount of heavy hydrocarbons present in the sample, this peak may or may not be visible near the end of the chromomatogram where indicated.

Appendix D

Letter Report Re. March 2002 Site Visit

Gartner
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Limited

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May 27, 2002 GLL 21-950

Contaminants / Waste Program
Indian and Northern Affairs Canada
Room 315
345 - 300 Main Street
Whitehorse, YT Y1A 2B5

Attn: Brett Hartshorne, Project Manager

Dear Mr. Hartshorne:

Re: Ketza River Mine – March 27, 2002 Site Visit

On March 27th, 2002, Gartner Lee Limited (GLL) conducted a site visit to the Ketza River Mine on behalf of DIAND Waste Management Program as part of a larger project for the assessment of environmental liability. The site visit was conducted by Mr. Forest Pearson and Mr. Dennis Lu of Gartner Lee Limited and Ms. Dorothy Dick of Ross River. The site was accessed by helicopter provided by Capitol Helicopters Inc. of Whitehorse.

The general scope of work include site inspection during winter conditions, water sampling and measurement of static water levels in the dam piezometers, where possible. Site conditions were generally snow covered with on average of over one to two metres of snow. The weather was partially sunny, windy and a temperature of –1°C. Photographs of site conditions are appended to this letter. An interpretation of water quality or pizometer readings was not included in this scope of work.

Although snow machine tracks were observed in the lower reaches of the Ketza River valley, there was no sign of human vistation to the mine site during the winter. Additionally, abundant wildlife tracks were observed in the Ketza River valley, although there were no animal tracks in the mine area. Four moose were observed at the north end of the Ketza River road where it enters the Tintina Trench valley. It is noted that the Ketza River has washed out the mine access road in at least two locations which appear to be the same washouts as observed in October 2001.

North Dam

The North Dam crest was wind swept and snow free during the site visit. No new cracks or signs of significant settlement in the dam crest were observed. Piezometer readings were as follows:

Piezometer No.	Water Level BTOP (m)	Total Depth BTOP (m)
P89-1	13.37	14.82
P90-8	7.83	8.83
P90-9	6.38	7.69
P90-10A	14.64	>31
P90-10B	dry	14.8
P96-11A	19.53	26.61
P96-11B	frozen at 0.5 m	
P96-11C	dry	17.87

The current pizeometer reading are variously lower or higher than readings taken on October 2001 by GLL and BGC Engineering Inc. in October, 2001. Open flow of seepage from the dam toe was observed. The flow quantity could not be measured, but is estimated to be five to ten litres per second. A water sample was collected from this site (KR-4).

South Dam

The South Dam crest was covered by a skiff of snow during the site visit and therefore, direct observation of the dam crest conditions were not possible. However, no signs of significant settlement in the dam crest were observed. The spillway was observed to be drifted in with over 1.5 metres of snow. Piezometer readings from the South Dam were as follows:

Piezometer No.	Water Level BTOP (m)	Total Depth BTOP (m)
P89-4	dry	7.72
P90-7A	dry	8.12
P90-7B	6.46	18.79
P90-7C	8.92	11.64
P96-12A	8.75	15.57
P96-12B	8.6	11.75
P96-12C	8.85	9.05

The current pizometer readings are all lower than the readings taken on October 10, 2001 by GLL and BGC Engineering Inc. Although the source of seepage from the toe of the south dam could not be observed due to snow cover, open water was present, implying constant seepage. A water sample was collected from this site (KR-5).

Tailings Pond

The tailings pond was frozen and covered with approximately 0.5 m of snow. The top of ice was estimated to be 2.0 m below the crest of the North Dam. No water samples were collected from the tailing pond. Waste oil drums at the north end of the pond were still present. The cyanide crate was not observed and assumed to be buried under drifted snow.

Cache Creek Diversion Ditch

The Cache Creek Diversion was ice covered and drifted in with over 1.5 metres of snow. No other direct observations of the ditch were possible.

