# KOALA MINE
# AIRPORT ESKER EVALUATION

0101-94-11439.3

MARCH, 1995




eba

# KOALA MINE
# AIRPORT ESKER EVALUATION

Submitted To:

BHP DIAMONDS INC.
VANCOUVER, BC

Prepared By:

EBA ENGINEERING CONSULTANTS LTD.
EDMONTON, ALBERTA

0101-94-11439.3

March, 1995

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# 1.0 INTRODUCTION

## 1.1 GENERAL

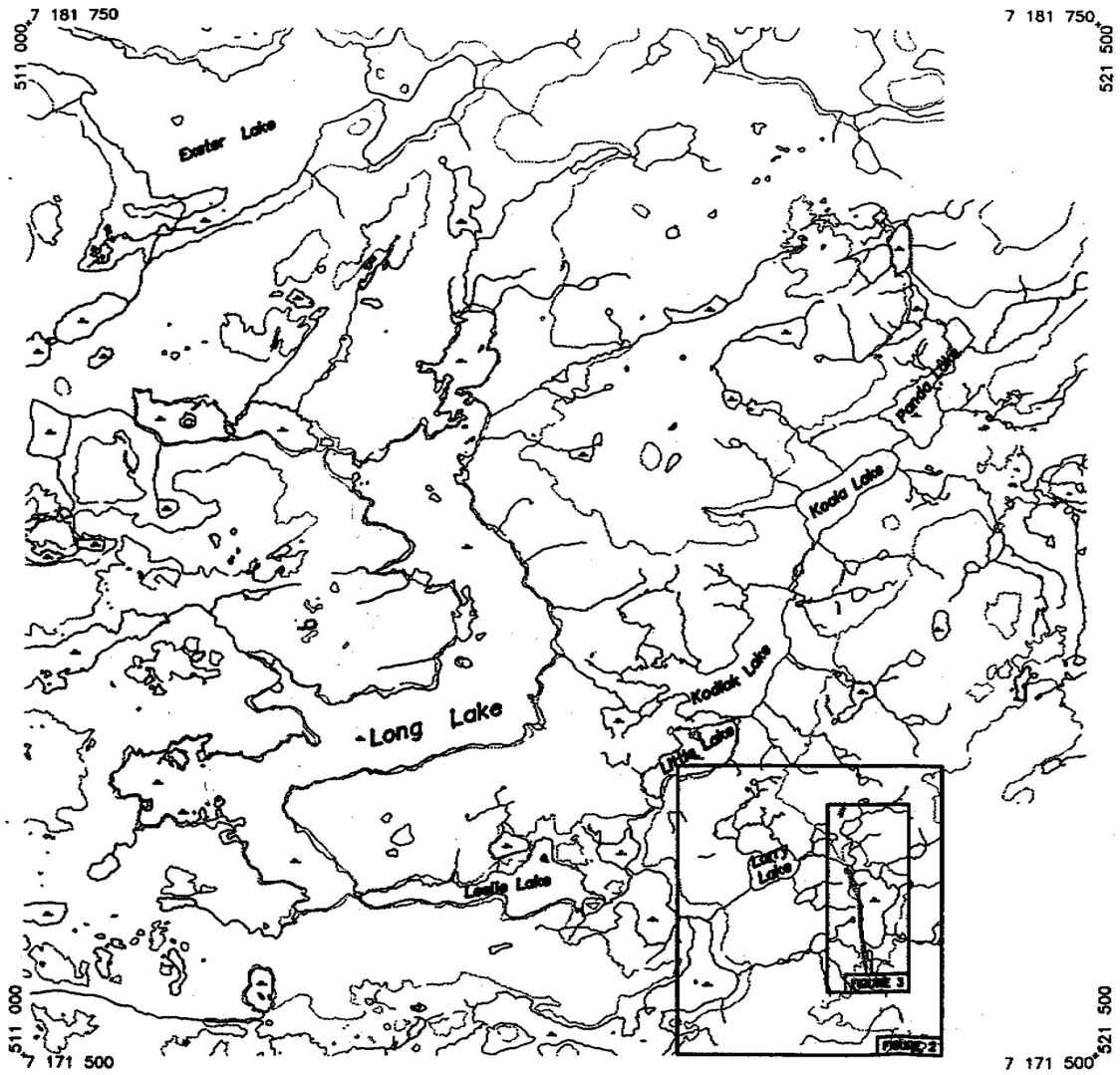
BHP Diamonds Inc. (BHP) is presently studying the feasibility of developing precious mineral deposits from several current lake basins in the immediate vicinity of the Koala mine site, located in the Northwest Territories. The site is situated approximately 300 km northeast of Yellowknife, as shown in Figure 1.

A principal source of granular construction material for exploration development to date is a prominent north-south oriented esker located approximately 1 km southeast of the existing Koala camp/processing facility. A long linear portion of the esker is a natural dam that impounds a significant size lake on the east side. The esker and immediate surrounding area is presented in Figure 2. The esker is also used to serve as a segment of a haul road between the bulk sample processing plant and the Fox portal. The esker is still being actively mined to obtain granular material for a number of end uses.

EBA Engineering Consultants Ltd. (EBA) was retained by BHP to evaluate the esker and provide development guidelines that will ensure the integrity of the esker and prevent the natural dam from being breached. The project was authorized on July 8, 1994 by Mr. B.L. Turner, Project Manager of BHP, under Purchase Order No. M53439D, Change Order No. 2.

## 1.2 SURFICIAL GEOLOGY

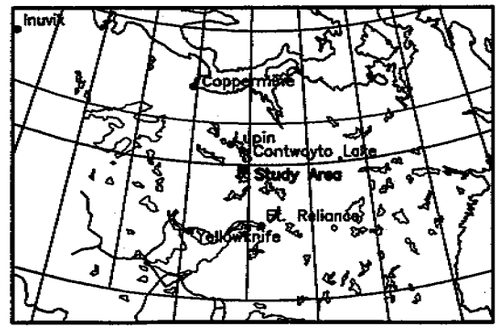
The region of the proposed mine lies within the Canadian Shield and is underlain by granitic rocks. The surficial geology of the region is described by Ward (1993). The surficial deposits that overlie the bedrock consist of glacial till, glaciofluvial deposits, organics, and alluvial flood plain deposits. The glacial till has a variable thickness up to 15 m and consists of a sand matrix containing silt, gravel, cobbles and boulders. Glaciofluvial deposits consist of eskers and outwash sands. Organics reach a thickness of up to two metres in bogs and fens: in raised areas, the thickness of organics is much less. Alluvial flood plain deposits are gravel to silt sized sediments with a thickness of up to five metres.




STUDY AREA

0 2500
metres

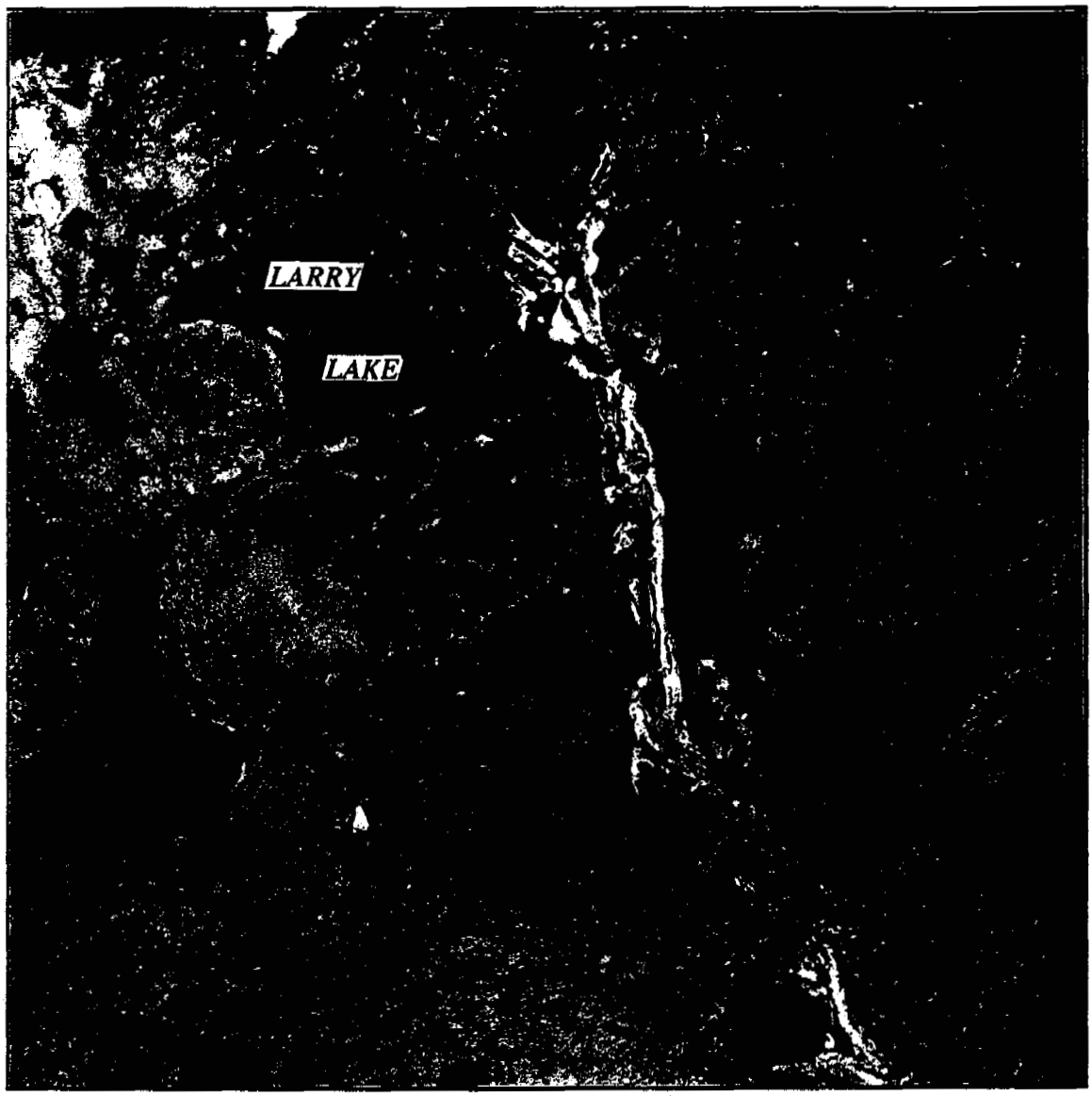

INDEX MAP
N.T.S.




LOCATION MAP
N.T.S.

| | | | |
|---|---|---|---|
| EBA Engineering Consultants Ltd. | | PROJECT | ESKER EVALUATION<br>KOALA MINE SITE |
| CLIENT | BHP DIAMONDS INC. | TITLE | GENERAL LOCATION PLAN |
| DATE 95-03-14 | DWN. AJH CHKD. MAV | FILE NO. 11439A1AA | FIGURE 1 |

Reduced (73%)




Date of Airphoto: August, 1993

0 1000

SCALE (metres)

**FIGURE 2 AERIAL VIEW OF ESKER (Before Exploitation)**

There are numerous shear zones and fault traces in the area. The glacier movement that was dominant in affecting the landscape advanced in a northward direction (Ward et al. 1994).

In many locations, the surface of the till has been water-washed, removing fine-grained soil and leaving a surface layer of cobbles and boulders. In some areas, the terrain is typified by extensive boulder fields as a result of the fines having been completely removed, leaving open voids among the boulders.

## 1.3 CLIMATE AND PERMAFROST

The Koala mine site is situated within the zone of continuous permafrost. The closest meteorological station to the site is at Contwoyto Lake, approximately 100 km north of the site. Mean annual air temperature for Contwoyto Lake is -11.8°C, based on Environment Canada weather records that were maintained until 1981.

## 1.4 EXECUTION OF THE INVESTIGATION

Several companies were involved with the activities undertaken to complete the site investigation. The companies and their respective responsibilities were as follows:

- BHP contracted the work and provided camp facilities and ancillary support during the site investigation.
- EBA planned the geotechnical/geophysical programs, logged borings, installed ground temperature cables, operated the equipment used to obtain geophysical data, and carried out laboratory testing of soil samples.
- Sub-Arctic Surveys Ltd. (SAS) assisted in borehole and geophysical survey line positioning.
- Tercon Contractors Ltd. (Tercon) provided and operated the drilling equipment used.

# 2.0 ESKER EVALUATION PROGRAM

## 2.1 AIRPHOTO INTERPRETATION & RECONNAISSANCE

The esker was initially assessed by EBA during a preliminary evaluation that reviewed potential granular material sources in the vicinity of the Koala site (EBA 1993). Preliminary (office) assessment included an airphoto study and a review of available maps. The airphoto interpretation study was conducted using 1:10,000 scale airphotos supplied by BHP. These airphotos were photographed in August, 1993.

The airphotos were again reviewed and used to plan the 1994 program, reported herein. Field reconnaissance was conducted by EBA personnel during the summer of 1994 both prior to and following the geotechnical and geophysical program.

