GRANULAR RESOURCE INVESTIGATION
NORTHERN RICHARDS ISLAND, NWT
(VOLUME I OF II)
GEOTECHNICAL PROGRAM

0101-11413

SEPTEMBER, 1995

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GRANULAR RESOURCE INVESTIGATION
NORTHERN RICHARDS ISLAND, NWT
(VOLUME I OF II)
GEOTECHNICAL PROGRAM
Part of the Northern Oil and Gas Action Program (NOGAP)
Project A4 - Granular Resource Inventory

SUBMITTED TO:

Indian and Northern Affairs Canada
Ottawa, Ontario

PREPARED BY:

EBA Engineering Consultants Ltd.
Edmonton, Alberta

0101-11413

September, 1995

EXECUTIVE SUMMARY

The discovery of petroleum reserves north of the Mackenzie Delta has led the Government of Canada to anticipate a possible future demand for granular resources in the region. As a result, Indian and Northern Affairs Canada (INAC) has compiled a comprehensive granular resource inventory as part of the Northern Oil and Gas Action Program (NOGAP) Project A4. A need was identified to investigate potential sources located specifically on the northern portion of Richards Island.

A geotechnical investigation was completed during March of 1994 for INAC at accessible sites that are considered representative of the terrain conditions existing within the potential resource targets. The purpose of the investigation was to provide preliminary information regarding the feasibility of exploiting sand deposits in this area to meet the expected demand for onshore granular resources associated with Mackenzie Delta oil and gas production. The investigation comprised eight sampled boreholes, which were sampled to a maximum penetration of 11.1 metres.

The site investigation examined characteristic geological features within three potential resource targets. Two of the resource targets comprise "Sand Ridges"; the third resource target contains "Glaciofluvial Terraces". The soil encountered on the sand ridges generally consists of poorly-graded sand with a highly variable fines content. Below the depth of seasonal thaw (active layer) the moisture content was determined to be greater than 20 percent, which will require careful planning consideration be given to extraction methodology and pit drainage requirements.

Only one borehole was drilled on the glaciofluvial terraces due to inclement weather encountered while on location and associated time constraints. Due to the limited investigation activities at the discontinuous glaciofluvial terraces, further investigation is recommended.

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1.0 INTRODUCTION

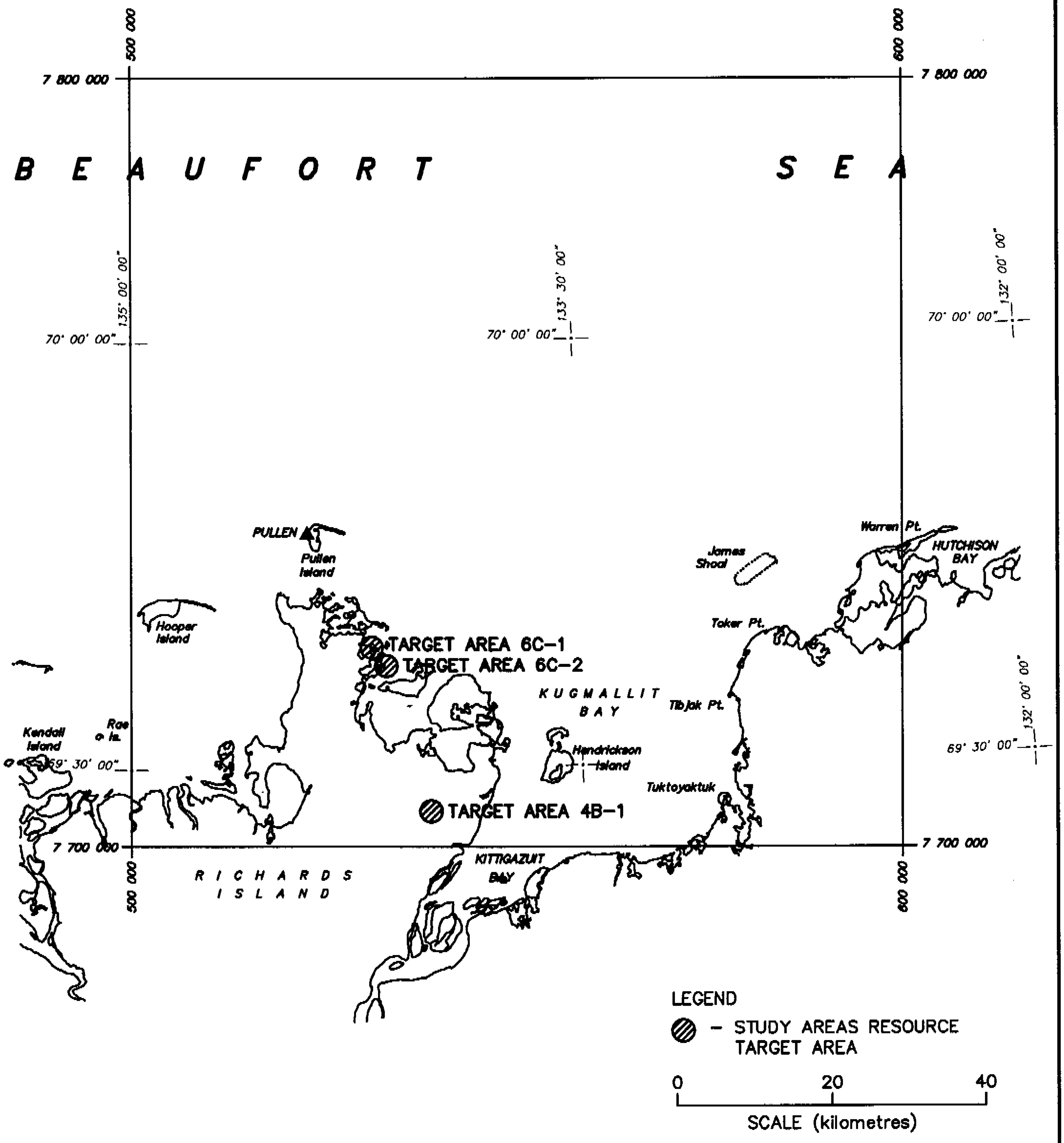
1.1 BACKGROUND

The discovery of petroleum reserves north of the Mackenzie Delta has led the Government of Canada to anticipate a possible future demand for granular resources in the region. This study is part of the Northern Oil and Gas Action Program (NOGAP) - Project A4: Granular Resources Inventory and Management. In anticipation of hydrocarbon development in the Beaufort Sea, the objective of NOGAP - Project A4 was to compile a comprehensive granular resources inventory for the Beaufort - Mackenzie Region. The inventory currently includes a range of deposits, from prospective sites identified on the basis of geotechnical and other scientific information to significant proven borrow sources for which detailed information on the location, type, quantities and qualities of materials is known. A need was identified to investigate potential sources located specifically on the northern portion of Richards Island.

Indian and Northern Affairs Canada (INAC) retained EBA Engineering Consultants Ltd. (EBA) to investigate potential granular resource deposits located on northern Richards Island as identified by others. An earlier study commissioned by INAC and completed by Terrain Analysis & Mapping Services Limited (TAMSL, 1993) identified potential granular resource deposits located on northern Richards Island. The deposits identified by TAMSL have been summarized in a report entitled "Potential Granular Resources and Their Geological Constraints, Northern Richards Island".

The overall objective of the EBA investigation has been to provide preliminary information regarding the feasibility of exploiting sand deposits in this area to meet the expected demand for onshore granular resources associated with Mackenzie Delta oil and gas production. Surficial sands are widespread and potentially easily developed; however, potential constraints inhibiting exploitation include the unknown extent of ground ice and the susceptibility of this terrain to thermal disturbance. For these reasons, these deposits had not previously been included in the existing granular resource inventory compiled by INAC under NOGAP Project A4.

This report presents a general background of the geological setting of Richards Island, describes the investigation that was conducted in March, 1994 and evaluates the granular materials encountered. Figure 1 presents a location map of the areas that were investigated on northern Richards Island during the 1994 winter field program.



EBA Engineering Consultants Ltd.	PROJECT GRANULAR RESOURCE INVESTIGATION NORTHERN RICHARDS ISLAND, N.W.T.
CLIENT INDIAN AND NORTHERN AFFAIRS CANADA	TITLE GENERAL LOCATION PLAN

DATE	94–06–22	DWN.	AJH	CHKD.	MAV	FILE NO.	11413A90

FIGURE 1

1.2 PROJECT AUTHORIZATION

This study was authorized by Supply and Services Canada (SSC) under Contract No. A7134-3-0048/01-ST. The designated Scientific Authority for the project was Mr. R.J. Gowan, P.Geol., Geotechnical Advisor for the Natural Resources and Environment Branch of INAC.

1.3 PROJECT SCOPE

The project scope, as defined in the contract, included the following:

- field program planning including logistics;
- general supervision of all field operations;
- log all soil samples recovered during borehole drilling;
- prepare soil samples for shipping;
- laboratory testing services; and
- data analyses and report preparation

2.0 METHODOLOGY

2.1 REVIEW OF EXISTING LITERATURE

Several granular resource inventory studies, dating back to 1972, have been completed for Richards Island. These studies were prompted by a relatively high demand for construction materials in the Tuktoyaktuk and southern Beaufort Sea areas due to oil and gas exploration activities. The majority of the studies completed previously centre on the southern portion of Richards Island. Nevertheless, these reports were briefly reviewed for guideline purposes. The granular studies previously conducted were completed by J.D. Mollard and Associates Ltd. (1972), Ripley, Klohn and Leonoff International Ltd. (1972), EBA (1975, 1986), TAMSL (1976, 1993), and BBT Geotechnical Consultants Ltd. et al., (1983).

The most recent and directly relevant inventory for the northern portion of Richards Island was completed by TAMSL (1993) for INAC. The TAMSL study included data compilation, literature review, airphoto interpretation, and field reconnaissance and it provided the most extensive documentation of granular resources in the study area.

The potential resource areas identified in the TAMSL report that INAC and EBA chose to evaluate were Resource Areas 6C-1 and 6C-2, which are located in the vicinity of Hansen Harbour and Wallace Bay, respectively. In addition, Resource Area 4B-1 was targeted as an area of special interest as it was believed to contain gravel.