Lower Subsidiary Creek and Northwest Interceptor Diversion Ditches

The interceptor ditches were drifted in and covered with at least 1.5 m of snow. No other direct observations of the ditch were possible. It was noted that significant drifting occurs across the Lower Subsidiary Creek diversion ditch downstream of the waste oil storage area. This drifting could be the mechanism causing freshet overflow from the ditch to the tailings pond. It is likely that this accumulation of drifted snow may take longer to melt than the rest of the ditch, causing damming of the ditch at this point. Any freshet site work should focus on removing the accumulation of snow at this point.

Surface Water Sampling

Four water samples were obtained during the site visit:

- KR-4 – Seepage from toe of North Dam
- KR-05 – Seepage from toe of South Dam
- KR-08 – Cache Creek upstream of Peel Creek
- KR-15 – Peel Creek upstream of Cache Creek

No other water samples could be collected due to thick ice cover and time constraints. Furthermore, flow measurements could not be made due to time limitations. Field measurements of pH, electrical conductivity and temperature were collected. Water samples were collected for general chemical parameters, total metals and dissolved metals. Total metals were preserved in the field with nitric acid. Dissolved metals were filted through 0.45 micron filter in the office later that day and subsequently preserved with nitric acid. All samples were kept in a cool, dark environment between sampling and delivery to the analytical laboratory. Water quality analysis were conducted by ALS Environmental of Vancouver, B.C.

Water quality data is summarized in Table 1 and original analytical reports are appended to this letter. Detailed comparison of these data with respect to historical water quality data has not completed within the scope of this letter report.

Mill Site

A cursory examination of the mill site was also conducted. The mill buildings appear to be in similar condition to the previous site visits. The buildings remain unsecured, including reagent and chemical storage areas.

Closure

In closure, a number of key observations are made:

- The site was covered with at least 1.5 metres of snow at the end of March and there was no sign of initiation of freshet.
- Tailings dam conditions visually appeared to be unchanged and seepage from the dam toes occurs throughout the winter
- Drifting of snow across the Lower Subsidiary Creek diversion ditch is likely the damming mechanism causing overflow of water to the tailings pond during freshet.

If you have any questions, or wish to discuss the observations presented in this letter report, please contact the undersigned at (867) 633-6474 extension 23.

Yours very truly,
GARTNER LEE LIMITED

Forest Pearson, B.Sc.
Engineering Geologist, EIT

Gartner Lee

Table 1. Summary of Water Quality Data
March 2002 Ketza River Mine Site Visit

Sample ID / *Date Sampled:*	KR-04 *3/27/2002*	KR-05 *3/27/2002*	KR-08 *3/27/2002*	KR-15 *3/27/2002*
Field Tests				
Conductivity (uS/cm)	681	645	479	1094
Temperature (degrees C)	1.7	2.2	0.1	0.6
pH	7.3	7.6	8.2	7.1
Physical Tests				
Conductivity (uS/cm)	706	589	600	1100
Hardness $CaCO_3$	335	276	320	567
pH	8.22	8.2	8.25	5.58
Dissolved Anions				
Acidity (to pH 8.3) $CaCO_3$	1	1	<1	8
Alkalinity-Total $CaCO_3$	176	151	185	5
Chloride Cl	0.7	0.5	0.6	<0.5
Sulphate SO_4	218	169	149	640
Total Metals				
Aluminum T-Al	0.077	<0.03	0.031	3.59
Antimony T-Sb	0.0003	0.0003	0.0002	<0.0002
Arsenic T-As	0.0816	0.0079	0.0067	0.0732
Barium T-Ba	0.0126	0.00546	0.0152	0.0159
Beryllium T-Be	<0.0005	<0.0005	<0.0005	<0.001
Bismuth T-Bi	<0.0005	<0.0005	<0.0005	<0.001
Boron T-B	<0.01	<0.01	<0.01	<0.02
Cadmium T-Cd	<0.00005	<0.00005	<0.00005	0.0019
Calcium T-Ca	106	78.7	84.5	155
Chromium T-Cr	<0.0005	<0.0005	<0.0005	<0.001
Cobalt T-Co	0.002	0.0014	0.0006	0.157
Copper T-Cu	0.0088	0.0009	0.0011	0.01
Iron T-Fe	0.16	0.05	<0.03	13
Lead T-Pb	0.00074	0.00016	0.00025	0.0009
Lithium T-Li	<0.005	<0.005	<0.005	0.01
Magnesium T-Mg	15.4	15.4	24.9	42.6
Manganese T-Mn	0.241	0.00293	0.00079	1.11
Molybdenum T-Mo	0.0014	0.00057	0.00054	<0.0001
Nickel T-Ni	0.0019	<0.0005	0.0006	0.109
Phosphorus T-P	<0.3	<0.3	<0.3	<0.3
Potassium T-K	<2	<2	<2	<2
Selenium T-Se	<0.001	<0.001	<0.001	<0.002
Silicon T-Si	2.85	1.74	2.28	6.47
Silver T-Ag	<0.00001	<0.00001	<0.00001	<0.00002
Sodium T-Na	7	5	4	<2
Strontium T-Sr	0.261	0.201	0.226	0.364
Thallium T-Tl	<0.0001	<0.0001	<0.0001	<0.0002
Tin T-Sn	<0.0001	<0.0001	<0.0001	<0.0002
Titanium T-Ti	<0.01	<0.01	<0.01	<0.01
Uranium T-U	0.00156	0.00159	0.00273	0.0008
Vanadium T-V	<0.001	<0.001	<0.001	<0.002
Zinc T-Zn	0.004	0.001	0.003	0.665