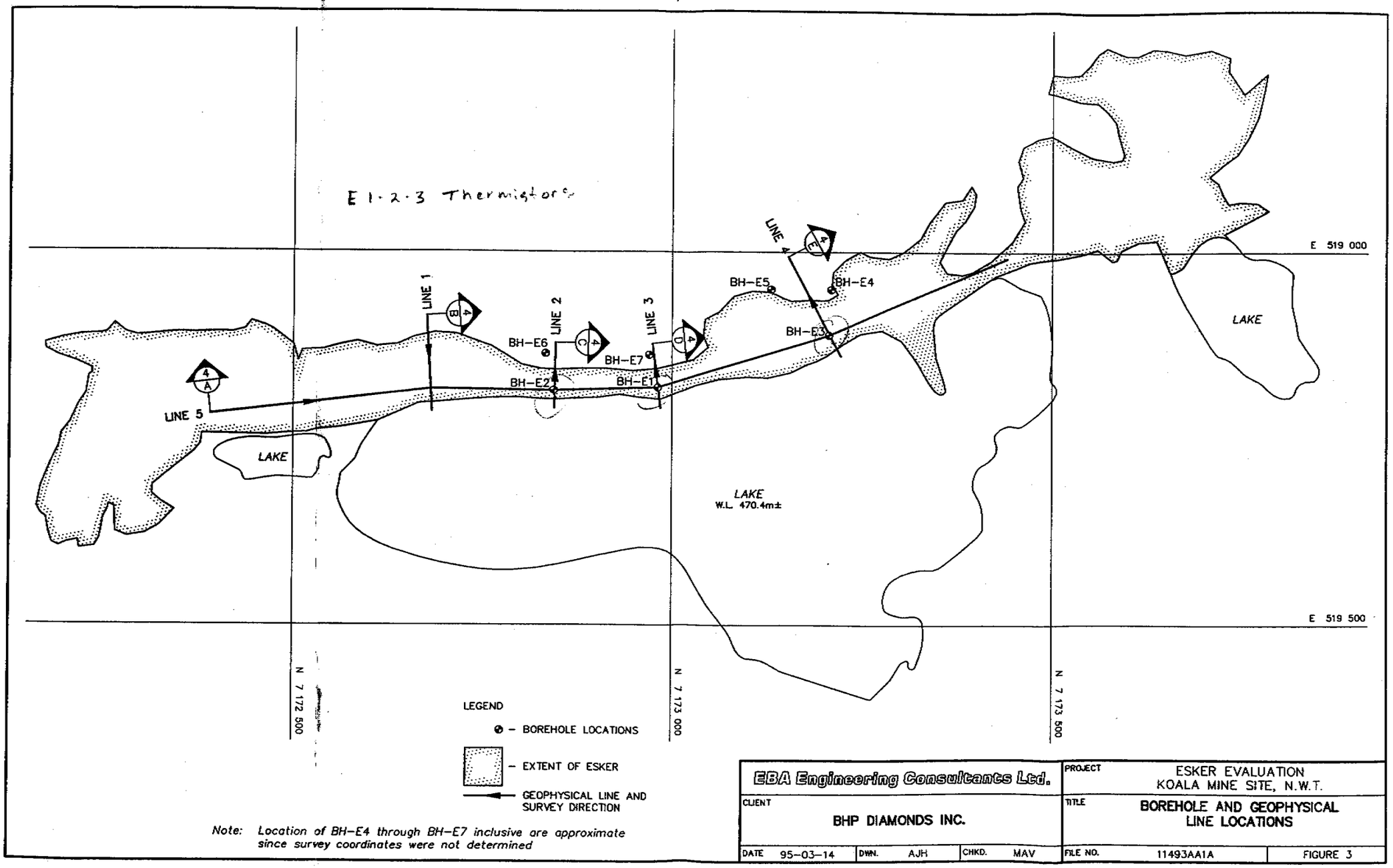
## 2.2 DRILLING AND SAMPLING

The borehole locations for the esker evaluation program are shown in Figure 3. Boreholes E-1 through E-7 inclusive were advanced using a Tamrock Zoomtrak DHA hydratrack drill rig operated by Tercon Contractors Ltd. This drill was equipped with a top-drive hydraulic percussion hammer, and boreholes were drilled with depths ranging from 3.0 to 21.2 m below the then-existing ground surface. Select representative disturbed samples were recovered from each borehole location. Thermistor strings were installed in Boreholes E-1, E-2, and E-3.

Classification and index testing were subsequently performed in EBA's laboratory. All laboratory testing was conducted in accordance with CSA procedures and specifications. Laboratory test included the following:

- Natural moisture content, and
- Particle size distribution analysis.

Borehole logs are presented in Appendix A. Laboratory test results are presented on the borehole logs, where appropriate, and on the summary table in Appendix B.




*Note: Location of BH-E4 through BH-E7 inclusive are approximate since survey coordinates were not determined*

| | | | |
|---|---|---|---|
| EBA Engineering Consultants Ltd. | | PROJECT | ESKER EVALUATION KOALA MINE SITE, N.W.T. |
| CLIENT | BHP DIAMONDS INC. | TITLE | BOREHOLE AND GEOPHYSICAL LINE LOCATIONS |
| DATE 95-03-14 | DWN. AJH / CHKD. MAV | FILE NO. 11493AA1A | FIGURE 3 |

Reduced (73%)

## 2.3 GROUND TEMPERATURE INSTRUMENTATION

Ground temperature monitoring cables were installed in three boreholes that were drilled on the crest of the esker, along the east side adjacent to the lake. Each of the installed thermistor cables is constructed with a multi-pin connector and eleven sensing beads. The cables were installed in the open boreholes and were backfilled with local sand.

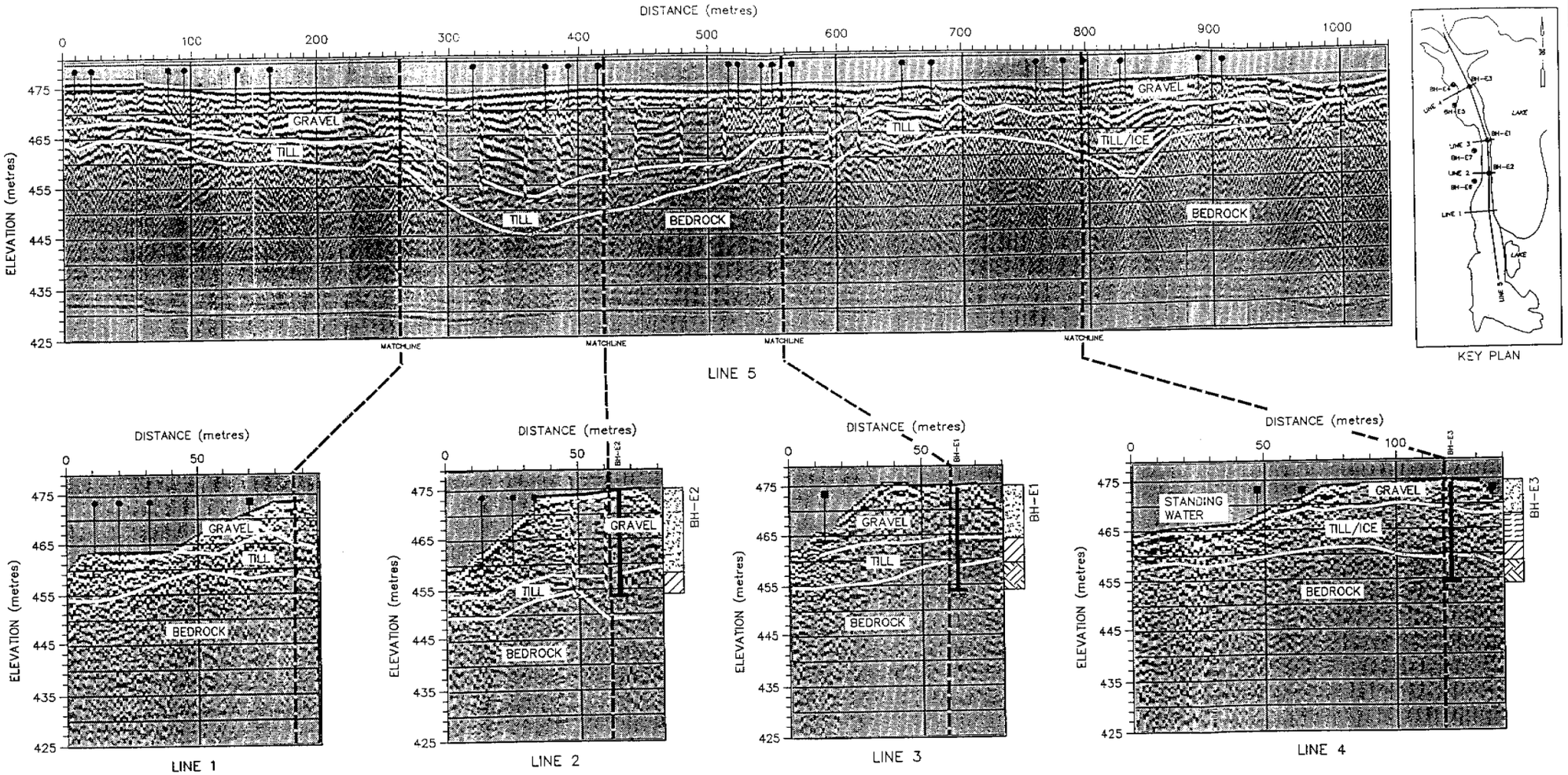
Ground temperature readings that have been collected to date are included in Appendix C. The readings indicate that the ground temperatures below the depth of significant seasonal influence vary between approximately -1.5 and -3°C. It is apparent that the proximity of the lake has an effect on the ground temperature since other ground temperature measurements taken in the vicinity of the mine site indicate somewhat colder temperatures, which vary between approximately -4 and -6°C (EBA 1995).

## 2.4 GROUND PENETRATING RADAR SURVEY

A ground penetrating radar survey (GPR) was conducted on August 21 and 22, 1994. The GPR survey was conducted along the longitudinal axis of the esker, adjacent to the lake, and along four transverse cross–sections. The geophysical survey was conducted to detect areas of massive ice as well as the esker/till contact. The GPR survey line locations, including the direction of chainage for each line, are presented in Figure 3.

The subsurface profiles that have been interpreted from the GPR lines are presented in Figure 4. The profiles have been corrected to illustrate the ground surface elevation that existed at the time when the GPR survey was conducted. The GPR survey was conducted with a PulseEKKO™ IV system using both 50 and 100 MHz antennae and a 1000 V transmitter.

The GPR equipment generates a pulsed electromagnetic signal from a transmitter that directs the pulse into the ground. Upon encountering an interface with contrasting dielectric properties, some of the signal is reflected and the remainder is transmitted through the interface. The ratio of the reflected signal to the incident signal is proportional to the dielectric contrast, as well as to the geometric properties of the interface. The reflected signal received by the antennae is processed by decoder circuits and digitally stored in a laptop computer for further signal processing and analysis. Depth of penetration and resolution of the signal are controlled by the




LEGEND

- ESKER MATERIAL
- ICE
- TILL
- BEDROCK
- MASSIVE ICE?
- MASSIVE ICE REFLECTION
- HIGH ATTENUATION ZONE
- BOREHOLE DEPTH AND LOCATION

| | | | | | |
|---|---|---|---|---|---|
| EBA Engineering Consultants Ltd. | | | | PROJECT | ESKER EVALUATION KOALA MINE SITE, N.W.T. |
| CLIENT | BHP DIAMONDS INC. | | | TITLE | GPR REFLECTIONS AND INTERPRETED PROFILES |
| DATE | 95-03-14 | DWN. | WMG | CHKD. | DCC |
| | | | | FILE NO. | 1439M85B |
| | | | | | FIGURE 4 |

material properties and the antennae frequency. Higher frequencies provide better resolution but less penetration.

The data were collected in a step mode. The transmitter and receiver were spaced by a fixed separation and a trace was collected at that point using a sampling interval of 0.8 nanoseconds (ns). Readings were mathematically amplified to strengthen the reflection signals and attenuate background noise. The antennae were moved along at constant step intervals and data were collected at each point along the length of the profiled line.

All data were logged using a PC laptop and were subsequently post-processed in the office. Signal saturation correction and time zero drift corrections were applied to the data set. The objectives of the processing are to remove random noise and to correct time zero drifting. Due to geometrical spreading of the transmitted wave fields and signal attenuation through material conductivity properties, the reflected signals from deeper reflectors show noticeably lower amplitudes than those from shallow reflectors. The results were thus plotted using spherical and exponential compensation (SEC) gain to recover relative amplitude information. This information was used qualitatively along with changes in the frequency content of the reflected signals in interpreting the data for the stratigraphic profiles.

Common mid-point (CMP) surveys were conducted to determine the average velocity of the near-surface materials. Based on this average velocity (0.15 m/nanosecond), bedrock depths and material thicknesses were estimated from the results of the GPR surveys. In CMP surveys, the transmitter and receiver antennae are initially space 0 m apart and moved away from each other at constant 0.5 m steps. The determined velocity was used in interpreting the stratigraphic profiles and was assumed constant with lithological layers. This introduces some error in the interpretation as this is a simplification of the actual velocity structure.

It should be noted that the best use of the geophysical profiles is to gain an overview of the soil stratigraphy at each site. Anticipated depth accuracy is expected to ±15% and, where possible, borehole data has been used to calibrate the interpreted results.

# 3.0 SITE DESCRIPTION

## 3.1 SURFACE CONDITIONS

The esker identified by EBA as "Esker Deposit No. 2", and known to BHP personnel as the "Airport Esker", has been described in a previous EBA report that reviewed potential granular material sources in the vicinity of the Koala site (EBA 1993).