2.2 AIRPHOTO INTERPRETATION

The surficial conditions of the potential resource areas that were selected for site investigation were interpreted using 1:56,000 scale airphotos that were obtained from the National Airphoto Library. The airphotos used were from Series A22974 and A23757 which were photographed in July of 1974. These interpretations were made prior to the field program to aid planning activities. Proposed drilling locations and site access were initially identified on the basis of airphoto interpretation.

3.0 FIELD PROGRAM

3.1 EQUIPMENT AND CREW

The drilling contractor, Midnight Sun Drilling Co. Ltd. of Whitehorse, Yukon, was contracted directly by INAC. Drilling was conducted using a CME 750 drill rig mounted on an all-terrain, rubber tire carrier. All holes were advanced using a 100-mm I.D. permafrost core barrel and/or solid flight augers. Continuous sample was recovered and visually logged. Representative samples were bagged and placed in plastic pails for shipment to EBA's Edmonton laboratory. Drilling was conducted as a single-shift operation. Mr. S. Traynor represented INAC in the field during this portion of the program.

In conjunction with the drilling program, a geophysical survey was conducted by EBA. The geophysical survey consisted of ground penetrating radar (pulseEKKO™ IV) and non-contacting resistivity surveys (EM-31, EM-34). The results from the geophysical program are reported under separate cover.

The location and elevation of each borehole were determined by Challenger Surveys and Services Ltd. of Calgary, Alberta during a post-mission survey using differential GPS techniques.

A sled camp was used as the base of operations. The camp was mobilized from Inuvik and moved only once during the program to maintain close proximity to the sites being investigated. In addition to the drill crew and senior engineering technologist employed at the drill rig, the camp complement included the INAC Scientific Authority, a cook, a drill/camp supervisor, a equipment operator/camp maintenance man, a scout/bear monitor, and a camp maintenance assistant.

A summary of daily activities for the entire project, of which this investigation was a component, is presented in Appendix A.

3.2 SITE INVESTIGATION

Three potential resource targets were investigated during the four-day field program. The location of each source is shown on Figure 1. The extent of the investigation in each area is summarized below:

RESOURCE AREA	RESOURCE TARGET	NUMBER OF BOREHOLES	MAXIMUM PENETRATION (m)
6C	6C-1	3	8.8
6C	6C-2	4	11.1
4B	4B-1	1	9.9

Detailed descriptions including colour and textural variations are presented on the boreholes logs in Appendix B.

3.3 LABORATORY PROGRAM

All samples obtained during the investigation were sealed in plastic bags and shipped to EBA's Edmonton facility for testing. The natural moisture content was determined for 49 samples. Sieve analyses were conducted on 18 samples to determine particle size distributions. Gradation curves are presented with the particle size test results in Appendix C.

Laboratory test results are summarized on the borehole log, where appropriate, and are tabulated on the laboratory test summary that is presented in Appendix C.

4.0 GEOLOGY

4.1 GENERALIZED GEOLOGICAL SETTING

The following describes the generalized geological setting for Richards Island. For more detailed information, the reader is referred to the report that has been prepared by TAMSL (1993), which presents a detailed geological history for the area.

Richards Island forms part of the Tuktoyaktuk Coastlands (Rampton, 1988) and is predominantly composed of middle to late Quaternary fluvial, deltaic and estuarine sediments that comprise clays, silts, and sands. The retreat of the most recent Wisconsinan glaciation provided final deposition on the island, leaving rolling ground moraine, lacustrine deposits, as well as ice-contact landforms including eskers and kames. A substantial number of higher elevation landforms exhibit evidence of wave modification, in the form of beach and terrace features.

Northern Richards Island is within the region of continuous permafrost with a mean annual air temperature of approximately -10°C. The area, excluding taliks under large lakes and the marine shoreline, is underlain by between 600 and 750 metres of permafrost (Dallimore, 1992). Ground ice is common, varying from interstitial ice, ice wedges and pingos, to massive bodies of nearly clear tabular ice. Mackay (1974) suggests that the growth of tabular ice can elevate the ground surface by 5 to 10 metres; evidence from boreholes previously drilled on Richards Island indicate that bodies of massive ice within glacially derived features can exceed 20 metres in thickness. In some instances, a portion of the relief of a landform may be attributed to the presence of ground ice.

Much of the present day Richards Island topography is complex terrain resulting from the growth and degradation of massive ice bodies (French, 1976).

4.2 RESOURCE SPECIFIC GEOLOGICAL FEATURES

The site specific geological features at each of the investigated target areas are presented in the TAMSL (1993) report.

4.2.1 Sand Ridges

Target Areas 6C-1 and 6C-2 were identified by TAMSL as being "Sand Ridges". The possibility of encountering a near-surface clay unit and/or massive ice was considered potentially prohibitive to recovering material from this type of feature. The characteristic surface cover, generally 0.1 to 0.3 m thick consists of moss, thin organic layers and silty sand. On the ridge flanks, the vegetation cover increases and the silty organic layers become thicker.

In Resource Area 6C, 10 to 15 m of sand have been noted on coastal exposures (TAMSL, 1993).

4.2.2 Marine and Glaciofluvial Terraces

Target Area 4B-1, which is located south of Summer Bay, is believed to be a glaciofluvial terrace. These terraces are composed primarily of sand with thin gravel layers noted.

5.0 SUBSURFACE CONDITIONS

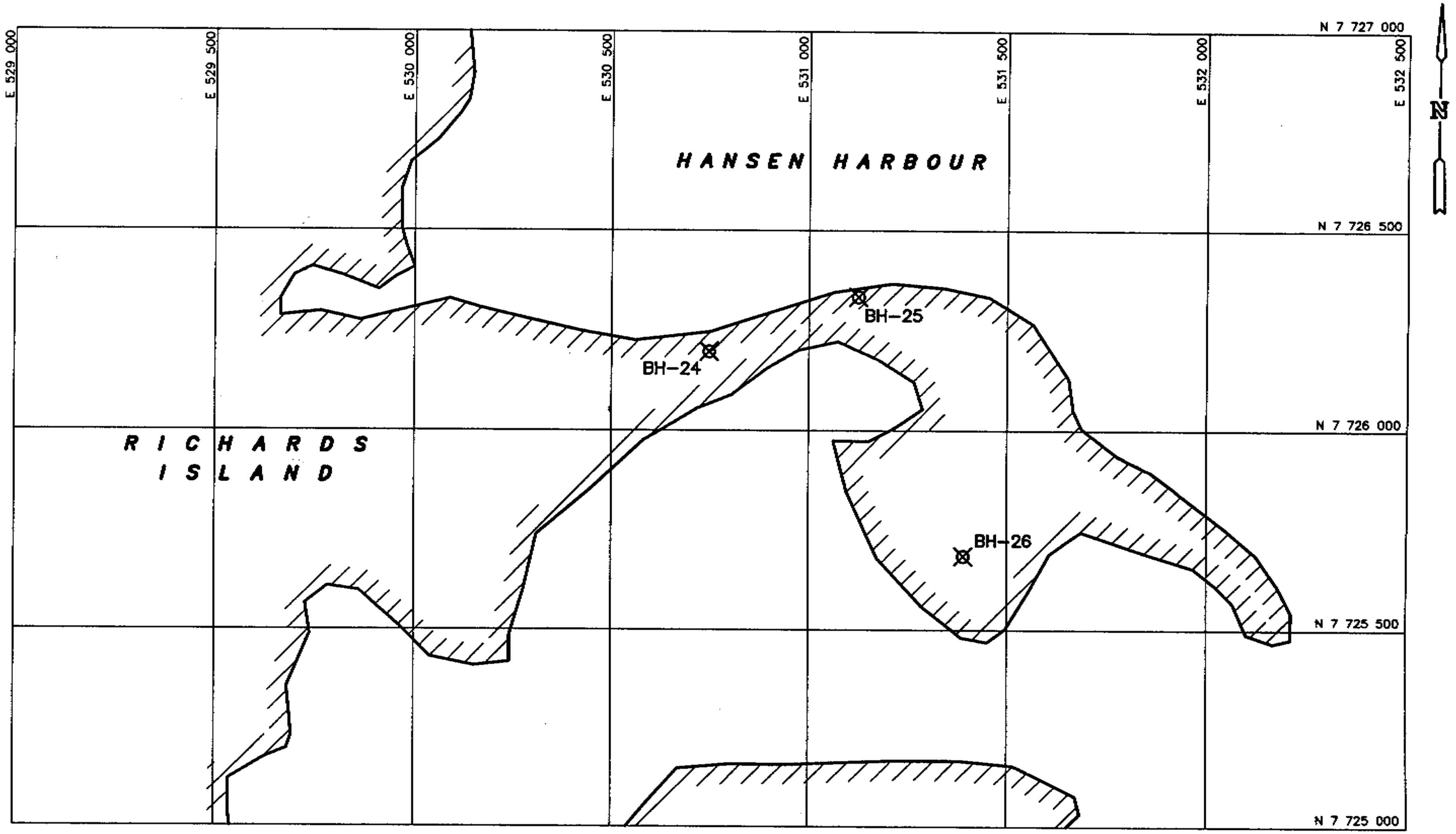
5.1 RESOURCE TARGET 6C-1

Resource Target 6C-1 is a sand ridge that is oriented in a general east-west direction, located on the southern shore of Hansen Harbour. A total of three boreholes (Borehole No. 11413-24, 25, and 26) were drilled at this target location. A detailed map with UTM coordinates showing the borehole locations for Resource Target 6C-1 is presented in Figure 2. The soil encountered consists of poorly-graded sand with a highly variable fines content (7-35 percent) and a trace of gravel. The moisture contents measured range from 7 to 27 percent with an average of 22 percent. Only three of the nineteen moisture contents determined were less than 20 percent; all three of these samples were obtained from within 1 m of surface.

Figure 3 presents diagnostic profiles of moisture, fines, sand, and gravel content versus depth. A composite gradation envelope for the particle size analyses that were conducted on 6 samples is presented in Figure 4.