Notes: Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

Gartner Lee

Table 1 Cont. Summary of Water Quality Data

March 2002 Ketza River Mine Site Visit

Sample ID *Date Sampled:*	KR-04 *3/27/2002*	KR-05 *3/27/2002*	KR-08 *3/27/2002*	KR-15 *3/27/2002*
Dissolved Metals				
Aluminum D-Al	0.038	<0.03	0.024	0.301
Antimony D-Sb	0.0002	0.0003	0.0002	<0.0002
Arsenic D-As	0.075	0.0056	0.0065	0.0051
Barium D-Ba	0.0131	0.00522	0.0152	0.0157
Beryllium D-Be	<0.0005	<0.0005	<0.0005	<0.001
Bismuth D-Bi	<0.0005	<0.0005	<0.0005	<0.001
Boron D-B	<0.01	<0.01	<0.01	<0.02
Cadmium D-Cd	<0.00005	<0.00005	0.00012	0.0019
Calcium D-Ca	108	83.7	86.1	156
Chromium D-Cr	0.0006	<0.0005	0.0006	<0.001
Cobalt D-Co	0.0018	0.0013	0.0006	0.155
Copper D-Cu	0.0029	0.001	0.0019	0.0053
Iron D-Fe	<0.03	<0.03	<0.03	7.94
Lead D-Pb	<0.00005	0.00006	0.0002	<0.0001
Lithium D-Li	<0.005	<0.005	<0.005	0.01
Magnesium D-Mg	15.8	16.3	25.5	43
Manganese D-Mn	0.207	0.00063	0.00061	1.11
Molybdenum D-Mo	0.00147	0.00057	0.00053	<0.0001
Nickel D-Ni	0.0016	<0.0005	0.0011	0.108
Phosphorus D-P	<0.3	<0.3	<0.3	<0.3
Potassium D-K	<2	<2	<2	<2
Selenium D-Se	<0.001	<0.001	<0.001	<0.002
Silicon D-Si	2.87	1.88	2.34	6.08
Silver D-Ag	<0.00001	<0.00001	<0.00001	<0.00002
Sodium D-Na	7	6	4	2
Strontium D-Sr	0.26	0.2	0.219	0.361
Thallium D-Tl	<0.0001	<0.0001	<0.0001	<0.0002
Tin D-Sn	<0.0001	<0.0001	<0.0001	<0.0002
Titanium D-Ti	<0.01	<0.01	<0.01	<0.01
Uranium D-U	0.00153	0.00157	0.00269	0.00018
Vanadium D-V	<0.001	<0.001	<0.001	<0.002
Zinc D-Zn	0.003	0.004	0.01	0.649