The esker is a prominent north–south oriented ridge located approximately 1 km southeast of the existing Koala camp/processing facility. Existing roads make the esker readily accessible. The esker has a base area of approximately 20 hectares and ranges from 7 to 12 m in height. A long linear portion of the esker is a natural dam that impounds a significant size lake on the east side. The esker has been used as a source of granular construction material and also serves as a segment of the access road to the Fox portal.

Surface vegetation had been removed where extraction of granular material had already taken place. On the west slope of the esker, in areas where the surface had not been disturbed, vegetation is limited to moss and lichen.

## 3.2 SUBSURFACE CONDITIONS

### 3.2.1 Generalized Stratigraphy

Seven boreholes were drilled during the geotechnical program. Three boreholes were drilled along the crest of the esker while the remaining four boreholes were positioned along the west side of the esker, near the toe of the slope. The geotechnical program was complemented with a geophysical program that obtained approximately 1,450 lineal metres of data. The geophysical program consisted of five survey lines; one line was run longitudinally along the crest while the remaining four lines were run in a transverse direction. The borehole and geophysical line locations are presented in Figure 3. The interpreted geophysical profiles for the five lines surveyed are presented in Figure 4.

The subsurface conditions can be generally described as comprising granitic rock that is overlain by glacial till, in turn overlain by glaciofluvial sand and gravel.

The composition of the glaciofluvial granular material varies with location and depth in the esker. The geophysical data collected indicates that the glaciofluvial material

is between 3 and 15 m thick. The material recovered from this source to date varies from a fine-grained uniform sand to a sand and gravel with cobbles and boulders. Less than four percent fines was found in five of the six samples obtained from the active layer during 1993 and 1994. A grain size envelope of the tested esker samples is presented in Figure 5.

The glacial till was not sampled during this investigation. However, samples of this material were previously obtained from the Koala plant site and subsequently tested (EBA 1995). The glacial till consists of a sand matrix containing boulders, gravel, and silt in variable proportions. Clay appears to be absent; the fines fraction in the till is non-plastic. Boulders and gravel are angular to sub-rounded, are composed of granite, and have probably been derived from the underlying bedrock. The geophysical profile indicates that the glacial till is approximately 5 m thick on average.

At several locations, the geophysical signal was attenuated; this is thought to have been caused by either higher fines contents (greater than 20% by volume) or high unfrozen moisture contents. The locations where this anomaly occurred are indicated on the geophysical profiles.

Bedrock sampled to date by EBA is granite. The granite is medium to fine-grained, mostly medium grey in colour, but occasionally dark grey or pink. The bedrock is generally of good quality. The interpreted contact between the glacial till and bedrock is shown on geophysical profile.

Subsurface conditions are detailed on the borehole logs presented in Appendix A. The borehole logs contain a geotechnical description of the soil and rock and present test data for the soil samples recovered. Appendix B provides a tabulated summary of the laboratory test results and presents the results of grain size analyses conducted on the samples.

### 3.2.2 Permafrost and Ground Ice

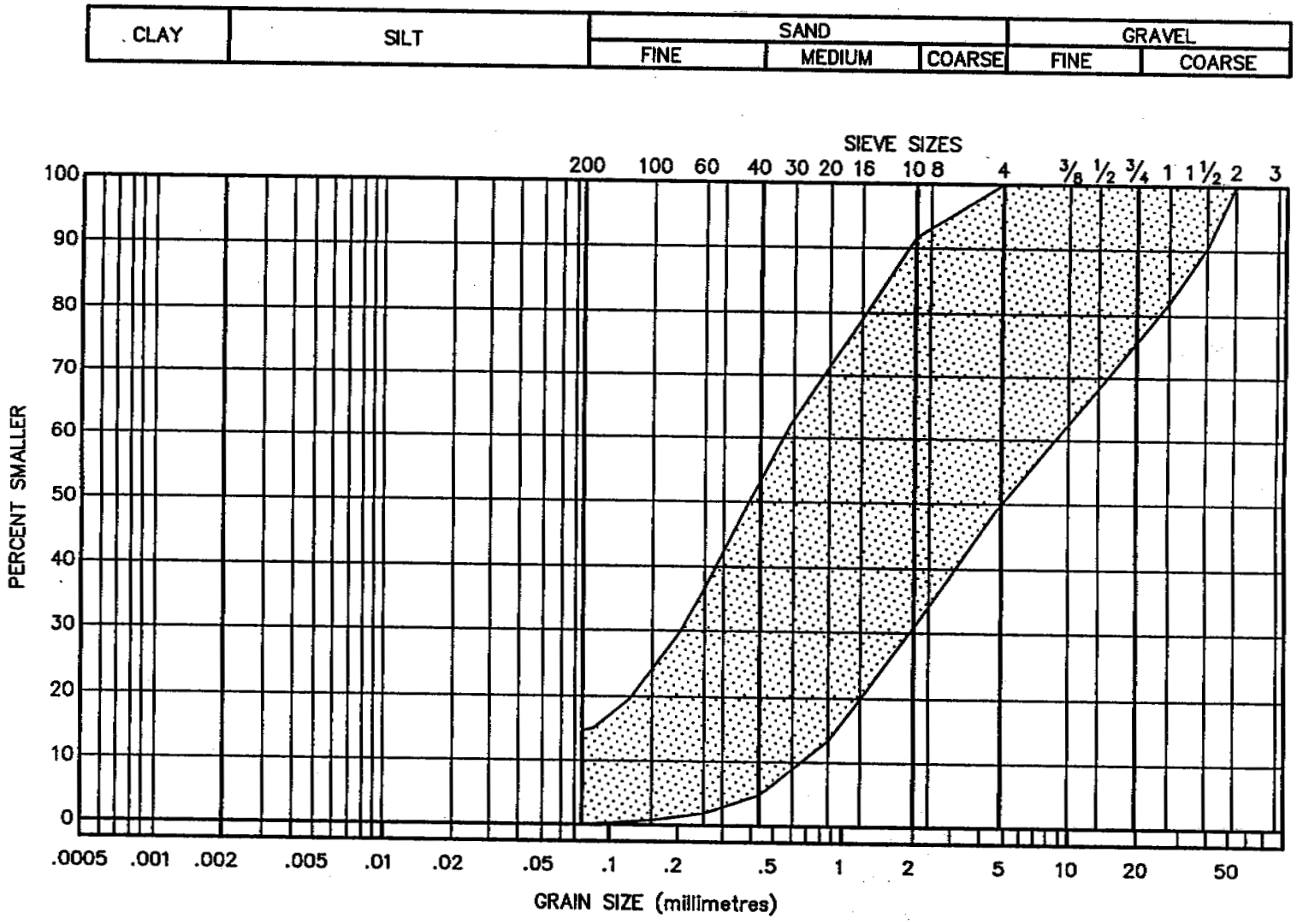
The Koala mine site is situated well within the zone of continuous permafrost. Ground temperatures at depth (greater than 10 m) as measured in and around the Koala mine site are typically between -4 to -6°C unless a water body is located nearby, as is the case at the esker. Ground temperature readings obtained from the three thermistor strings installed in the esker indicate that the ground temperatures below the depth of significant seasonal influence vary between approximately -1.5

and -3°C. Unfrozen zones (taliks) will exist below any water body of significant size and may exist below drainage channels between the lakes.

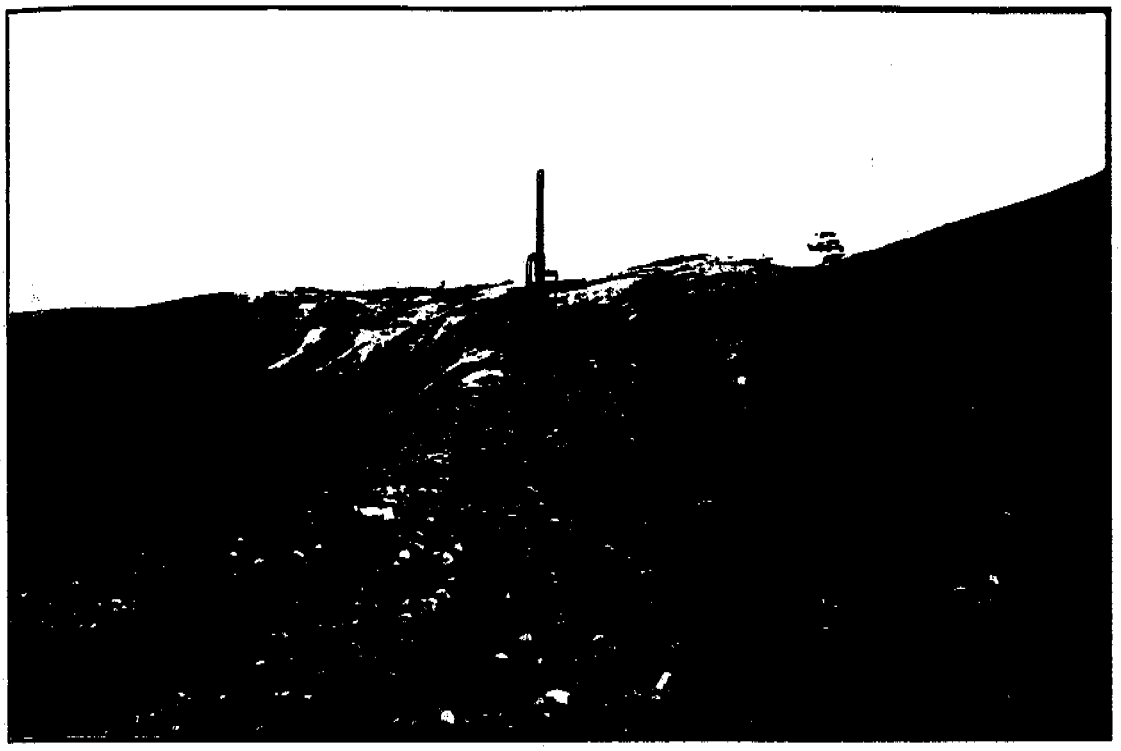
At the time of the geotechnical investigation (July 28 to 30, 1994), the depth of seasonal thaw, as determined by excavating a test trench at three locations using a D-7 dozer, ranged between 0.8 and 1.2 m. The active layer thickness as inferred from the ground temperature data obtained to date ranges from 1.0 and 1.8 m. The active layer thickness information presented above was determined on the crest of the esker where the surface had been previously disturbed.

Surficial permafrost features, such as circular depressions and sinkholes, noted on the natural esker surface indicate the presence of massive ground ice. Thermokarst terrain, which can be described as irregular topography resulting from the melting of excess ground ice and subsequent thaw settlement, is evident along the west side of the esker (see Figure 6). Melt water from the thawing ice was observed along the base of the esker's west side in several places.

Portions of the esker are ice-cored, as has been evidenced by massive ground ice exposures at various locations during gravel extraction operation. Massive ground ice exposed at one location during extraction operations is presented in Figure 7. A massive ice zone was also encountered in Borehole E-3. Locations of possible massive ground ice, as interpreted from the geophysical data, are shown on Figure 4.

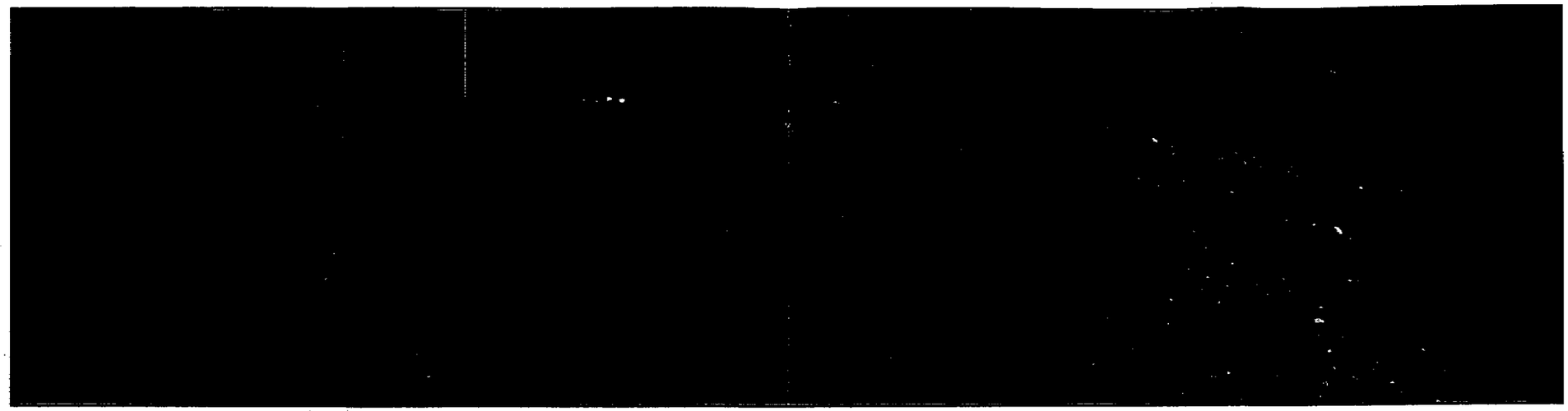



| | | | |
|---|---|---|---|
| EBA Engineering Consultants Ltd. | | PROJECT | ESKER EVALUATION<br>KOALA MINE SITE, N.W.T. |
| CLIENT | BHP DIAMONDS INC. | TITLE | GRAIN SIZE ENVELOPE<br>OF TESTED ESKER SAMPLES |
| DATE 95-03-28 | DWN. AJH / CHKD. DCC | FILE NO. 11439A50A | FIGURE 5 |



*Note ponded melt water at the base of the esker.