5.2 RESOURCE TARGET 6C-2

Resource Target 6C-2 is a sand ridge that is oriented in a general southwest-northeast direction, located on the south side of Wallace Bay. This area consists of two sand ridges, one to the north and one to the south of an unnamed lake (531 700 mE and 7 722 800 mN), which is situated on a lower terrace. A total of four boreholes



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CLIENT
INDIAN AND NORTHERN AFFAIRS CANADA

PROJECT
GRANULAR RESOURCE INVESTIGATION
NORTHERN RICHARDS ISLAND, N.W.T.

TITLE
BOREHOLE LOCATION PLAN
RESOURCE TARGET 6C-1

DATE	94-06-27	DWN.	AJH	CHKD.	MAV	FILE NO.	11413A13

FIGURE 2

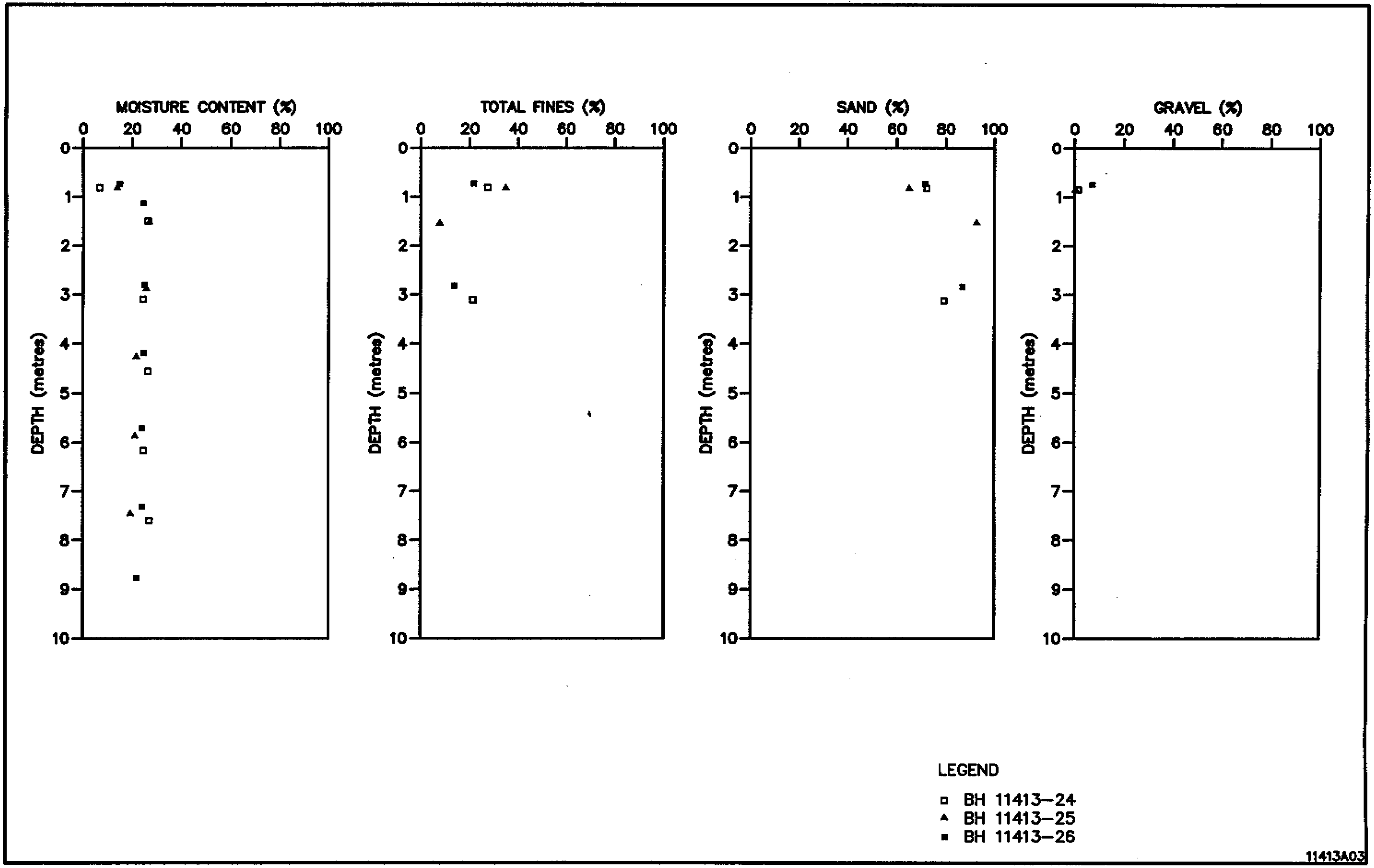
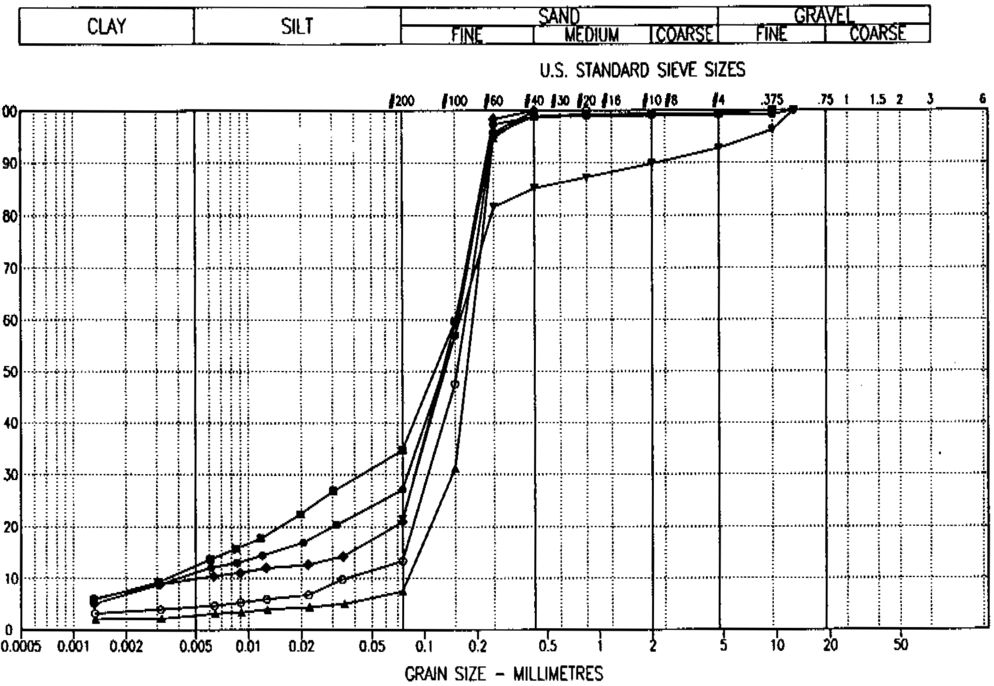


FIGURE 3 PERCENTAGES OF MOISTURE, TOTAL FINES, SAND AND GRAVEL VS. DEPTH, RESOURCE TARGET 6C–1

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
●——●	24	0.80 - 0.90	10.9	16.2	72.0	0.9	37.8	10.3	SM
◆——◆	24	3.00 - 3.20	9.8	11.2	79.0	0.0	28.2	10.5	SM
■——■	25	0.80 - 0.90	12.1	22.5	64.7	0.7	42.7	4.4	SM
▲——▲	25	1.40 - 1.60	2.7	4.8	92.5	0.0	2.4	1.3	SP-SM
▼——▼	26	0.60 - 0.90	21.4		71.2	7.4	3.0	1.0	SM
○——○	26	2.70 - 2.90	4.4	9.0	86.6	0.0	4.9	2.0	SM

Project: 101-11413 Date Tested: 94/04/21 BY: MH

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FIGURE 4 GRADING ENVELOPE RESOURCE TARGET 6C-1

(Borehole No. 11413-20, 21, 22 and 23) were drilled at this target location. The borehole locations for Resource Target 6C-2 are presented in Figure 5.

One of the four boreholes was drilled on the southern ridge; this borehole penetrated poorly-graded sand with the fines content ranging from 7 to 14 percent. The sand unit encountered contains a trace of gravel within the upper zone. The lowest moisture content determined from the samples retained from this borehole was 17 percent.