Notes: Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

ALS Environmental

CHEMICAL ANALYSIS REPORT

Date: April 29, 2002

ALS File No. P3227

Report On: 21-950 Ketza River Mine
Water Analysis

Report To: **Gartner Lee Ltd.**
Suite C
206 Lowe Street
Whitehorse, YT
Y1A 1W6

Attention: **Mr. Forest Pearson**

Received: April 2, 2002

ALS ENVIRONMENTAL
per:

Natasha Markovic-Mirovic, B.Sc. - Project Chemist
Brent C. Mack, B.Sc. - Project Chemist

REMARKS

Please note the detection limits for certain Total and Dissolved Metals were increased for the sample identified as 'KR-15' due to the high levels of other Metals persent in the sample.

RESULTS OF ANALYSIS - Water

Sample ID			KR-04	KR-05	KR-15	KR-08
Sample Date			02 03 27	02 03 27	02 03 27	02 03 27
ALS ID			*1*	*2*	*3*	*4*
Physical Tests						
Conductivity	(uS/cm)		706	589	1100	600
Hardness	CaCO3		335	276	567	320
pH			8.22	8.20	5.58	8.25
Dissolved Anions						
Acidity (to pH 8.3)		CaCO3	1	1	8	<1
Alkalinity-Total		CaCO3	176	151	5	185
Chloride	Cl		0.7	0.5	<0.5	0.6
Sulphate	SO4		218	169	640	149

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. P3227

RESULTS OF ANALYSIS - Water

Sample ID		KR-04	KR-05	KR-15	KR-08
Sample Date		02 03 27	02 03 27	02 03 27	02 03 27
ALS ID		*1*	*2*	*3*	*4*
Total Metals					
Aluminum	T-Al	0.077	<0.03	3.59	0.031
Antimony	T-Sb	0.0003	0.0003	<0.0002	0.0002
Arsenic	T-As	0.0816	0.0079	0.0732	0.0067
Barium	T-Ba	0.0126	0.00546	0.0159	0.0152
Beryllium	T-Be	<0.0005	<0.0005	<0.001	<0.0005
Bismuth	T-Bi	<0.0005	<0.0005	<0.001	<0.0005
Boron	T-B	<0.01	<0.01	<0.02	<0.01
Cadmium	T-Cd	<0.00005	<0.00005	0.0019	<0.00005
Calcium	T-Ca	106	78.7	155	84.5
Chromium	T-Cr	<0.0005	<0.0005	<0.001	<0.0005
Cobalt	T-Co	0.0020	0.0014	0.157	0.0006
Copper	T-Cu	0.0088	0.0009	0.0100	0.0011
Iron	T-Fe	0.16	0.05	13.0	<0.03
Lead	T-Pb	0.00074	0.00016	0.0009	0.00025
Lithium	T-Li	<0.005	<0.005	0.01	<0.005
Magnesium	T-Mg	15.4	15.4	42.6	24.9
Manganese	T-Mn	0.241	0.00293	1.11	0.00079
Molybdenum	T-Mo	0.00140	0.00057	<0.0001	0.00054
Nickel	T-Ni	0.0019	<0.0005	0.109	0.0006
Phosphorus	T-P	<0.3	<0.3	<0.3	<0.3
Potassium	T-K	<2	<2	<2	<2
Selenium	T-Se	<0.001	<0.001	<0.002	<0.001
Silicon	T-Si	2.85	1.74	6.47	2.28
Silver	T-Ag	<0.00001	<0.00001	<0.00002	<0.00001
Sodium	T-Na	7	5	<2	4
Strontium	T-Sr	0.261	0.201	0.364	0.226
Thallium	T-Tl	<0.0001	<0.0001	<0.0002	<0.0001
Tin	T-Sn	<0.0001	<0.0001	<0.0002	<0.0001
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.00156	0.00159	0.00080	0.00273
Vanadium	T-V	<0.001	<0.001	<0.002	<0.001
Zinc	T-Zn	0.004	0.001	0.665	0.003