FIGURE 6 THERMOKARST TERRAIN



Top: View along the crest of the esker looking approximately north. Impounded to the right and area in the left foreground is one area where ice was exposed.

Bottom: Slope of esker where ice was exposed as indicated above.

Note: Photos taken July 27, 1994.

**FIGURE 7 CREST OF ESKER AND EXPOSED ICE**

Reduced (73%)

# 4.0 GENERAL DEVELOPMENT GUIDELINES

## 4.1 GUIDELINES

The following recommendations have been developed to preserve the integrity of the natural dam that forms the lake. The crest elevation above the lake should maintain a minimum freeboard of 3 m. The crest width should be no less than 10 m wide and the sideslopes of the esker should be developed no steeper than 2 horizontal to 1 vertical (2H:1V).

Should massive ground ice (ice lens or wedge) be exposed during extraction operations, it must be handled in one of two ways. Where it is possible to readily determine both the horizontal and vertical extent of the ice, the ice can be excavated or, if the resulting thaw settlement is considered to be manageable, allowed to thaw in-place. In the event that the volume of ground ice encountered is deemed to be too massive to excavate and the resulting thaw settlement unmanageable, the exposed ice should be left in place and protected with a minimum of two metres of soil cover. The area should be staked to ensure that no further attempt will be made to extract material.

The estimated amount of material that remains available in this esker source for exploitation, as determined using the guidelines presented above, ranges from 150,000 to 200,000 $m^3$. This estimate is based on survey information dated August, 1994. Extraction and stockpiling that continued after the survey date will reduce the available quantities.

The following sections provide general comments with regard to development. All development and restoration should be conducted in accordance with "Environmental Guidelines Pits and Quarries" developed by Indian and Northern Affairs Canada (MacLaren Plansearch 1989).

## 4.2 PIT DEVELOPMENT

### 4.2.1 Summer Extraction

All material obtained to date from this source has been excavated using a progressive thaw and strip operation. The active layer is easily excavated at any time of the year due to its dry, friable nature even when frozen. However, it is not feasible to excavate the well bonded permafrost without pre-thawing or use of explosives. During the summer months, warm air temperatures have thawed the exposed surficial layer of the esker. As the gravel thawed, the material was scraped and stockpiled to continuously expose a fresh surface.

The thickness of daily thaw of gravel exposed to the air will be a function of the moisture content (latent heat) and the climatic conditions. Reworking and handling during stripping provides an opportunity for some drainage, which results in a lower moisture content in the stockpiled gravel, a definite improvement if the material is to be used for winter construction.

Experience gained in winter island construction in the Canadian Beaufort Sea indicates that summer-thawed gravel must be stockpiled in a loose manner and drained to achieve a moisture content of less than about five percent to remain completely workable under winter conditions (Hayley and MacLeod, 1977).

### 4.2.2 Drainage Considerations

Drainage in the vicinity of source development and stockpile material area is critically important to efficient operations. The rate of thaw of permafrost in granular soils is retarded by water and/or enhanced by drainage. Furthermore, standing water may initiate irregular thaw of ice-rich zones, creating deep holes that may cause a hazard to equipment operators. Drainage management plans must be incorporated into the borrow source development and layout plan.

### 4.2.3 Stockpile Management

Processed borrow materials should be stockpiled in such a manner as to prevent segregation and contamination. Separate stockpiles should be created for specific end use such as surfacing gravel, general fill, oversize material and reject materials. Granular material will freeze hard in the stockpile if it is wet from thawing ground ice or if excessive precipitation gets into the material. Developing gravel from a

frozen stockpile can be as costly as the initial excavation of it. The stockpile moisture content must be monitored and kept below 5% if recovery in winter using loaders is planned.

Material in the stockpile that has thawed and subsequently drained should be separated from the frozen portion of the stockpile. This will allow additional material to thaw more readily after start up the following year.

## 4.3 RESTORATION PROCEDURES

Restoration of the borrow area must comply with INAC land use restrictions as outlined in "Environmental Guidelines Pits and Quarries". Restoration of the borrow area will consist of three major components:

- Disposal of rejected material.
- Backfilling of sinkholes, exposed ice, and stabilization of pit walls/slopes.
- Drainage and erosion control.

Rejected material (i.e. cobbles, boulders, etc.) may be disposed of in low lying areas of the borrow site. The sideslopes of the borrow area must be properly dressed to provide a final stable sideslope. The slopes and the surrounding area shall be free of waste piles and left in a neat, trimmed and tidy condition.

All obstruction to natural drainage caused by construction shall be removed and the surrounding are restored to its original conditions. Grading should be such that runoff will not cause erosion that could have an impact on streams or lakes.

The borrow area should be monitored with annual inspections for a few years following abandonment to confirm that it has been left in a thermally stable condition and is not subject to progressive thaw deterioration.

## 5.0 CLOSURE

The information and development guidelines presented in this report are based on the findings from both a geotechnical and geophysical investigation at the subject site. The conditions presented are believed representative of the site; however, should subsequent phases of this portion of the Koala project encounter different conditions, EBA should be notified so that the guidelines presented can be re-evaluated in light of the new findings.

We trust that this report satisfies your present requirements.

Respectfully submitted,
EBA Engineering Consultants Ltd.

REGISTERED ENGINEERING TECHNOLOGIST
MARK A. VALERIOTE
# 05626
ALBERTA

M.A. Valeriote, R.E.T.
Frontier Division

REGISTERED PROFESSIONAL ENGINEER
DONALD HAYLEY
LICENSEE
N.W.T.

D.W. Hayley, P.Eng.
Senior Project Director

REGISTERED PROFESSIONAL ENGINEER
D. C. CATHRO
LICENSEE
N.W.T.

D.C. Cathro, P.Eng.
Chief Engineer
Frontier Division

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
PERMIT NUMBER
P 018
EBA ENGINEERING CONSULTANTS LTD.

MAV/tr

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| | | |
|---|---|---|
| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E1 |
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7172981 E519182 | ELEVATION: 474.90 (m) |

SAMPLE TYPE ■ SHELBY TUBE ▨ DISTURBED ⊠ SPT ▤ NO RECOVERY ▮ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION |
|---|---|---|---|
| 0.0 | SAND (SP) AND GRAVEL – trace of silt to clean, medium to coarse grained sand, fine to coarse grained, rounded to subangular gravel, damp in active layer, moist content increases with depth, non plastic | ▨ | Unfrozen |
| 1.0 | | | Frozen |
| 2.0 | | | |
| 3.0 | | | |
| 4.0 | | | |
| 5.0 | | | |
| 6.0 | | | Ice lense encountered. |
| 7.0 | | | |
| 8.0 | | | |
| 9.0 | | | |
| 10.0 | | | |
| 11.0 | SAND (TILL) (SM) – gravelly, some silt, cobbles and boulders disseminated throughout | | |
| 12.0 | | | |

PLASTIC M.C. LIQUID (20 40 60 80)

● FINES (%) ● (20 40 60 80)

▲ SAND (%) ▲ (20 40 60 80)

■ GRAVEL (%) ■ (20 40 60 80)

DEPTH(m)

EBA ENGINEERING CONSULTANTS LTD.
EDMONTON, ALBERTA

| | |
|---|---|
| LOGGED BY: MAV | COMPLETION DEPTH: 21.0 m |
| REVIEWED BY: MAV | COMPLETE: 94/07/28 |
| Fig. No: 11439-15 | Page 1 of 2 |

95/02/01 01:19PM

| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E1 |
|---|---|---|
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7172981 E519182 | ELEVATION: 474.90 (m) |

SAMPLE TYPE ■ SHELBY TUBE ▨ DISTURBED ☒ SPT ▤ NO RECOVERY ▥ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION | PLASTIC M.C. LIQUID (20 40 60 80) | ● FINES (%) ● / ▲ SAND (%) ▲ / ■ GRAVEL (%) ■ (20 40 60 80) | DEPTH(m) |
|---|---|---|---|---|---|---|
| 12.0 | | | | | | 12.0 |
| 13.0 | | | | | | 13.0 |
| 14.0 | | | | | | 14.0 |
| 15.0 | | | | | | 15.0 |
| | BEDROCK - GRANITE | | | | | |
| 16.0 | | | | | | 16.0 |
| 17.0 | | | | | | 17.0 |
| 18.0 | | | | | | 18.0 |
| 19.0 | | | | | | 19.0 |
| 20.0 | BEDROCK - GRANITE - (continued) | | | | | 20.0 |
| 21.0 | END OF BOREHOLE (21.0 metres)<br>Note: Thermistor string #950 installed to 18.7 metres below grade. | | | | | 21.0 |
| 22.0 | | | | | | 22.0 |
| 23.0 | | | | | | 23.0 |
| 24.0 | | | | | | 24.0 |

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| LOGGED BY: MAV | COMPLETION DEPTH: 21.0 m |
|---|---|
| REVIEWED BY: MAV | COMPLETE: 94/07/28 |
| Fig. No: 11439-15 | Page 2 of 2 |

95/02/01 01:21PM

| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E2 |
|---|---|---|
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7172843 E519186 | ELEVATION: 475.10 (m) |

SAMPLE TYPE ■ SHELBY TUBE ▨ DISTURBED ⊠ SPT ☰ NO RECOVERY ▮▮ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION | PLASTIC — M.C. — LIQUID (20 40 60 80) | ●FINES (%)● / ▲SAND (%)▲ / ■GRAVEL (%)■ (20 40 60 80) | DEPTH(m) |
|---|---|---|---|---|---|---|
| 0.0 | SAND (SM) AND GRAVEL - trace to some silt, brown | | Unfrozen | | | 0.0 |
| | SAND (SM) - some silt, fine grained, uniform, grey | ▨ | | | | |
| 1.0 | SAND (SP) AND GRAVEL - clean, medium to coarse grained sand, fine to coarse grained, rounded to subangular gravel, non plastic | | Frozen | | | 1.0 |
| 2.0 | | | | | | 2.0 |
| 3.0 | | | | | | 3.0 |
| 4.0 | | | | | | 4.0 |
| 5.0 | | | | | | 5.0 |
| 6.0 | | | | | | 6.0 |
| 7.0 | | | | | | 7.0 |
| 8.0 | | | | | | 8.0 |
| 9.0 | | | | | | 9.0 |
| 10.0 | | | | | | 10.0 |
| 11.0 | | | | | | 11.0 |
| 12.0 | | | | | | 12.0 |

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| LOGGED BY: MAV | COMPLETION DEPTH: 21.2 m |
|---|---|
| REVIEWED BY: MAV | COMPLETE: 94/07/29 |
| Fig. No: 11439-16 | Page 1 of 2 |

95/02/01 01:22PM

| | | |
|---|---|---|
| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E2 |
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7172843 E519186 | ELEVATION: 475.10 (m) |

SAMPLE TYPE ■ SHELBY TUBE ▨ DISTURBED ⊠ SPT ▤ NO RECOVERY ▥ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION | PLASTIC M.C. LIQUID 20 40 60 80 | ●FINES (%)● 20 40 60 80 ▲SAND (%)▲ 20 40 60 80 ■GRAVEL (%)■ 20 40 60 80 | DEPTH(m) |
|---|---|---|---|---|---|---|
| 12.0 | | | | | | 12.0 |
| 13.0 | | | | | | 13.0 |
| 14.0 | | | | | | 14.0 |
| 15.0 | | | | | | 15.0 |
| 16.0 | | | | | | 16.0 |
| 17.0 | SAND (TILL) (SM) – gravelly, some silt, cobbles and boulders disseminated throughout | | | | | 17.0 |
| 18.0 | | | | | | 18.0 |
| 19.0 | | | | | | 19.0 |
| 20.0 | SAND (TILL) – (continued) | | | | | 20.0 |
| 21.0 | | | | | | 21.0 |
| | END OF BOREHOLE (21.2 metres) Note: Thermistor string #951 installed to 19.1 metres below grade. | | | | | |
| 22.0 | | | | | | 22.0 |
| 23.0 | | | | | | 23.0 |
| 24.0 | | | | | | 24.0 |

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| | |
|---|---|
| LOGGED BY: MAV | COMPLETION DEPTH: 21.2 m |
| REVIEWED BY: MAV | COMPLETE: 94/07/29 |
| Fig. No: 11439-16 | Page 2 of 2 |

95/02/01 01:23PM

| | | |
|---|---|---|
| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E3 |
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7173207 E519111 | ELEVATION: 474.60 (m) |

SAMPLE TYPE ■ SHELBY TUBE ▨ DISTURBED ⊠ SPT ▤ NO RECOVERY ▥ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION |
|---|---|---|---|
| 0.0 | SAND (SP) – trace to some gravel, trace of silt to clean, fine to coarse grained sand, damp in active layer, non plastic | N | Unfrozen |
| 1.0 | | | Frozen |
| 7.0 | ICE – massive | | |

PLASTIC M.C. LIQUID 20 40 60 80

● FINES (%) ● 20 40 60 80

▲ SAND (%) ▲ 20 40 60 80

■ GRAVEL (%) ■ 20 40 60 80

DEPTH(m): 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0

EBA ENGINEERING CONSULTANTS LTD.
EDMONTON, ALBERTA

| | |
|---|---|
| LOGGED BY: MAV | COMPLETION DEPTH: 20.9 m |
| REVIEWED BY: MAV | COMPLETE: 94/07/29 |
| Fig. No: 11439-17 | Page 1 of 2 |

95/02/01 01:24PM

| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E3 |
|---|---|---|
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7173207 E519111 | ELEVATION: 474.60 (m) |