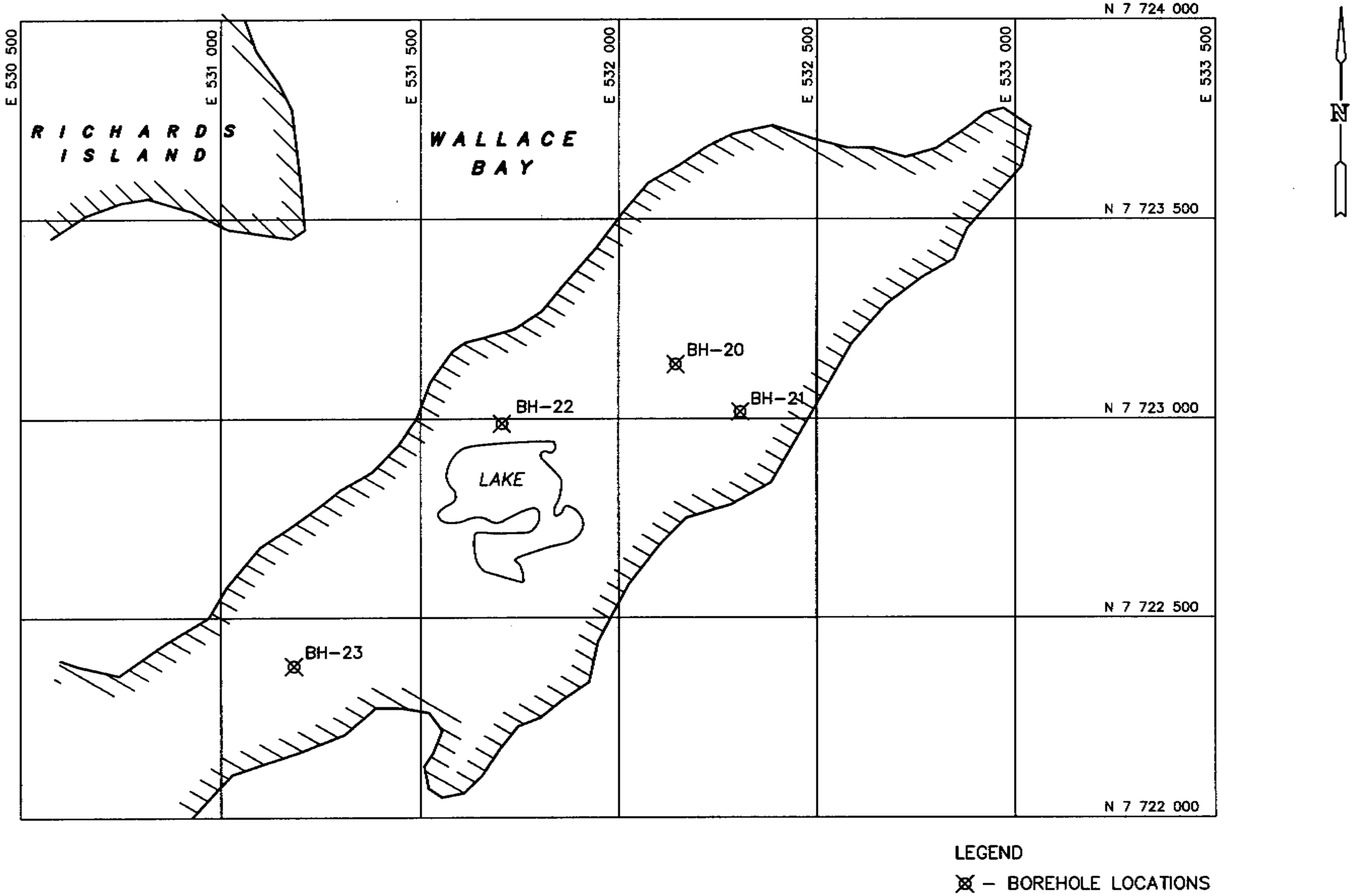
The other three boreholes were drilled on the northern ridge. One of these boreholes was drilled towards the southern portion of this feature and encountered a till with fines contents in excess of 59 percent. The minimum moisture content determined from the samples retained from this borehole was 26 percent. The two other boreholes that were drilled on the northern ridge penetrated poorly-graded sand with the fines contents ranging from 7 to 14 percent. Measured moisture contents ranged from 16 to 26 percent.

Figure 6 presents diagnostic profiles of moisture, fines, sand, and gravel content versus depth. A composite gradation envelope for the particle size analyses that were conducted on 8 samples is presented in Figure 7.

5.3 RESOURCE TARGET 4B-1

Resource Target 4B-1 is a series of discontinuous glacialfluvial terraces, located south of Summer Bay. Only one borehole (Borehole No. 11413-27) was drilled at this location due to inclement weather encountered while on location and to the associated time constraints. The borehole location for Resource Target 4B-1 is presented in Figure 8. The borehole, which was positioned where TAMSL had mapped a gravel deposit, encountered gravelly sand with a trace of silt overlying sand with some silt and a trace of gravel. A moisture content of 5 percent was determined for a sample that was retained from within the upper 1.5 m. All other samples recovered below this depth, with the exception of one, had moisture contents greater than 20 percent.

Figure 9 presents diagnostic profiles of moisture, fines, sand and gravel content versus depth. A composite gradation envelope for the particle size analyses that were conducted on 4 samples is presented in Figure 10.



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PROJECT	GRANULAR RESOURCE INVESTIGATION NORTHERN RICHARDS ISLAND, N.W.T.
CLIENT	INDIAN AND NORTHERN AFFAIRS CANADA
TITLE	**BOREHOLE LOCATION PLAN** **RESOURCE TARGET 6C-2**

DATE	94-06-27	DWN.	AJH	CHKD.	MAV	FILE NO.	11413A05B	FIGURE 5	

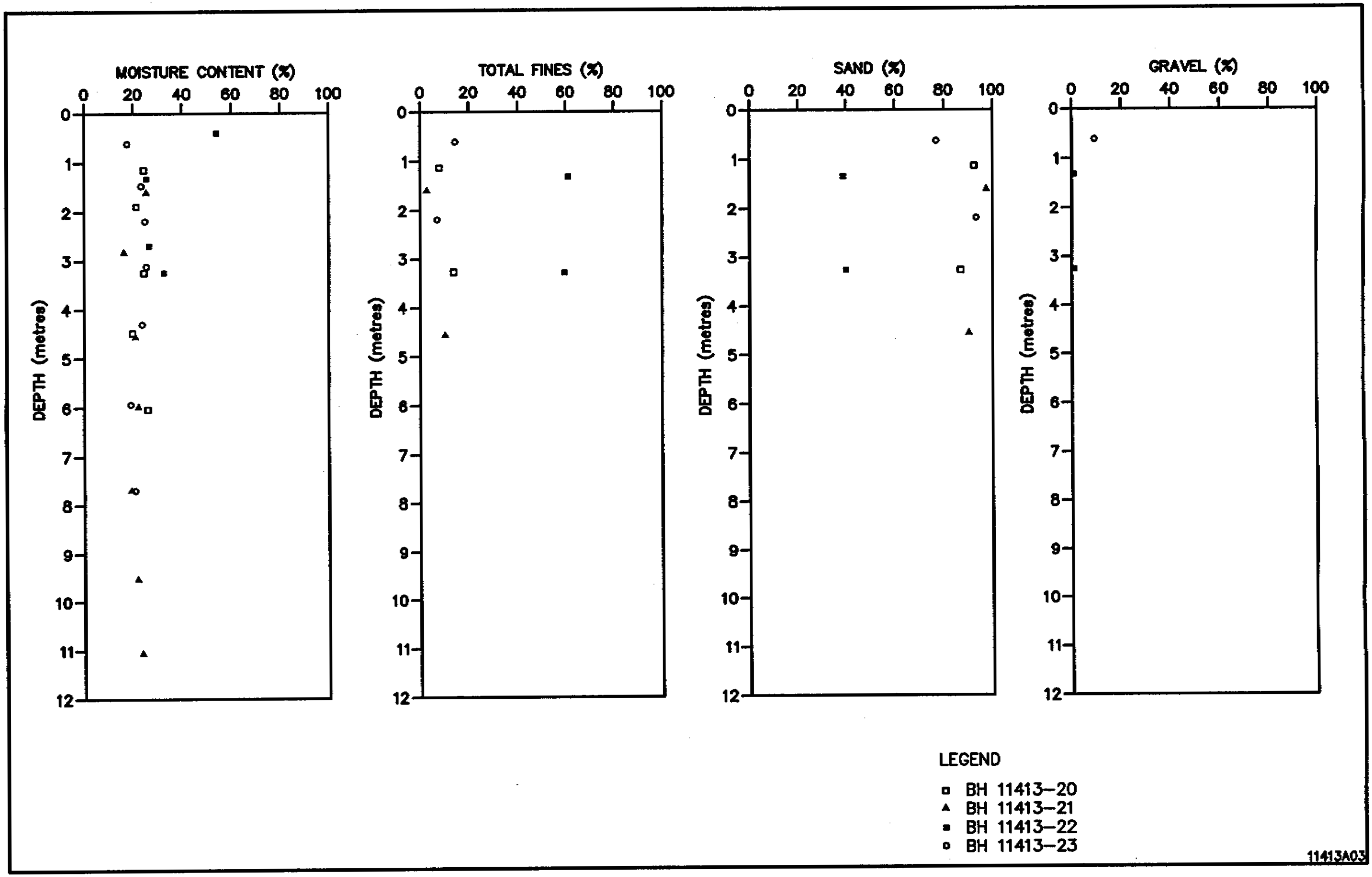
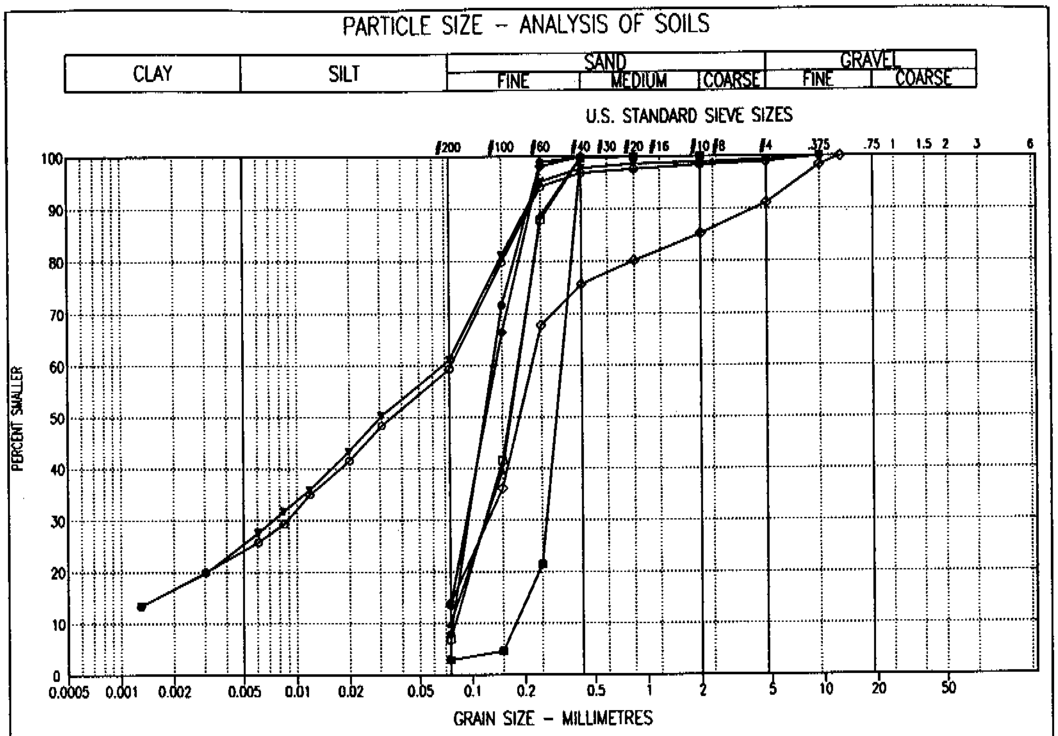