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. P3227

RESULTS OF ANALYSIS - Water

Sample ID		KR-04	KR-05	KR-15	KR-08
Sample Date		02 03 27	02 03 27	02 03 27	02 03 27
ALS ID		*1*	*2*	*3*	*4*
Dissolved Metals					
Aluminum	D-Al	0.038	<0.03	0.301	0.024
Antimony	D-Sb	0.0002	0.0003	<0.0002	0.0002
Arsenic	D-As	0.0750	0.0056	0.0051	0.0065
Barium	D-Ba	0.0131	0.00522	0.0157	0.0152
Beryllium	D-Be	<0.0005	<0.0005	<0.001	<0.0005
Bismuth	D-Bi	<0.0005	<0.0005	<0.001	<0.0005
Boron	D-B	<0.01	<0.01	<0.02	<0.01
Cadmium	D-Cd	<0.00005	<0.00005	0.0019	0.00012
Calcium	D-Ca	108	83.7	156	86.1
Chromium	D-Cr	0.0006	<0.0005	<0.001	0.0006
Cobalt	D-Co	0.0018	0.0013	0.155	0.0006
Copper	D-Cu	0.0029	0.0010	0.0053	0.0019
Iron	D-Fe	<0.03	<0.03	7.94	<0.03
Lead	D-Pb	<0.00005	0.00006	<0.0001	0.00020
Lithium	D-Li	<0.005	<0.005	0.01	<0.005
Magnesium	D-Mg	15.8	16.3	43.0	25.5
Manganese	D-Mn	0.207	0.00063	1.11	0.00061
Molybdenum	D-Mo	0.00147	0.00057	<0.0001	0.00053
Nickel	D-Ni	0.0016	<0.0005	0.108	0.0011
Phosphorus	D-P	<0.3	<0.3	<0.3	<0.3
Potassium	D-K	<2	<2	<2	<2
Selenium	D-Se	<0.001	<0.001	<0.002	<0.001
Silicon	D-Si	2.87	1.88	6.08	2.34
Silver	D-Ag	<0.00001	<0.00001	<0.00002	<0.00001
Sodium	D-Na	7	6	2	4
Strontium	D-Sr	0.260	0.200	0.361	0.219
Thallium	D-Tl	<0.0001	<0.0001	<0.0002	<0.0001
Tin	D-Sn	<0.0001	<0.0001	<0.0002	<0.0001
Titanium	D-Ti	<0.01	<0.01	<0.01	<0.01
Uranium	D-U	0.00153	0.00157	0.00018	0.00269
Vanadium	D-V	<0.001	<0.001	<0.002	<0.001
Zinc	D-Zn	0.003	0.004	0.649	0.010

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

Appendix 1 - METHODOLOGY

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows

Conductivity in Water

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

Recommended Holding Time:
Sample: 28 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

pH in Water

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

Recommended Holding Time:
Sample: 2 hours
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Acidity in Water

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

Recommended Holding Time:
Sample: 14 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Alkalinity in Water by Colourimetry

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

Recommended Holding Time:
Sample: 14 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Chloride in Water

This analysis is carried out using procedures adapted from APHA Method 4500 "Chloride". Chloride is determined using the ferricyanide colourimetric method.

Recommended Holding Time:
Sample: 28 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Sulphate in Water

This analysis is carried out using procedures adapted from APHA Method 4500-SO4 "Sulphate". Sulphate is determined using the turbidimetric method.

Recommended Holding Time:
Sample: 28 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:

Sample:	6 months
Reference:	EPA
For more detail see:	ALS "Collection & Sampling Guide"

End of Report

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

CLIENT: Gartner Lee Limited

ADDRESS: 204 [illegible] St, Suite C

CITY: Whitehorse PROV.: YT POSTAL CODE: Y1A 1J6

CONTACT: Forest Pearson SAMPLER: Dennis Lu

TELEPHONE: 867-633-6474 FAX: 867 633 6321

PROJECT NAME/NO.: 21-950 Ketza River Mine

P.O. NO.: QUOTE NO.:

DATE SUBMITTED: Mar 28, 2002 ALS CONTACT:

ALS Environmental
1988 Triumph Street
Vancouver, BC
Canada V5L 1K5
TEL: 604-253-4188
TOLL FREE: 1-800-665-0243
FAX: 604-253-6700
www.alsenviro.com

ANALYSIS REQUESTED

LAB USE ONLY: P3227

FOR LAB USE ONLY

SAMPLE IDENTIFICATION	Y	M	D	TIME	MATRIX	[illegible]	Total metals	Dissolved metals	[illegible]	[illegible]	Sulphate	Chloride	NOTE
KR-04	02	03	27	: AM/PM	water		Y	Y	Y	Y	Y	Y	
KR-05	02	03	27	: AM/PM	water		Y	Y	Y	Y	Y	Y	
KR-15	02	03	27	: AM/PM	"		Y	Y	Y	Y	Y	Y	
~~[illegible]-02~~ KR-08	02	03	27	: AM/PM	"		Y	Y	Y	Y	Y	Y	
				: AM/PM									
				: AM/PM									
				: AM/PM									
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				: AM/PM									
				: AM/PM									
				: AM/PM									

TURN AROUND REQUIRED:

☑ ROUTINE (7 - 10 WORKING DAYS) ☐ RUSH (SPECIFY DATE): ____

SPECIAL INSTRUCTIONS (BILLING DETAILS, QC REPORTING, ETC.):

RELIQUISHED BY:	DATE Mar 28/02	RECEIVED BY:	DATE
[signature]	TIME		TIME
RELIQUISHED BY:	DATE	RECEIVED BY:	DATE [illegible]
	TIME	[signature]	TIME

FOR LAB USE ONLY

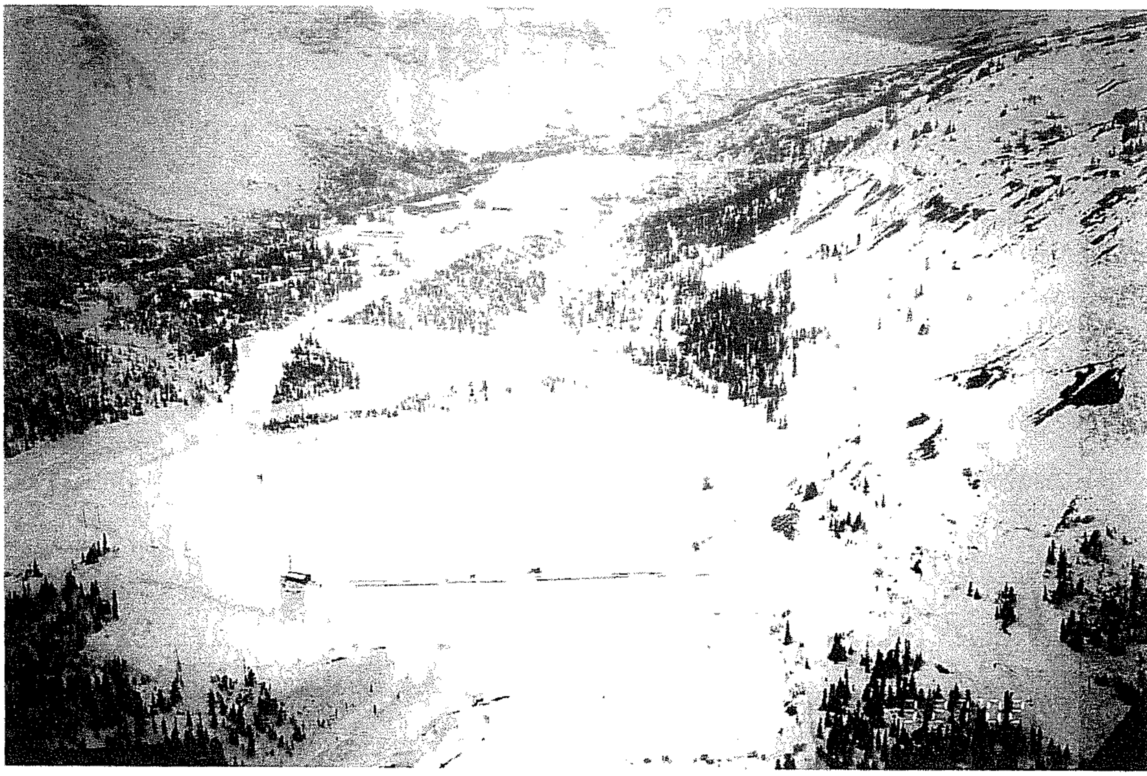
COOLER SEAL INTACT UPON RECEIPT? ☐ YES ☐ NO ☐ N/A