SAMPLE TYPE ■ SHELBY TUBE ▨ DISTURBED ☒ SPT ▤ ▥ NO RECOVERY ▥ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION | PLASTIC M.C. LIQUID (20 40 60 80) | ● FINES (%) ● / ▲ SAND (%) ▲ / ■ GRAVEL (%) ■ (20 40 60 80) | DEPTH(m) |
|---|---|---|---|---|---|---|
| 12.0 | | | | | | 12.0 |
| 13.0 | SAND (TILL) (SM) – gravelly, some silt, cobbles and boulders disseminated throughout | | | | | 13.0 |
| 14.0 | | | | | | 14.0 |
| 15.0 | | | | | | 15.0 |
| 16.0 | | | | | | 16.0 |
| 17.0 | BEDROCK – GRANITE | | | | | 17.0 |
| 18.0 | | | | | | 18.0 |
| 19.0 | | | | | | 19.0 |
| 20.0 | BEDROCK – GRANITE – (continued) | | | | | 20.0 |
| 21.0 | END OF BOREHOLE (20.9 metres) Note: Thermistor string #952 installed to 18.7 metres below grade. | | | | | 21.0 |
| 22.0 | | | | | | 22.0 |
| 23.0 | | | | | | 23.0 |
| 24.0 | | | | | | 24.0 |

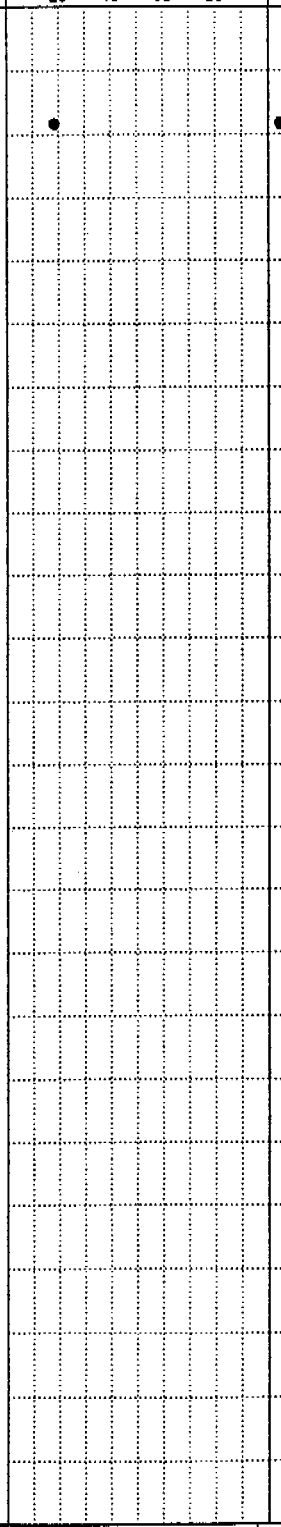
| EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA | LOGGED BY: MAV | COMPLETION DEPTH: 20.9 m |
|---|---|---|
| | REVIEWED BY: MAV | COMPLETE: 94/07/29 |
| | Fig. No: 11439-17 | Page 2 of 2 |

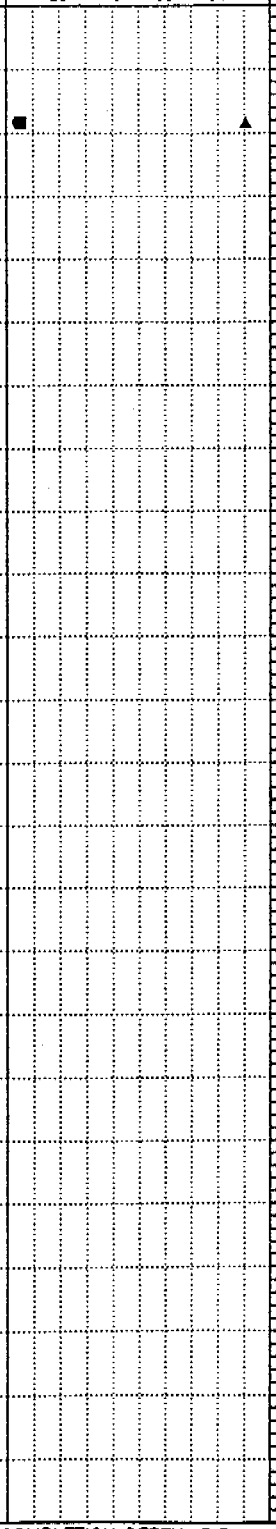
95/02/01 01:25PM

| | | |
|---|---|---|
| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E4 |
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7173210 E519050 | ELEVATION: 464.00 (m) |

SAMPLE TYPE ■ SHELBY TUBE ▨ DISTURBED ⊠ SPT ☰ ▯ NO RECOVERY ▮ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION |
|---|---|---|---|
| 0.0 | MOSS AND ORGANIC SILT | | Unfrozen |
| | SAND (SP) – trace of gravel, trace of silt, fine to coarse grained sand, wet, non plastic | ▨ | |
| 1.0 | | | |
| 2.0 | | | Frozen<br>Ice lense encountered. |
| 3.0 | | | |
| 4.0 | SAND (TILL) (SM) – gravelly, some silt, cobbles and boulders disseminated throughout | | |
| 5.0 | | | |
| 6.0 | END OF BOREHOLE (5.5 metres)<br>Standpipe installed to 2.9 metres | | |
| 7.0 | | | |
| 8.0 | | | |
| 9.0 | | | |
| 10.0 | | | |
| 11.0 | | | |
| 12.0 | | | |




DEPTH(m) 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0

EBA ENGINEERING CONSULTANTS LTD.
EDMONTON, ALBERTA

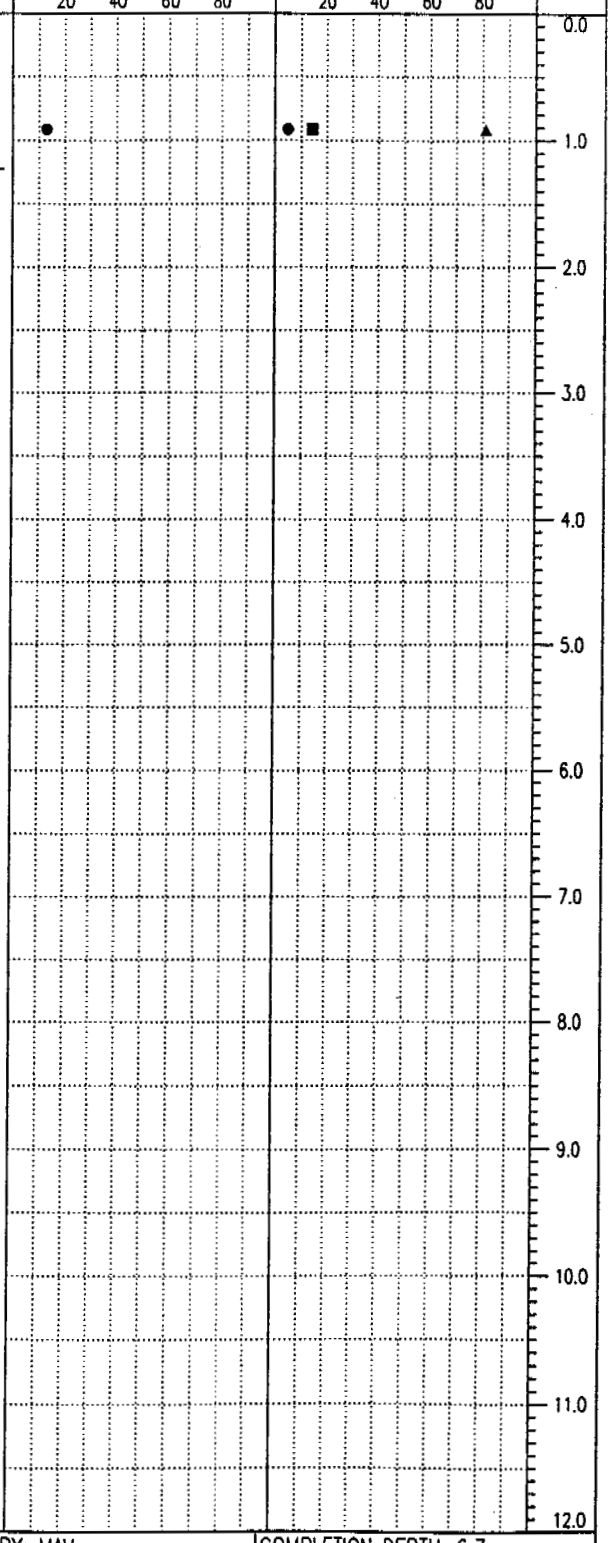
| | |
|---|---|
| LOGGED BY: MAV | COMPLETION DEPTH: 5.5 m |
| REVIEWED BY: MAV | COMPLETE: 94/07/29 |
| Fig. No: 11439-18 | Page 1 of 1 |

95/02/01 01:26PM

| | | |
|---|---|---|
| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E5 |
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7173130 E519050 | ELEVATION: 464.00 (m) |

SAMPLE TYPE ■ SHELBY TUBE ⁄ DISTURBED ☒ SPT ▤ NO RECOVERY ▯ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION |
|---|---|---|---|
| 0.0 | MOSS AND ORGANIC SILT | | Unfrozen |
| | SAND (SW) – some fine grained gravel, trace of silt, fine to coarse grained sand, moist to wet, non plastic, dark brown | ⁄ | |
| 2.0 | | | Frozen |
| | SAND (TILL) (SM) – gravelly, some silt, cobbles and boulders disseminated throughout | | |
| 4.0 | | | |
| | BEDROCK – GRANITE | | |
| 6.0 | | | |
| 7.0 | END OF BOREHOLE (6.7 metres) Standpipe installed to 3.0 metres | | |
| 8.0 | | | |
| 9.0 | | | |
| 10.0 | | | |
| 11.0 | | | |
| 12.0 | | | |

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| | |
|---|---|
| LOGGED BY: MAV | COMPLETION DEPTH: 6.7 m |
| REVIEWED BY: MAV | COMPLETE: 94/07/29 |
| Fig. No: 11439-19 | Page 1 of 1 |

95/02/21 03:49PM

| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E6 |
|---|---|---|
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7172845 E519139 | ELEVATION: 463.50 (m) |

SAMPLE TYPE ■ SHELBY TUBE ▨ DISTURBED ☒ SPT ☰ NO RECOVERY ▯ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION |
|---|---|---|---|
| 0.0 | MOSS AND ORGANIC SILT | | Unfrozen |
| | SAND (SM) – some fine grained gravel, some silt, fine to coarse grained sand, damp in active layer, non plastic | | |
| 1.0 | | | |
| | | | Frozen |
| 2.0 | | | Ice lense encountered. |
| 3.0 | END OF BOREHOLE (3.0 metres) | | |
| | Note: Borehole terminated due to sloughing coarse gravel and cobbles. Unable to retract drill rod, bit lost down hole. | | |
| 4.0 | | | |
| 5.0 | | | |
| 6.0 | | | |
| 7.0 | | | |
| 8.0 | | | |
| 9.0 | | | |
| 10.0 | | | |
| 11.0 | | | |
| 12.0 | | | |

PLASTIC M.C. LIQUID
20 40 60 80

● FINES (%) ●
20 40 60 80

▲ SAND (%) ▲
20 40 60 80

■ GRAVEL (%) ■
20 40 60 80

DEPTH(m)

EBA ENGINEERING CONSULTANTS LTD.
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| | |
|---|---|
| LOGGED BY: MAV | COMPLETION DEPTH: 3.0 m |
| REVIEWED BY: MAV | COMPLETE: 94/07/30 |
| Fig. No: 11439-20 | Page 1 of 1 |

95/02/01 01:28PM

| | | |
|---|---|---|
| KOALA MINE SITE | BHP DIAMONDS INC. | BOREHOLE NO: 11439-E7 |
| ESKER EVALUATION | DRILL: TAMROCK ZOOMTRAK TURBO DHA | PROJECT NO: 0101-11439.3 |
| KOALA LAKE, N.W.T. | UTM ZONE: 12 N7172977 E519137 | ELEVATION: 465.00 (m) |

SAMPLE TYPE ■ SHELBY TUBE ▨ DISTURBED ☒ SPT ▤ NO RECOVERY ▯ CORE

| DEPTH(m) | LITHOLOGICAL DESCRIPTION | SAMPLE TYPE | GROUND ICE DESCRIPTION |
|---|---|---|---|
| 0.0 | MOSS AND ORGANIC SILT | | Unfrozen |
| | SAND (SM) – some fine grained gravel, some silt, fine to coarse grained sand, damp in active layer, non plastic | ▨ | |
| 2.0 | | | Frozen |
| | SAND (SP) AND GRAVEL – trace of silt, cobbles disseminated throughout | | |
| 4.0 | END OF BOREHOLE (3.7 metres)<br>Note: Borehole terminated due to sloughing coarse gravel and cobbles. Unable to retract drill rod. | | |

PLASTIC M.C. LIQUID (20 40 60 80)

● FINES (%) ● (20 40 60 80)

▲ SAND (%) ▲ (20 40 60 80)

■ GRAVEL (%) ■ (20 40 60 80)

DEPTH(m) 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0

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| | |
|---|---|
| LOGGED BY: MAV | COMPLETION DEPTH: 3.7 m |
| REVIEWED BY: MAV | COMPLETE: 94/07/30 |
| Fig. No: 11439-21 | Page 1 of 1 |