FIGURE 6 PERCENTAGES OF MOISTURE, TOTAL FINES, SAND AND GRAVEL VS. DEPTH, RESOURCE TARGET 6C–2



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●——●	20	1.10 - 1.20	7.9	92.1	0.0	1.8	1.0	SP-SM
◆——◆	20	3.20 - 3.40	13.4	86.6	0.0	2.5	1.2	SM
■——■	21	1.50 - 1.70	2.9	97.1	0.0	1.9	1.2	SP
▲——▲	21	4.50 - 4.70	10.0	90.0	0.0	2.6	1.1	SP-SM
▼——▼	22	1.20 - 1.40	24.9 36.2	38.2	0.7	–	–	
○——○	22	3.20 - 3.40	23.8 35.6	39.5	1.1	–	–	
◇——◇	23	0.30 - 0.90	13.9	77.2	8.9	3.6	1.2	SM
□——□	23	2.10 - 2.30	6.9	93.1	0.0	2.3	1.0	SP-SM

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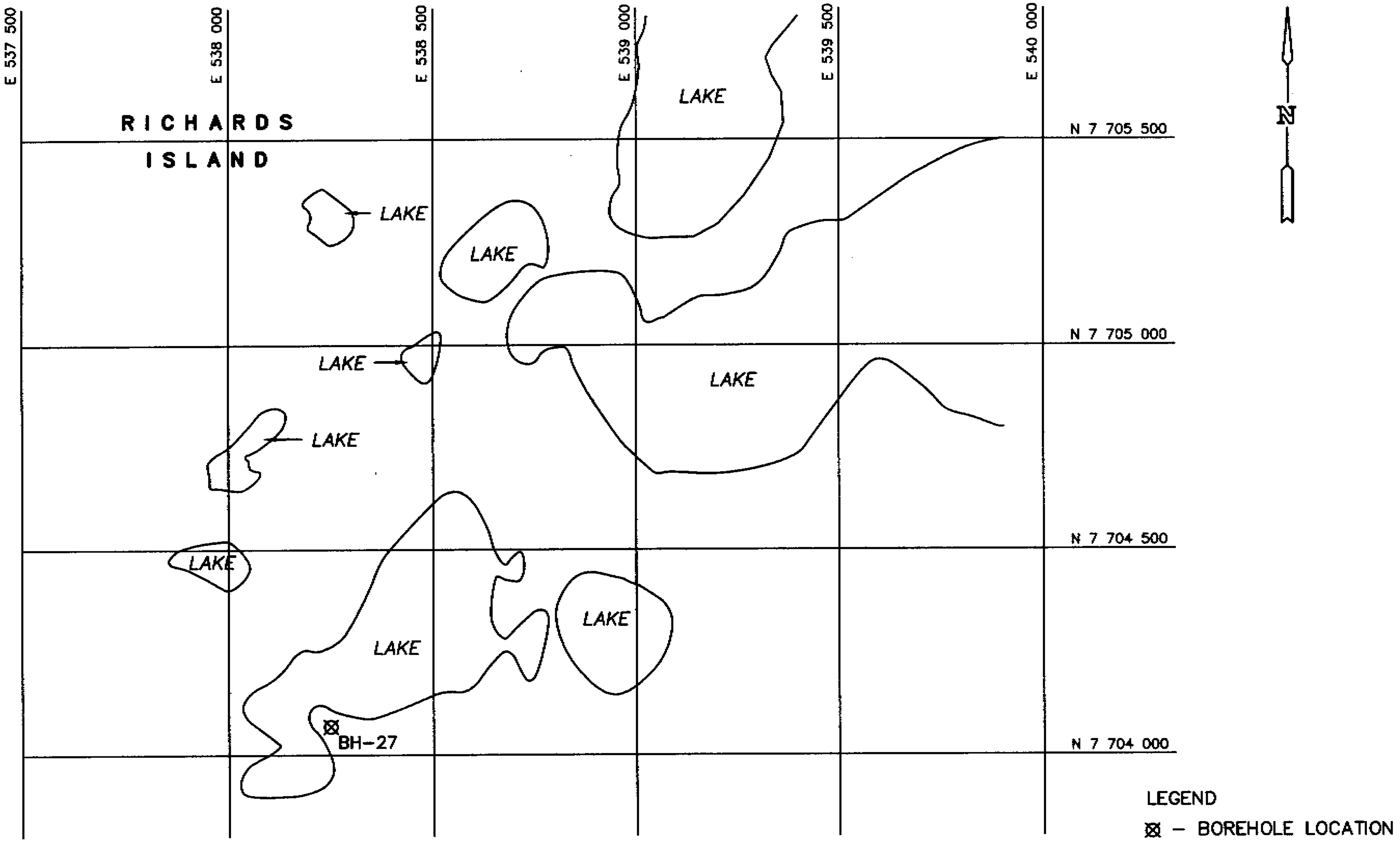
FIGURE 7 GRADING ENVELOPE RESOURCE TARGET 6C-2



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CLIENT **INDIAN AND NORTHERN AFFAIRS CANADA**	PROJECT GRANULAR RESOURCE INVESTIGATION NORTHERN RICHARDS ISLAND, N.W.T.
	TITLE **BOREHOLE LOCATION PLAN** **RESOURCE TARGET 4B-1**

DATE	94-06-27	DWN.	AJH	CHKD.	MAV	FILE NO.	11413A08B	FIGURE 8

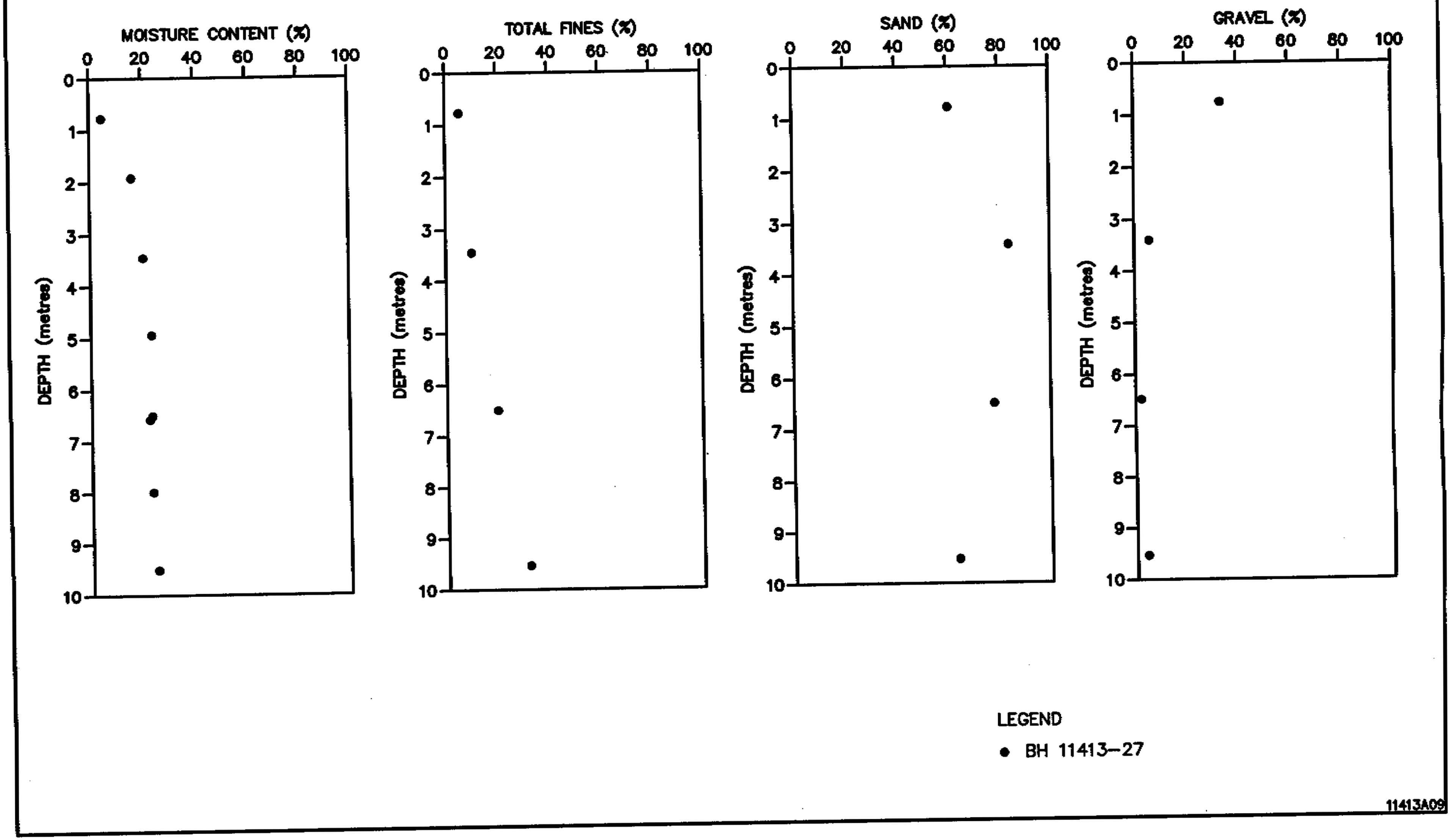
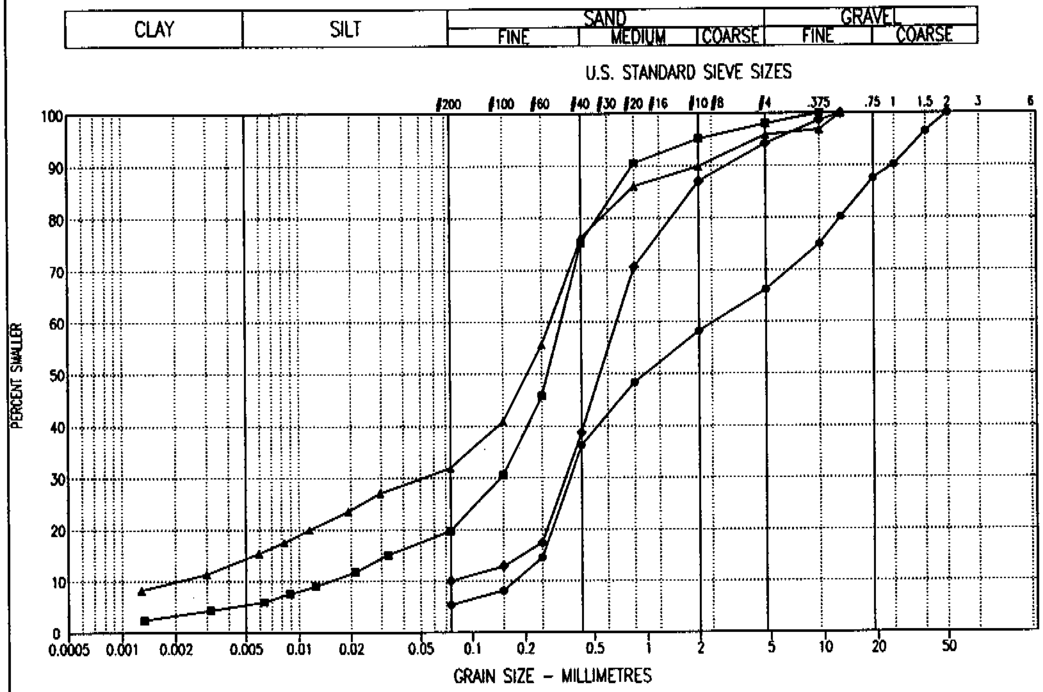