SAMPLE TEMPERATURE UPON RECEIPT: 16 °C

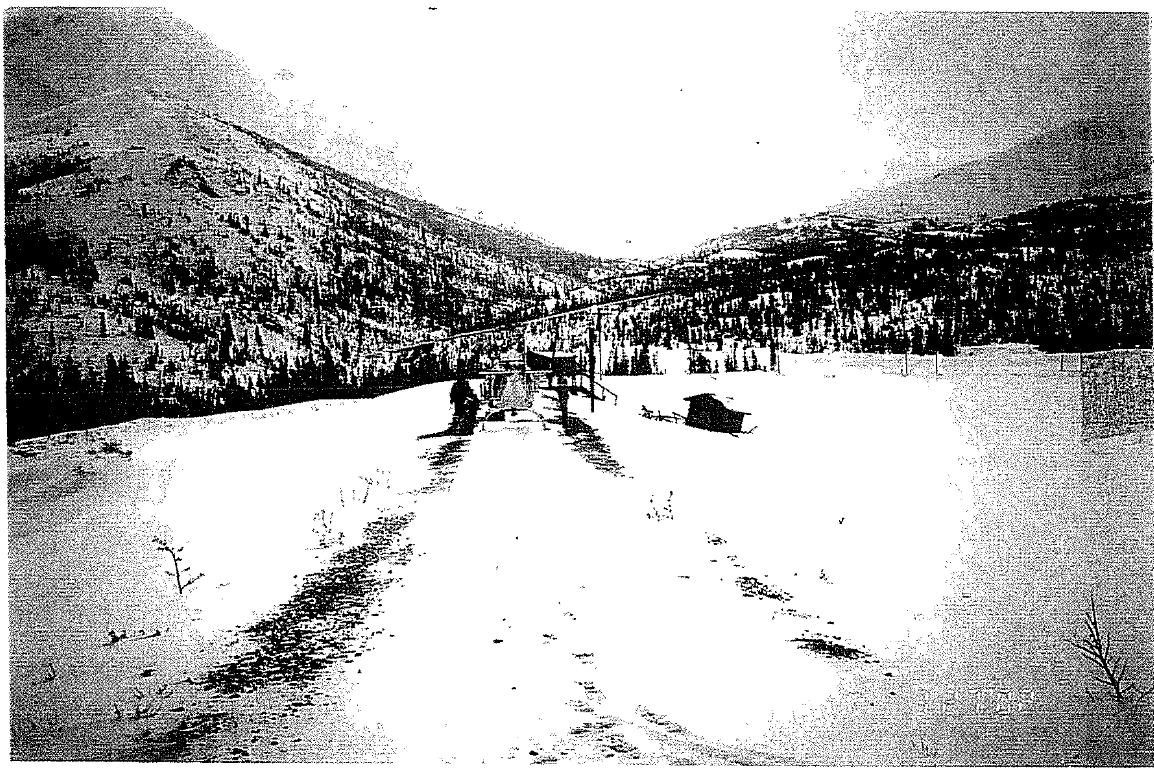
FROZEN? ☐ YES ☐ NO

REPORT COP

SEE WHITE PAPER C SOURCE VER



Photograph 1. Overview of Ketza River mine and tailings ponds.



Photograph 2. View along crest of north dam.

Photograph 5 Crest of south dam.

Photograph 6. Site KA-5, toe of south dam.

Photograph 7. Overview of north dam, note seepage from toe.

Photograph 8. Lower subsidiary creek diversion. Note drifting across ditch to left of drum cache.