95/02/01 01:30PM

# APPENDIX B

# LABORATORY TEST RESULTS

**ESKER EVALUATION**
**GEOTECHNICAL INVESTIGATION**
**LABORATORY TEST RESULT SUMMARY**

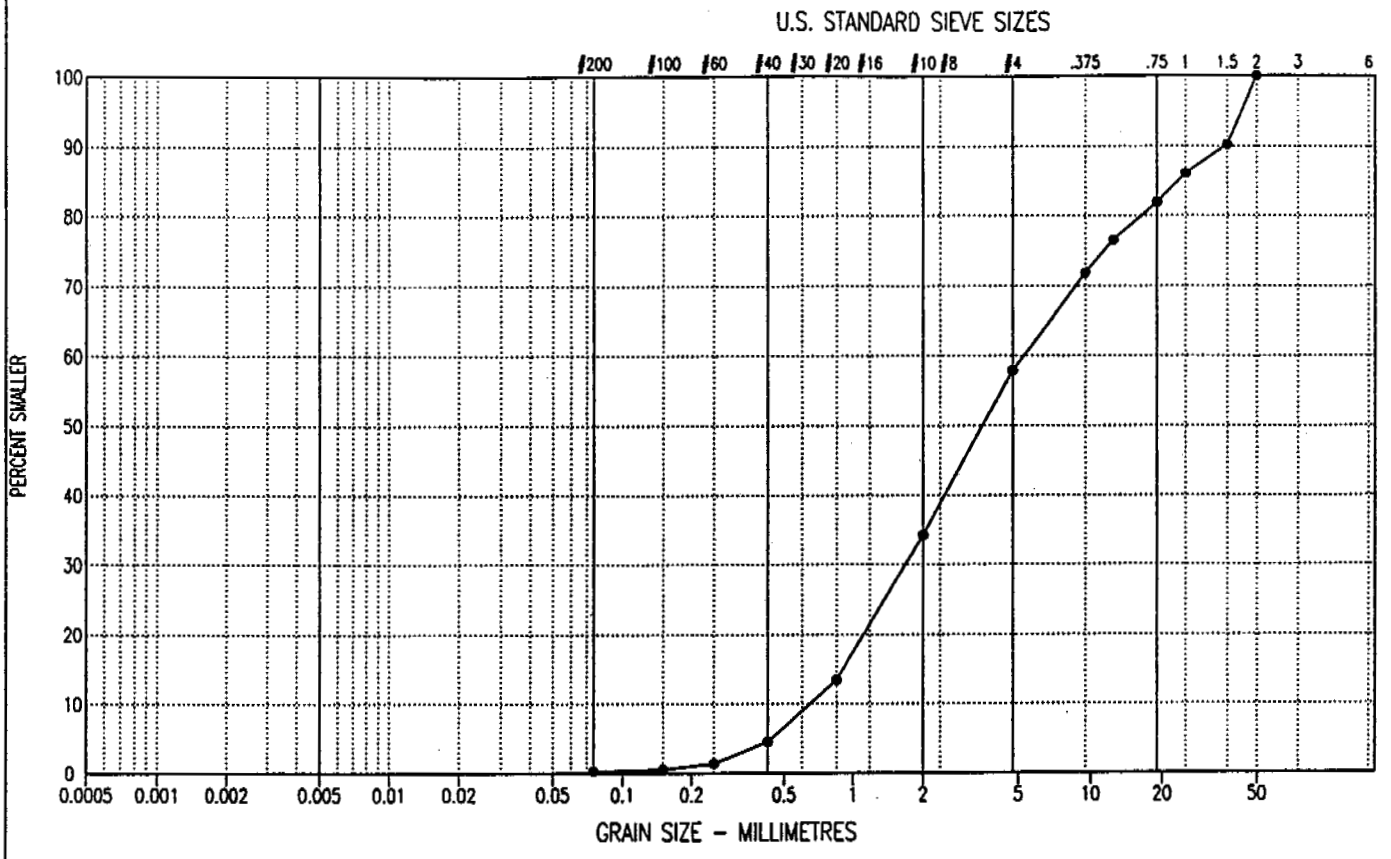
| Borehole | Depth from (m) | Depth to (m) | Moisture Content (%) | Silt (%) | Sand (%) | Gravel (%) | USC |
|---|---|---|---|---|---|---|---|
| E-1 | 0.6 | 0.9 | 2.1 | 0.3 | 57.6 | 42.1 | SP |
| E-2 | 0.8 | 1.1 | 2.2 | 0.5 | 50.1 | 49.4 | SP |
| E-3 | 0.6 | 0.8 | 3.0 | 1.3 | 97.7 | 1.0 | SP |
| E-4 | 0.6 | 1.2 | 18.3 | 4.5 | 90.4 | 5.1 | SP |
| E-5 | 0.6 | 1.5 | 12.8 | 4.9 | 80.9 | 14.2 | SW |
| E-7 | 0.6 | 1.2 | 8.6 | 13.6 | 70.8 | 15.6 | SM |

EBA File No: 0101-11439.3

# EBA Engineering

## PARTICLE SIZE – ANALYSIS OF SOILS

| CLAY | SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|---|
| | | FINE | MEDIUM | COARSE | FINE | COARSE |




| SYMBOL | BOREHOLE NUMBER | DEPTH (m) | DESCRIPTION | | | Cu | Cc | U.S.C |
|---|---|---|---|---|---|---|---|---|
| | | | CLAY & SILT % | SAND % | GRAVEL % | | | |
| ●——● | ESKER-1 | 0.60 – 0.90 | 0.3 | 57.6 | 42.1 | 8.0 | 0.8 | SP |

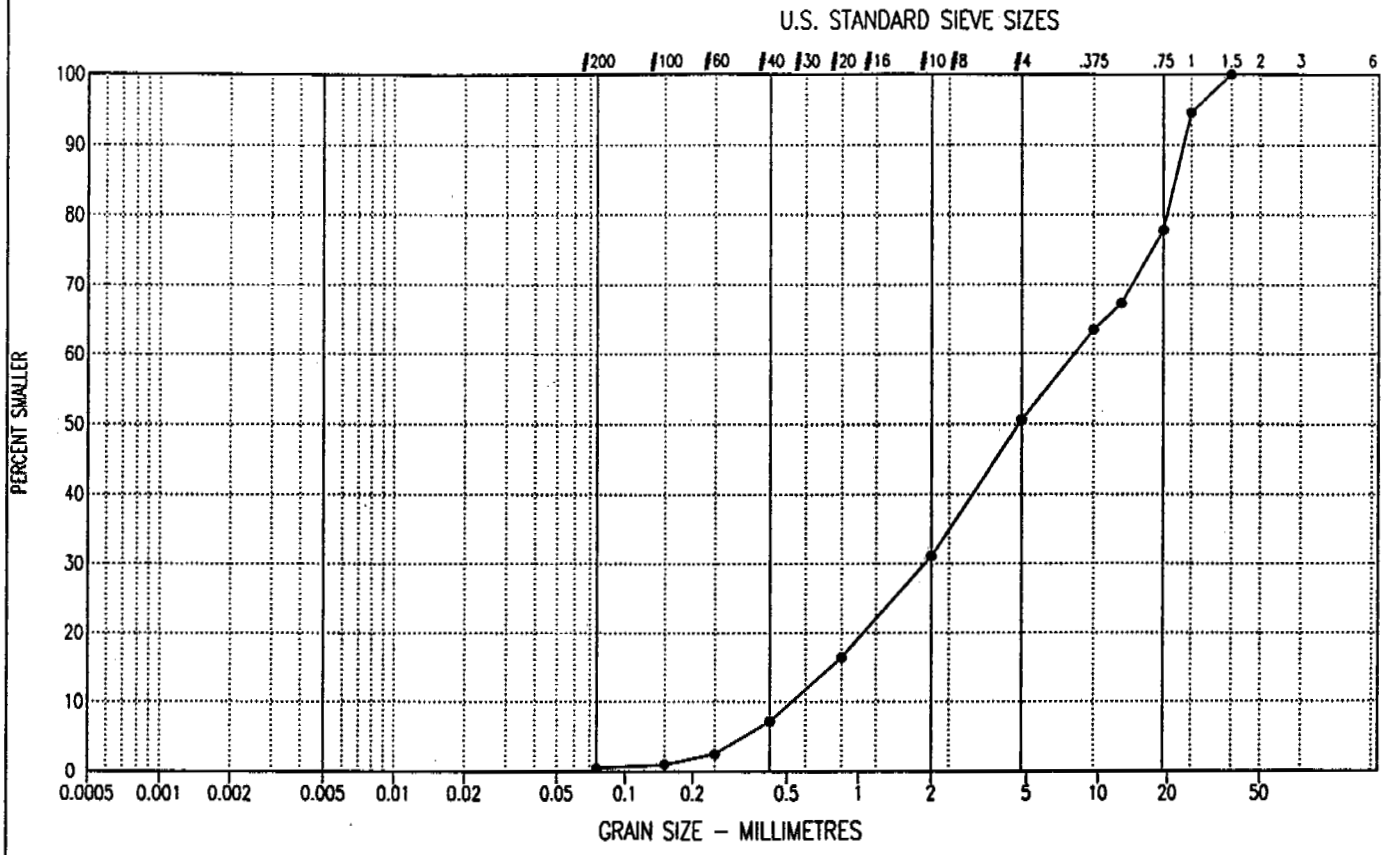
Project: 101-11439.4 Date Tested: 94/08/05 BY: LT

Tested in accordance with ASTM D422 unless otherwise noted.

# EBA Engineering

## PARTICLE SIZE – ANALYSIS OF SOILS

| CLAY | SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|---|
| | | FINE | MEDIUM | COARSE | FINE | COARSE |




| SYMBOL | BOREHOLE NUMBER | DEPTH (m) | DESCRIPTION | | | Cu | Cc | U.S.C |
|---|---|---|---|---|---|---|---|---|
| | | | CLAY & SILT % | SAND % | GRAVEL % | | | |
| ●——● | ESKER-2 | 0.80 – 1.10 | 0.5 | 50.1 | 49.4 | 14.8 | 0.8 | SP |

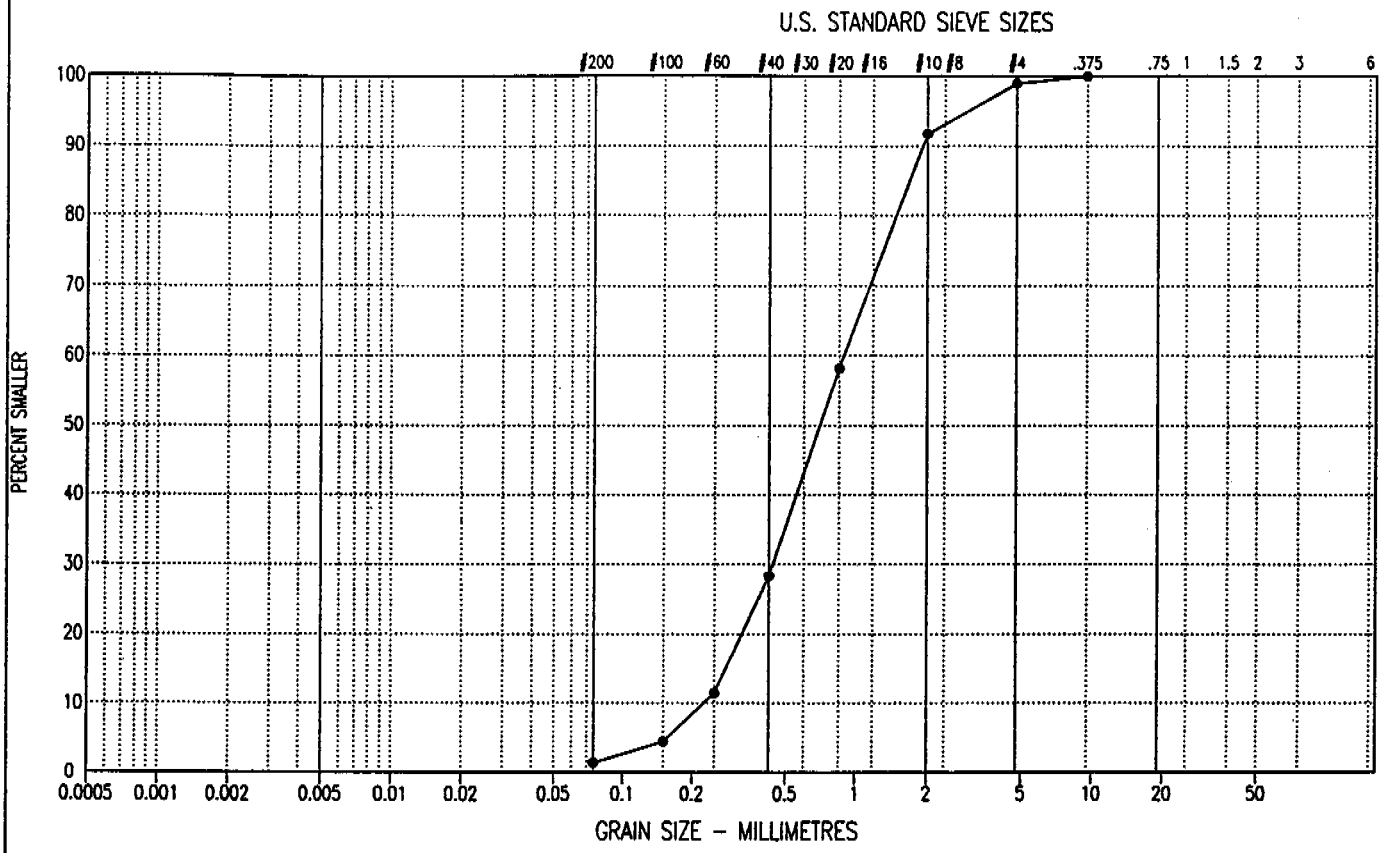
Project: 101-11439.4 Date Tested: 94/08/05 BY: LT

Tested in accordance with ASTM D422 unless otherwise noted.