FIGURE 9 PERCENTAGES OF MOISTURE, TOTAL FINES, SAND AND GRAVEL VS. DEPTH, RESOURCE TARGET 4B–1

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
●	27	0.30 - 1.20	5.3	60.9	33.8	14.6	0.3	SP-SM
◆	27	3.00 - 3.80	10.0	84.2	5.8	9.5	2.4	SW-SM
■	27	6.10 - 6.90	5.3 14.5	78.2	2.0	21.7	4.2	SM
▲	27	9.10 - 9.90	14.1 17.8	63.9	4.2	129.7	5.1	SM

Project: 101-11413 Date Tested: 94/04/11 BY: COC

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FIGURE 10 GRADING ENVELOPE RESOURCE TARGET 4B-1

TABLE 1
GRANULAR MATERIAL TYPES

CLASS	MATERIAL DESCRIPTION	POTENTIAL APPLICATIONS
1	Excellent quality material consisting of clean, well-graded, structurally-sound sands and gravel suitable for use as high-quality (eg. runway or roof surfacing materials, or as asphalt or concrete aggregate, with a minimum of processing.	Concrete Aggregate (CA), Surfacing Material (SM)
2	Good quality material generally consisting of well-graded sands and gravels with limited quantities of silt. This material will provide good quality base and surface course aggregates or structure-supporting fill. Production of concrete aggregates may be possible with extensive processing, except where deleterious materials are present.	Concrete Aggregate (CA), Surfacing Material (SM)
3	Fair quality material consisting generally of poorly-graded sands and gravels with or without substantial silt content. This material will provide fair quality general fill for roads, flexible foundation pads, or lay-down yards.	Base (B), Subbase (SB), Embankment (E)
4	Poor quality material generally consisting of silty, poorly-graded, fine-grained sand, with minor gravel. May also contain weak particles and deleterious materials and are considered suitable only for marginal, general (non-structural) fills.	Subbase (SB), Embankment (E)
5	Bedrock of fair to good quality, felsenmeer, or talus. Potentially excellent sources of construction material, ranging from general fill to concrete aggregate or building stone if quarried and processed. Also includes erosion control materials such as rip-rap or armour stone.	Rip-rap, or if processed properly, equivalent to Class 1 or any other class of material.

6.0 EVALUATION OF GRANULAR RESOURCES

6.1 CLASSIFICATION

All materials encountered during the field exploration program have been classified according to the Unified Classification System (USC) as defined in Appendix B and shown on the borehole logs. This general classification makes no direct reference to the end use of the material.

The Government of the Northwest Territories (GNWT) uses a system whereby granular materials are classified according to their most suitable application. The territorial government's system provided the following five material groups:

- Concrete Aggregate (CA),
- Surfacing Material (SM),
- Base (B),
- Subbase (SB),
- Embankment (E) and
- Rip-Rap.

INAC has developed a classification system that considers both the description of the material and the most suitable end use. This system includes the five following classes:

Class 1	Excellent Quality Material,
Class 2	Good Quality Material,
Class 3	Fair Quality Material,
Class 4	Poor Quality Material and
Class 5	Bedrock, Felsenmeer and Talus.

The material descriptions and potential applications that are considered to correspond with each of these classes are summarized in Table 1.

6.2 EXPLOITATION FEASIBILITY

Based on the data obtained from the limited drilling conducted the sand deposits investigated in Resource Area 6C (i.e. 6C-1 and 6C-2) could likely be used as Class 4 fill. However, where it was determined that both the moisture content and fines content are greater than 10 percent, which accounts for the majority of the material encountered, extraction methodology and subsequent drainage are important planning considerations. Higher moisture contents inhibit thawing and can increase excavation costs and reduce material quality. Adequate drainage of the pit must be maintained to ensure availability of recoverable material and to attain the required annual extraction rates. None of the boreholes encountered massive ground ice; therefore, extensive thermokarst activity, which has been associated with the development of some other deposits in the region (e.g. Ya Ya Lakes), is not anticipated should these sites be developed. However, a detailed site specific drilling program should be conducted prior to development.

Winter extraction normally consists of ripping the friable frozen granular material and pushing it into a temporary windrow or stockpile. Poorly-bonded or friable granular material will usually be recovered from near the surface (seasonal active layer) of a well-drained deposit. In the event that the required volume cannot be obtained by ripping, a drill and blast operation would be necessary.

Summer operations typically consist of windrowing or stockpiling the thawed material, commencing when thaw has progressed approximately 0.5 m into the deposit. The progressive thaw operation cycle is largely dependant on the rate of thawing and on drainage considerations. Experience has shown that winter extraction from frozen stockpiles placed the previous summer may be just as difficult as winter extraction directly from the borrow source. Frozen stockpiles with a low moisture content are usually sufficiently friable for direct loading without ripping.

Due to the limited investigation activities at Resource Target 4B-1 detailed evaluation of this site is not possible. The information obtained does indicate that some higher quality material may be available; therefore, further investigation is recommended. A summer reconnaissance program should be conducted to properly map surface exposures on the glaciofluvial terraces. Additional geophysical surveys (GPR and EM-34) in conjunction with a drilling program are required.

7.0 CLOSURE

The geotechnical information contained in this report was obtained from samples collected during the 1994 winter program carried out for INAC. This report has been prepared for the exclusive use of INAC for specific application to their granular resource inventory.

EBA Engineering Consultants Ltd. has appreciated the opportunity to work on this project and would like to acknowledge the cooperation and guidance provided by Mr. R. Gowan and Mr. S. Traynor of INAC, Mr. S. Dallimore of the GSC and Midnight Sun Drilling Co. Ltd. Without the close cooperation between client, consultant, and the drilling contractor the achievements described in the preceding would certainly not have been realized.

Respectfully submitted,
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APPENDIX A

OPERATIONAL CALENDAR

TABLE A.1
OPERATIONAL CALENDAR
GEOTECHNICAL INVESTIGATIONS
BEAUFORT SEA, RICHARDS ISLAND AND CARIBOU CREEK, NWT

Friday March 4, 1994

08:00
- Scheduled departure from Edmonton to Inuvik; plane delayed.

10:15
- Depart Edmonton.

14:30
- Arrive Inuvik.
- Pick-up rental truck.
- Check into Finto Motor Inn
- Pick-up freight at Points North and transfer to field camp located at Arctic Tire.

16:00
- Contact Continental Helicopters regarding possible March 5 charter.
- Fuel rental truck.
- Arctic Tire continue to prepare camp.

Saturday, March 5, 1994

08:00
- Awaiting call from Continental Helicopters regarding weather conditions.

10:00
- Pick-up supplies from various local stores.

11:45
- Received message from Continental Helicopters; unable to fly today due to weather.

12:15
- Drive to Source 222 located south of Inuvik.

14:30
- Camp has been moved to the Tuk ice road.

Evening
- Phone conversation with R.J. Gowan (DIAND)
- Telephone call from S. Blasco (GSC)
- Telephone call from D. Jamieson (MSD)

Sunday March 6, 1994

07:30 • Meet D. Jamieson (MSD) at camp; preparations on-going.

10:40 • Camp begins moving north on Tuk ice road (loader, with fuel sloop, flat deck, kitchen, utility and sleeper trailers in tow).

10:45 • Arrange reconnaissance flight to Pullen Island, North Head of Richards Island and Source 222 at Caribou Creek with Continental Helicopters.

11:45 • Depart from Continental Helicopter's hangar.

12:40 • Arrive at Pullen Island.

12:45 • Monitor Pullen #4 monument with GPS receiver.

13:05 • Airborne, reconnaissance 6C-1, 6C-2, 4B-1 and Source 222.

15:15 • Return to Continental's hangar.

16:00 • Fuel rental truck.
• Check material availability at the Northern Store as requested by MSD.

17:30 • Telephone call from D. Jamieson (MSD), camp presently at Bar-C. Recent snowfall makes going slow. Plan to camp overnight south of Kittigazuit.

Monday, March 7, 1994

08:00 • Make project logistic arrangements in Inuvik.

09:15 • Phone call from D. Jamieson (MSD); plane coming from Whitehorse with MSD freight on-board delayed in Whitehorse. Began clearing ice road to North Head at 08:30.

10:30 • Unable to start rental truck.

13:15	• R.J. Gowan (DIAND) arrives Inuvik.
14:00	• Pick-up air cargo for MSD.
14:30	• Meet R.J. Gowan at Inuvik DIAND office.
16:00	• Meet with S. Blasco at Inuvik Research Centre.
17:15	• Pick-up repaired rental truck.
19:00	• Depart Inuvik for camp.
20:45	• Turn off Tuk ice road; heading to North Head.
23:30	• Camp stops in position; loader still on route with fuel sloop.