# EBA Engineering

## PARTICLE SIZE - ANALYSIS OF SOILS

| CLAY | SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|---|
| | | FINE | MEDIUM | COARSE | FINE | COARSE |




| SYMBOL | BOREHOLE NUMBER | DEPTH (m) | DESCRIPTION | | | Cu | Cc | U.S.C |
|---|---|---|---|---|---|---|---|---|
| | | | CLAY & SILT % | SAND % | GRAVEL % | | | |
| ●——● | ESKER-3 | 0.60 - 0.80 | 1.3 | 97.7 | 1.0 | 4.0 | 1.0 | SP |

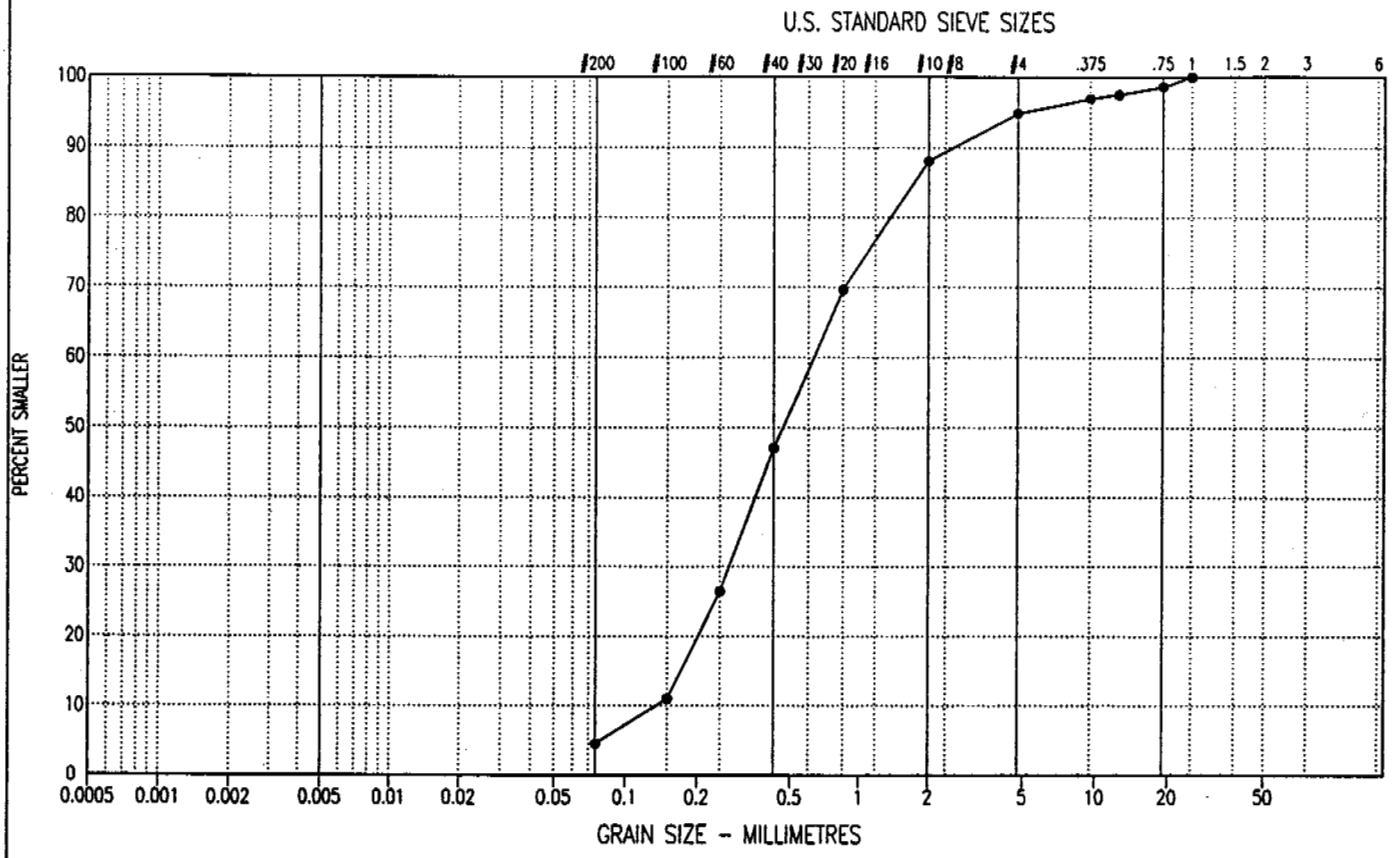
Project: 101-11439.4 Date Tested: 94/08/05 BY: DB

Tested in accordance with ASTM D422 unless otherwise noted.

# EBA Engineering

## PARTICLE SIZE – ANALYSIS OF SOILS

| CLAY | SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|---|
| | | FINE | MEDIUM | COARSE | FINE | COARSE |




| SYMBOL | BOREHOLE NUMBER | DEPTH (m) | DESCRIPTION | | | Cu | Cc | U.S.C |
|---|---|---|---|---|---|---|---|---|
| | | | CLAY & SILT % | SAND % | GRAVEL % | | | |
| ●——● | ESKER–4 | 0.60 – 1.20 | 4.5 | 90.4 | 5.1 | 4.9 | 0.9 | SP |

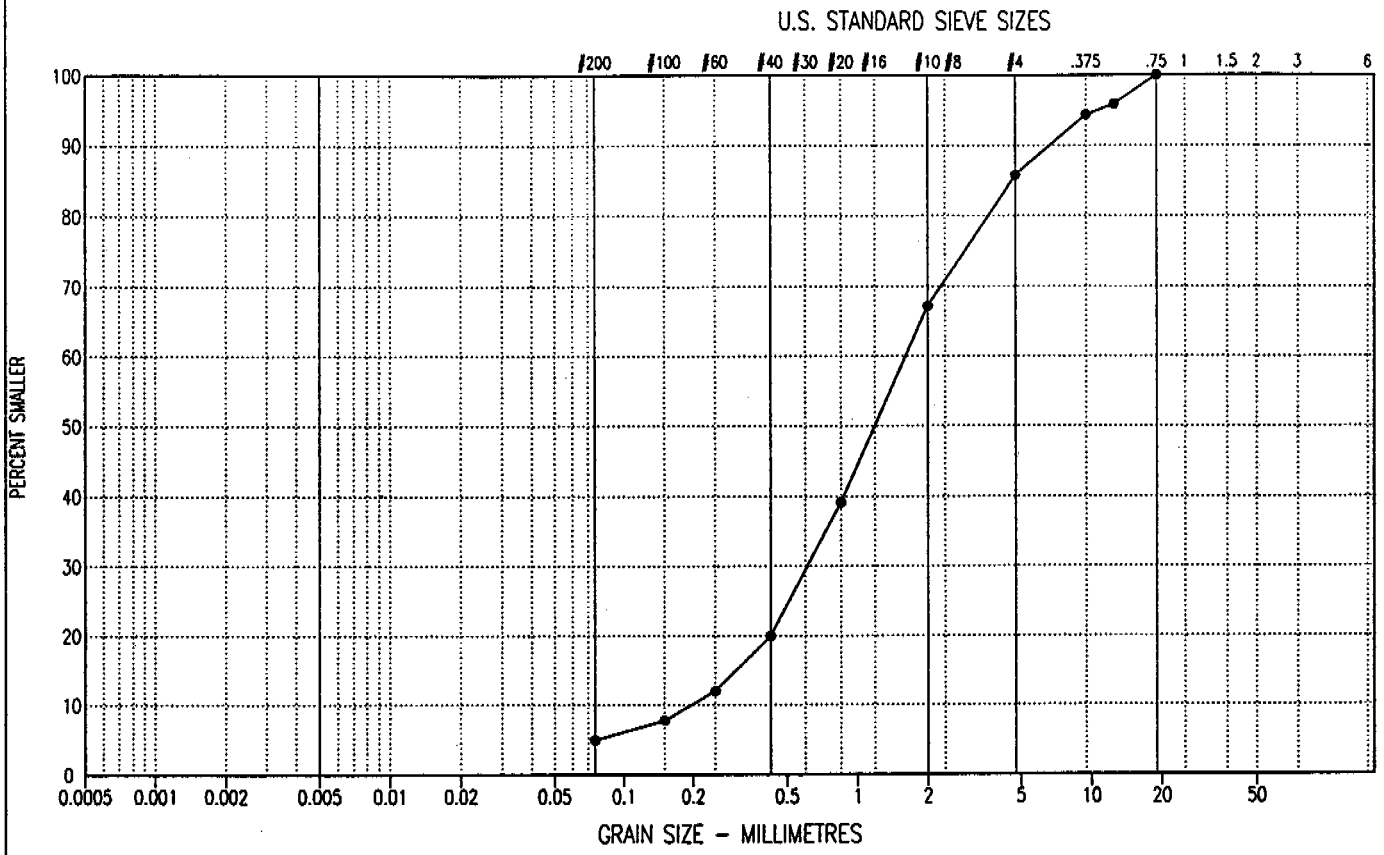
Project: 101–11439.4 Date Tested: 94/08/05 BY: DB

Tested in accordance with ASTM D422 unless otherwise noted.

# EBA Engineering

## PARTICLE SIZE – ANALYSIS OF SOILS

| CLAY | SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|---|
| | | FINE | MEDIUM | COARSE | FINE | COARSE |




| SYMBOL | BOREHOLE NUMBER | DEPTH (m) | DESCRIPTION | | | Cu | Cc | U.S.C |
|---|---|---|---|---|---|---|---|---|
| | | | CLAY & SILT % | SAND % | GRAVEL % | | | |
| ●——● | ESKER-5 | 0.60 – 1.50 | 4.9 | 80.9 | 14.2 | 8.4 | 1.2 | SW |

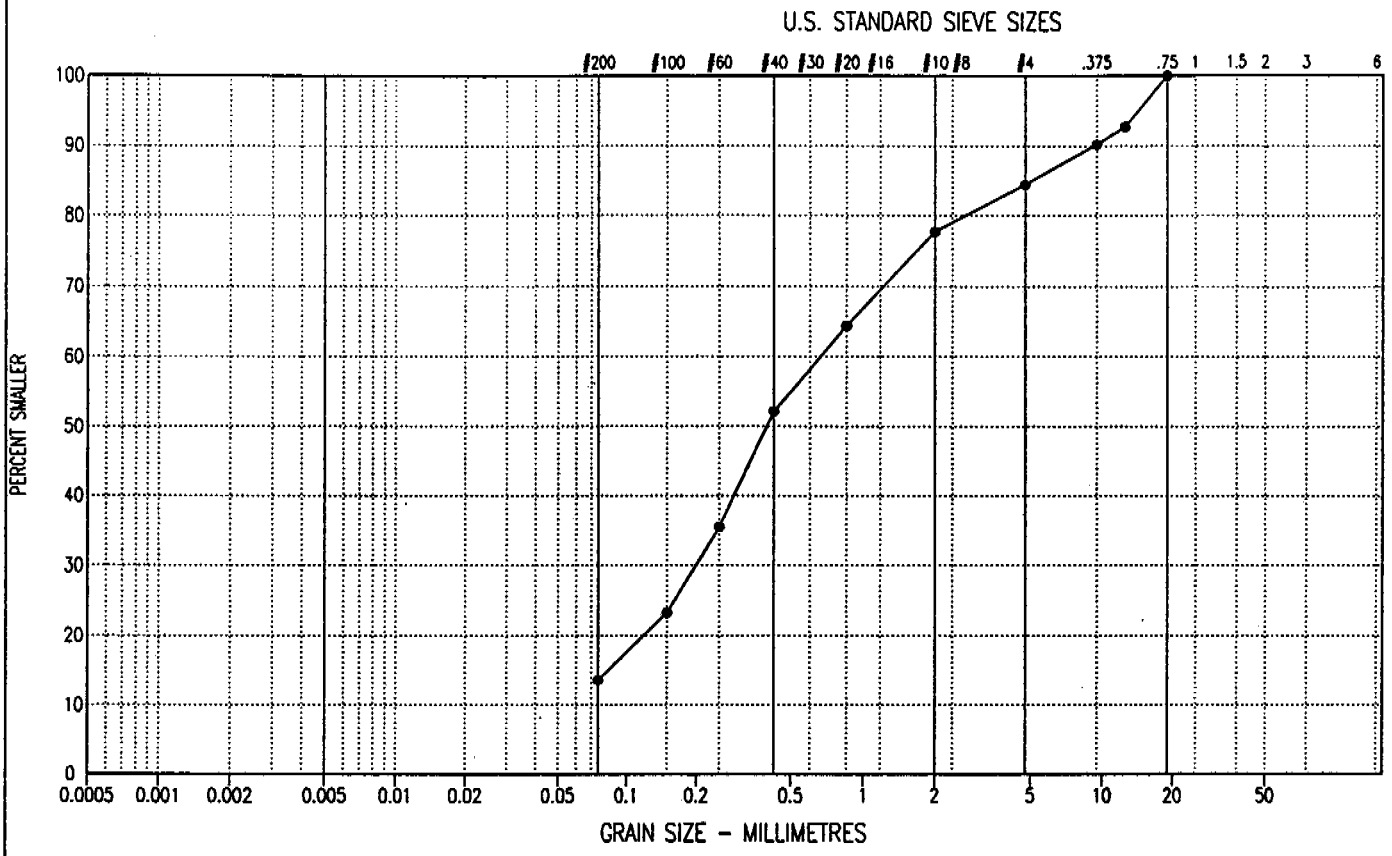
Project: 101-11439.4 Date Tested: 94/08/08 BY: DB

Tested in accordance with ASTM D422 unless otherwise noted.

# EBA Engineering

## PARTICLE SIZE – ANALYSIS OF SOILS

| CLAY | SILT | SAND | | | GRAVEL | |
|---|---|---|---|---|---|---|
| | | FINE | MEDIUM | COARSE | FINE | COARSE |




| SYMBOL | BOREHOLE NUMBER | DEPTH (m) | DESCRIPTION | | | Cu | Cc | U.S.C |
|---|---|---|---|---|---|---|---|---|
| | | | CLAY & SILT % | SAND % | GRAVEL % | | | |
| ●——● | ESKER-7 | 0.60 – 1.20 | 13.6 | 70.8 | 15.6 | 12.7 | 1.1 | SM |

Project: 101-11439.4 Date Tested: 94/08/07 BY: DB

Tested in accordance with ASTM D422 unless otherwise noted.

# APPENDIX C

# GROUND TEMPERATURE PROFILES

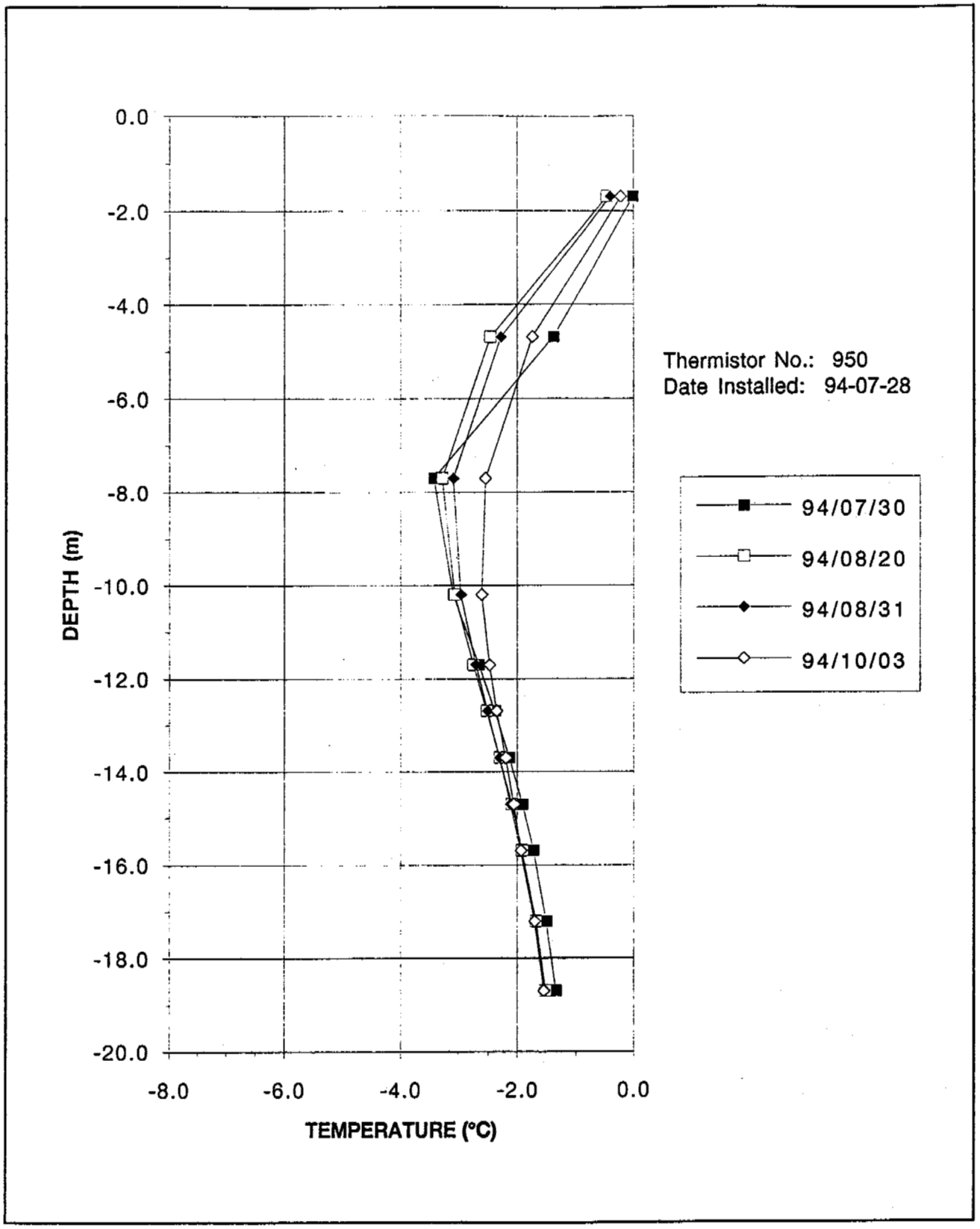



**FIGURE C.1** **GROUND TEMPERATURE PROFILE**
**BOREHOLE E-1**
**ESKER EVALUATION**

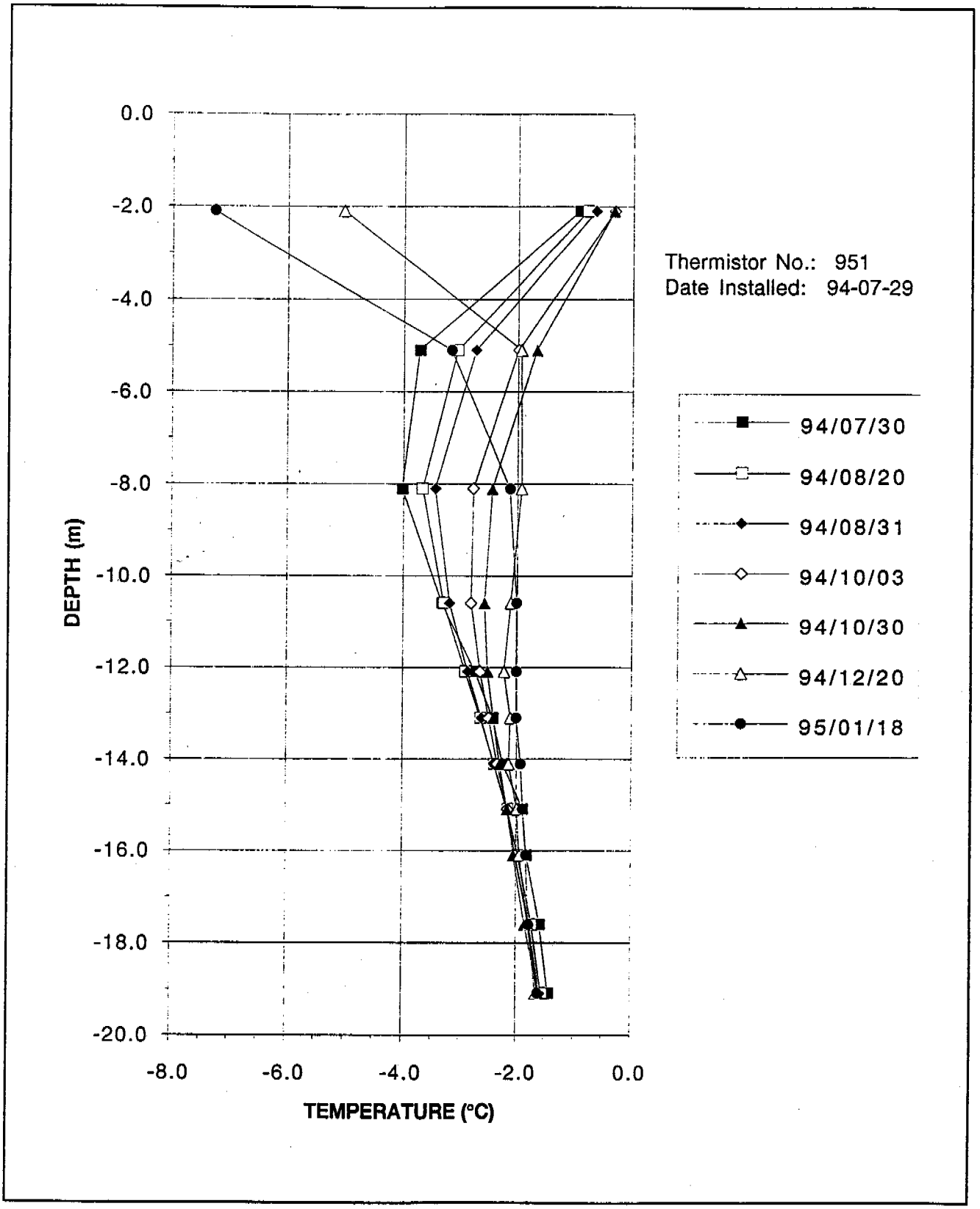



**FIGURE C.2** **GROUND TEMPERATURE PROFILE**
**BOREHOLE E-2**
**ESKER EVALUATION**

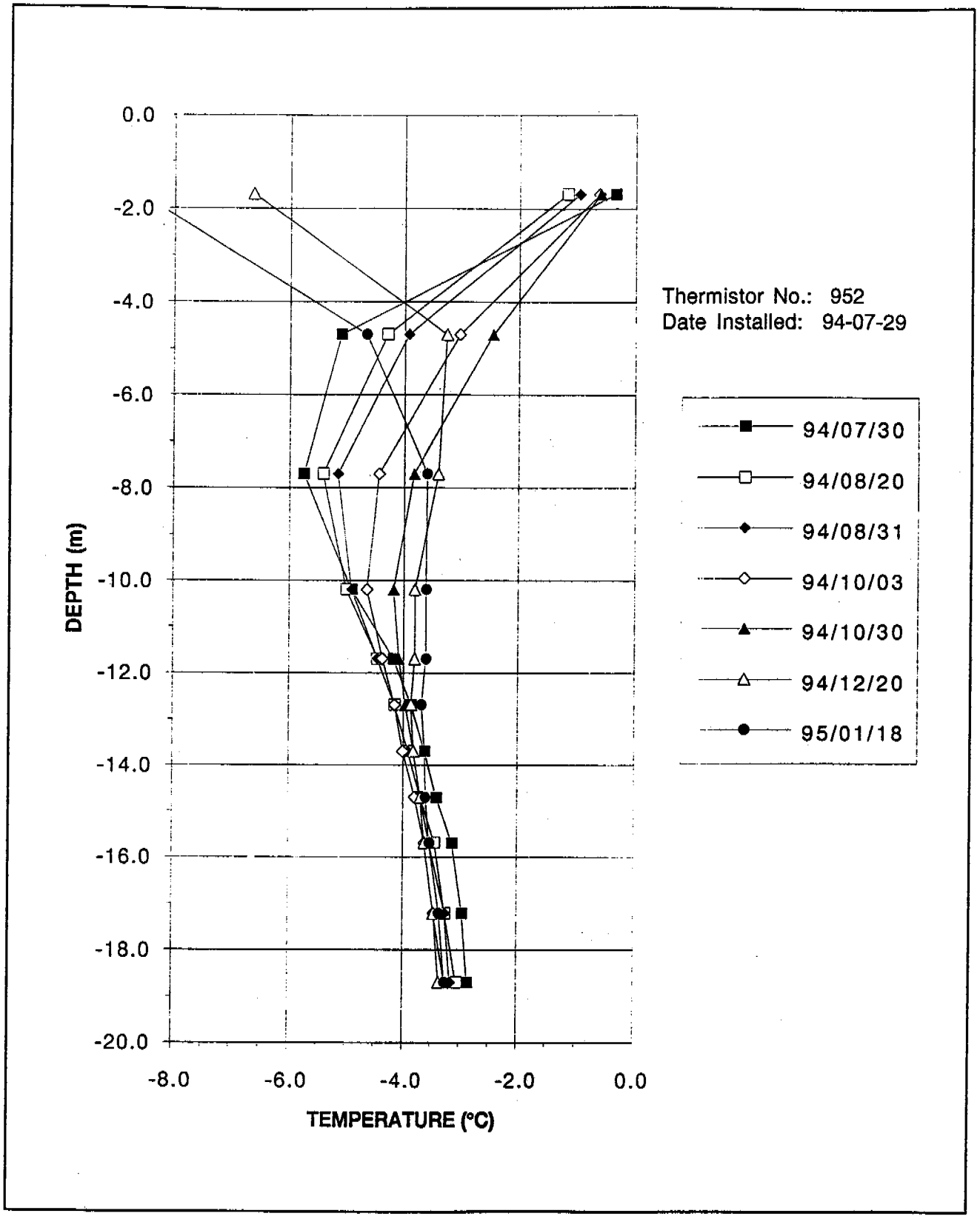



**FIGURE C.3** **GROUND TEMPERATURE PROFILE**
**BOREHOLE E-3**
**ESKER EVALUATION**