March 8, 1994

08:00	• Making final camp arrangements. • Loader and D6 cat widening ice road between camp and the Tuk ice road.
10:00	• Meeting with R.J. Gowan (DIAND) to discuss offshore borehole locations, and program planning. • Prepare field equipment.
13:00	• Depart camp to layout "New Prospect" boreholes located approx. 4 km north of Pullen Island. D6 cat clearing access road to "New Prospect" location.
18:30	• Access cleared to two borehole locations at "New Prospect" site, return to camp.
19:05	• Arrive camp, loader still working on ice road. • MSD drill rig and drill container in camp.
20:45	• Loader returns to camp.
21:30	• D6 returns to camp.

<u>March 9, 1994</u>

08:00 • Leave camp; haul rig on low boy pulling drill shack behind.

09:30 • Rig on-site at BH 11413-02 ("New Prospect" GS6-3-S).

10:30 • Rig off-loaded; move to BH 11413-01 ("New Prospect" GS6-4-S).

11:30 • Rig on location BH 11413-01. Auger ice hole to draw water. Auger ice hole at borehole location prepare to drill.

14:00 • Trip in HW casing.

20:30 • Recover last sample; trip out.

21:30 • HW casing out of hole, rig down. Move all equipment to BH 11413-02 ("New Prospect" GS6-3-S).

21:45 • On location; prepare equipment to overnight on location.

22:00 • Leave for camp.

22:30 • Arrive at camp.

<u>March 10, 1994</u>

08:00 • Meeting to review MSD daily bills to date.

09:15 • Leave camp.

09:45 • On location BH 11413-02 ("New Prospect" GS6-3-S). Preparation prior to drilling on-going.

11:45 • Trip in HW casing.

12:20 • Recover sample #1

18:40 • Final sample recovered.

19:30 • All casing out of hole rig down, load drill rig on to low boy trailer. Prepare equipment to overnight on location.

20:00 • Depart for camp.

20:30 • Arrive camp.

March 11, 1994

08:00 • Depart camp, travel to BH 11413-02 ("New Prospect" GS6-3-S).

09:00 • Move rig on low boy, pull drill shack with loader to BH 11413-03 ("Breaker's Shoal PS2-1-S).

10:30 • Drill rig and drill shack on site. Set up and prepare to drill.

12:15 • Recover sample #1.

20:45 • Recover final sample; trip out.

21:15 • Drill secure, depart for camp.

21:45 • Arrive camp.

March 12, 1994

08:15 • Depart from camp.

08:35 • On site at "Breaker's Shoal" BH 11413-03.

09:00 • Move drill rig and ancillary equipment to BH 11413-04.

09:15 • On location; set up to drill.

11:30 • Recover sample #1.

20:30 • Recover final sample, trip out.

21:00 • Leave for camp.

21:30 • Arrive at camp.

March 13, 1994

08:15 • Depart camp.

08:45 • On site at BH 11413-04. Rig move.

09:45 • Move to BH 11413-05 "Permafrost" GSC-TSD.

10:45 • On location set up to drill.

12:15 • Recover sample #1.

19:00 • Recover sample #16, trip out.

20:15 • Depart for camp.

20:45 • Arrive camp.

March 14, 1994

08:00 • High winds from the west; decide to attempt to travel to rig.

08:30 • On-site BH 11413-05.
• Too windy to attempt rig move, decision made to extend hole in permafrost with NQ coring.

11:45 • HW casing set to 9.7 m.

12:45 • NQ core run #1; trial run to clear material in HW casing.

15:15 • End of borehole at 14.4 m after nine core runs. Trip out; secure rig.

16:30	• Depart for camp.
17:00	• Arrive camp. • Meeting with R.J. Gowan, discuss progress to date and schedule.

March 15, 1994

08:00	• Depart camp.
08:35	• Arrive at rig located at BH 11413-05.
09:15	• Begin rig move.
09:45	• On location BH 11413-06 "Non Permafrost", set up to drill.
11:00	• Auger hole through ice, trip in HW casing.
11:25	• Recover first sample.
18:30	• Recover final sample; trip out.
19:20	• Depart from drill site.
19:55	• Arrive at camp.

March 16, 1994

08:00	• Depart camp.
08:45	• Arrive at drill rig. Unable to start D6, tarp in and heat with master heaters, repair blade on loader.
11:15	• Begin move from BH 11413-06 to BH 11413-07.
11:45	• On location, set up.
12:50	• Auger ice hole, trip in.

14:45	• Recover final sample, trip out.
16:20	• Begin move to BH 11413-08.
17:15	• On location.
17:50	• Trip in HW casing.
20:15	• BH 11413-08 complete, trip out.
20:50	• Depart for camp.
21:30	• Arrive camp.

<u>March 17, 1994</u>

08:00	• Depart from camp.
08:45	• Arrive at drill rig located at BH 11413-08. Service drill rig. D6 clearing access to BH 11413-09.
09:15	• Prepare to move drill rig.
09:30	• Begin rig move.
10:15	• Rig on location BH 11413-09.
10:45	• Recover sample #1.
13:30	• Recover final sample, trip out.
14:45	• Begin rig move to BH 11413-10.
15:00	• Rig on location.
15:45	• Recover first sample.
18:15	• Borehole 11413-10 complete, trip out.

18:45 • Move rig to BH 11413-11.

19:00 • Rig on location, prepare equipment to overnight on site.

19:15 • Depart for camp.

20:00 • Arrive camp.

<u>March 18, 1994</u>

08:00 • Depart from camp. High winds overnight created snow drifts along ice road between camp and BH 11413-11. Loader clearing road with MSD and EBA personnel following behind.

09:30 • Arrive at drill rig.

10:15 • Auger ice hole, trip in HW casing.

13:00 • Recover final sample trip out.

13:45 • Begin rig move to BH 11413-12.

14:15 • On location, set up to drill.

15:25 • Recover first sample.

17:15 • Recover final sample, trip out.

17:55 • Begin rig move to BH 11413-13.

18:30 • On location, pad cleared, set up.

19:15 • Depart drill site for camp.

20:00 • Arrive camp.

March 19, 1994

08:00	• Depart camp.
08:35	• Arrive at drill rig which is set up on BH 11413-13, auger ice hole and trip in HW casing.
09:15	• Obtain first sample.
10:50	• Recover final sample, trip out.
11:30	• Begin rig move to BH 11413-14.
12:15	• On location BH 11413-14, set up to drill.
15:10	• Borehole 11413-14 complete, trip out casing.
15:45	• Begin rig move to BH 11413-15.
16:00	• Rig on location.
16:45	• Trip in HW casing.
19:20	• Recover final sample trip out.
20:15	• Move drill rig to the location where low-boy trailer will pick it up.
20:30	• Leave site for camp.
21:00	• Arrive camp.

March 20, 1994

08:00	• Crew departs camp with low-boy trailer to pick up drill rig.
10:45	• Drill rig arrives on site at MR2 Island location, off load drill rig.
12:00	• Begin drilling BH 11413-16.

16:00	• Borehole complete, move to BH 11413-17.
17:15	• Begin drilling.
20:00	• Trip out hollow steam augers.
20:15	• Depart drill site for camp.
20:30	• Arrive camp.

March 21, 1994

08:00	• Depart from camp.
08:15	• Arrive at drilling located at BH 11413-17.
08:45	• Begin drilling with solid augers to advance borehole to 13.7 m below top of ice.
10:15	• Thermistor string installed in BH 11413-17, move drill rig to next location.
11:15	• Begin drilling BH 11413-18 using solid augers.
12:00	• Borehole complete; trip out.
12:30	• Rig move.
13:15	• On location and set up at BH 11413-19.
14:00	• Begin drilling.
18:30	• Borehole terminated due to heaving sand; trip out.
19:30	• Thermistor string installed, depart for camp.
19:50	• Arrive camp.

March 22, 1994

08:00	Depart camp for drill rig located at BH 11413-19. Move drill to low bed trailer and load; travel to Target 6C-2.
12:00	Rig arrives at Target 6C-2, off load.
13:15	D6 cat arrives at Target 6C-2, clear snow drift to access shoreline.
14:00	Begin rig move.
14:45	On site BH 11413-20, set up.
15:15	Begin drilling.
18:00	End of borehole 11413-20.
18:30	Begin rig move.
19:00	Set up and ready to drill BH 11413-21.
20:00	End of shift; depart for camp.
20:30	Arrive camp.

March 23, 1994

08:00	Depart camp for drill rig.
08:30	Arrive at drill rig, continue drilling and sampling BH 11413-21.
12:15	Complete BH 11413-21, trip out and move rig.
13:00	Begin drilling and sampling BH 11413-22.
14:15	Complete BH 11413-22.
15:30	On location BH 11413-23, begin drilling and sampling.

17:00 • Borehole complete; move equipment to Target 6C-1.

19:30 • On location Target 6C-1.

20:00 • Arrive at camp.

<u>March 24, 1994</u>

08:00 • Depart camp.

08:30 • Arrive at Target 6C-1, drill rig and ancillary equipment parked on ice road. Move to Borehole 11413-24.

09:30 • Begin drilling BH 11413-24.

11:30 • Borehole complete, move rig to BH 11413-25.

13:30 • Borehole 11413-25 complete, move rig to BH 11413-26.

14:30 • Begin drilling BH 11413-26.

16:45 • Borehole 11413-26 complete, move equipment to ice road.

17:30 • Depart from ice road to camp.

18:15 • Depart camp with truck & trailer to haul D6 cat back to camp.

<u>March 25, 1994</u>

08:00 • Prepare for camp move.

08:45 • D6 departs pulling camp.

17:30 • On location at Skiff Point.

18:15 • Travel via snowmobile to conduct site reconnaissance.

20:15	• Arrive back at camp.

March 26, 1994

08:00	• Depart from camp via snowmobile to select access route to travel to Target 4B-1.
09:30	• Return to camp, prepare drill rig and D6.
11:00	• Depart from camp.
13:45	• Arrive on location BH 11413-27.
15:30	• BH 11413-27 complete, move rig to BH 11413-28.
16:15	• "White out" conditions, depart drill site for camp.
17:30	• Arrive at camp.

March 27, 1994

08:00	• Travel from camp on snowmobiles to the drill rig and D6 which were left overnight on location.
09:00	• Return to camp to drop off snowmobile to geophysicist.
09:30	• Return to drill rig.
10:00	• Arrive at drill rig, rig is moving to camp due to cold temperature and blowing snow. Drill shack (shelter) was not moved to drill location.
12:00	• Arrive at camp; prepare to demob camp to Inuvik.
14:45	• Begin camp move.
15:45	• Camp on Tuk ice road at approx km 140. Depart for Inuvik.
17:30	• Arrive Inuvik.

March 28, 1994

08:00 • Demob EBA equipment from camp located on the ice road at Inuvik.

10:00 • Make arrangements with Challenger to conduct post-mission survey. Arrange with Continental Helicopters to conduct post mission survey.

11:45 Depart Inuvik for Caribou Creek. (Source 222).

12:45 • Off load drill rig and D6 at Caribou Creek, move to borehole location.

14:15 • Begin drilling BH 11413-28.

15:45 • Complete drilling BH 11413-28.

16:00 • Begin drilling BH 11413-29.

17:00 • Complete drilling BH 11413-29.

17:15 • Begin drilling BH 11413-30.

18:15 • Complete drilling BH 11413-30.

18:30 • Depart Caribou Creek.

19:15 • Arrive Inuvik.

March 29, 1994

08:00 • Depart Inuvik.

08:45 • Arrive at Caribou Creek site, move drill rig to BH 11413-31.

10:00 • Begin drilling.

11:00 • BH 11413-31 complete.

11:15 • Begin drilling BH 11413-32.

12:15 • BH 11413-32 complete. Move rig to low bed trailer.

12:30 • DIAND Land Use Officers on-site.

13:15 • Depart Caribou Creek.

14:00 • Brief meeting with M. Collie at DIAND office.

15:00 • Finalize bills with MSD.

March 30, 1994

08:00 • Deliver soil samples and EBA equipment to Points North Transport.

13:00 • Vic Hut (Challenger Surveys) arrives Inuvik.

14:00 • Locate survey control movements in Inuvik, conduct post mission survey at Caribou Creek site.

19:30 • Survey complete, arrive Inuvik.

March 31, 1994

07:45 • Depart Inuvik for Continental Helicopter's hangar.

08:45 • Depart Continental hangar to conduct post-mission survey.

19:50 • Depart Target 6C-2 (Wallace Bay), return to Inuvik.

20:45 • Arrive at Continental hangar, unload helicopter.

21:15 • Arrive Inuvik.

<u>April 1, 1994</u>

09:00 • Depart Inuvik for Continental Helicopter's hangar.

09:30 • Depart hangar to complete post-mission survey at Target 6C-1, 6C-2 and 4B-1.

15:50 • Post-mission survey complete, depart Target 4B-1 for Inuvik.

16:35 • Arrive Inuvik airport.

18:30 • Depart Inuvik on AC Flight #8958.

22:00 • Arrive Edmonton International Airport.

APPENDIX B

BOREHOLE LOGS

EBA ENGINEERING CONSULTANTS LTD.

GEOTECHNICAL REPORT GENERAL CONDITIONS

A.1 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site and development. It is not applicable to adjacent sites nor is it valid for types of development other than that to which it refers. Any variation from the site, or development, necessitates a geotechnical review in order to determine the validity of the design concepts evolved herein.

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A.2 NATURE AND EXACTNESS OF SOIL DESCRIPTION

Classification and identification of soils are based upon commonly accepted methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system prevail, they are specifically mentioned.

Classification and identification of soil and geologic units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

A.3 LOGS OF BORINGS

The boring logs are a compilation of conditions and classification of soils as obtained from field observations and laboratory testing of selected samples. Soil zones have been interpreted. Change from one geologic zone to the other, indicated on the logs as a distinct line, is in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil zone transition elevations may require special evaluation.

A.4 STRATIGRAPHIC AND GEOLOGIC SECTIONS

The stratigraphic and geologic sections indicated on drawings contained in this report are evolved from logs of borings. Stratigraphy is known precisely only at the locations of the borings. Actual geology and stratigraphy between borings may vary from that shown on these drawings. Natural variations in geologic conditions are inherent and a function of historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of exact locations of geologic units is necessary, it is cautioned that such determination requires special attention.

A.5 GROUNDWATER CONDITIONS

Groundwater conditions represented in this report refer only to those observed at the times recorded on logs of borings, and/or within the text of this report. These conditions vary with geologic detail between borings; annual, seasonal and special meteorologic conditions; and with construction activity. Where instruments have been established to record groundwater variations on an ongoing basis, the records will be specifically referred to. Interpretation of groundwater conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and construction activity. Deviations from these observations, may occur. No other warranty, express, or implied, is made by EBA.

A.6 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geologic materials to meteorological elements. Many geologic materials deteriorate rapidly upon exposure to climatic elements. Severe deterioration of materials may be caused by precipitation and/or the action of frost on exposures. Unless otherwise specifically indicated in this report, walls and floors of excavations must be protected from elements, particularly all forms of moisture, desiccation from arid conditions and frost action.

A.7 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise advised, support of excavation walls, ground adjacent to anticipated construction activity and of structures adjacent to the construction, must be provided. The support of ground and structures adjacent to the anticipated construction, with preservation of adjacent ground and structures from the adverse impact of construction activity, is therefore required.

A.8 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and adjacent structural performance. The influence of all anticipated construction activities should by considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known. EBA provides no warranty in respect to adverse circumstances resulting from construction activity.

A.9 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geologic deposits, the judgmental character of the art of soil and foundation engineering, as well the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations then may serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein to the benefit of the project.

A.10 DRAINAGE SYSTEMS

Where drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwised specified, it is a condition of this report that effective drainage systems are required and that they must be considered in relation to project purpose and function.

A.11 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil type and soil condition. Construction activity and environmental circumstances can materially change a soil condition. The elevation at which a soil type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geologic materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil conditions assumed in this report exist in fact.

A.12 SAMPLES

EBA will retain all soil and rock samples for 30 days. Further storage or transfer of samples can be made at owner expense upon written request.

A.13 STANDARD OF CARE

Services performed by EBA for this report are conducted in a manner consistent with that level and skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty, express or implied, is made.

SYSTEM INTERNATIONAL UNITS

QUANTITY	NAME	SYMBOL	EXPRESSED IN TERMS OF OTHER SI UNITS	EXPRESSED IN TERMS OF BASE AND SUPPLEMENTARY UNITS
SI UNITS				
length	metre	m		
mass	kilogram	kg		
time	second	s		
electric current	ampere	A		
thermodynamic temperature	kelvin	K		
amount of substance	mole	mol		
luminous intensity	candela	cd		
SI SUPPLEMENTARY UNITS				
plane angle	radian	rad		
solid angle	steradian	sr		
EXAMPLES OF SI DERIVED UNITS WITH SPECIAL NAMES				
frequency	hertz	Hz	1/s	s^{-1}
force	newton	N	$m \cdot kg/s^2$	$m \cdot kg \cdot s^{2}$
pressure, stress	pascal	Pa	N/m^2	$m^{-1} \cdot kg \cdot s^{-2}$
energy, work, quantity of heat	joule	J	$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$
power, radiant flux	watt	W	J/s	$m^2 \cdot kg \cdot s^{-3}$
EXAMPLES OF SI DERIVED UNITS WITHOUT SPECIAL NAMES				
velocity - linear	metre per second		m/s	$m \cdot s^{-1}$
- angular	(radian per second)		rad/s	$rad \cdot s^{1}$
acceleration - linear	(metre per second) per second		m/s^2	$m \cdot s^{-2}$
- angular	(radian per second) per second		rad/s^2	$rad \cdot s^{2}$
concentration (of amount of substance)	mole per cubic metre		mol/m^3	$mol \cdot m^{-3}$
dynamic viscosity	pascal second		$Pa \cdot s$	$m^{-1} \cdot kg \cdot s^{-1}$
moment of force	newton metre		$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$
surface tension	newton per metre		N/m	$kg \cdot s^{-2}$
heat flux density, irradiance	watt per square metre		W/m^2	$kg \cdot s^{-3}$
heat capacity, entropy	joule per kelvin		J/K	$m^2 \cdot s^{-2}\ K^{-1}$
specific heat capacity, specific entropy	joule per kilogram kelvin		$J/(kg \cdot K)$	$m^2 \cdot s^{-2} \cdot K^{-1}$
specific energy	joule per kilogram		J/kg	$m^2 \cdot s^{2}$
thermal conductivity	watt per metre kelvin		$W/(m \cdot K)$	$m \cdot kg \cdot s^{-3} \cdot K^{1}$

OTHER UNITS PERMITTED FOR USE WITH SI

QUANTITY	NAME	SYMBOL	DEFINITION
time	minute	min	1 min = 60 s
	hour	h	1 h = 3,600 s
	day	d	1 d = 86,400 s
	year	a	
plane angle	degree	°	1° = (π/180) rad
	minute	′	1′ = (π/10,800) rad
	second	″	1″ = (π/648,000) rad
area	hectare	ha	1 ha = 10,000 m^2
volume	litre	L	1,000 L = 1 m^3
temperature	degree Celsius	°C	0° C = 273.15° K temperature interval 1 C° = 1 K°
mass	tonne	t	1 t = 1,000 kg = 1 Mg

MULTIPLYING FACTOR	PREFIX	SYMBOL	MULTIPLYING FACTOR	PREFIX	SYMBOL
1,000,000,000,000,000,000 = 10^{18}	exa	E	0.1 = 10^{1}	deci*	d
1,000,000,000,000,000 = 10^{15}	peta	P	0.01 = 10^{2}	centi*	c
1,000,000,000,000 = 10^{12}	tetra	T	0.001 = 10^{-3}	milli	m
1,000,000,000 = 10^{9}	giga	G	0.000,001 = 10^{-6}	micro	μ
1,000,000 = 10^{6}	mega	M	0.000,000,001 = 10^{-9}	nano	n
1,000 = 10^{3}	kilo	k	0.000,000,000,001 = 10^{12}	pico	p
100 = 10^{2}	hecto*	h	0.000,000,000,000,001 = 10^{-15}	femto	f
10 = 10^{1}	deca*	da	0.000,000,000,000,000,001 = 10^{18}	atto	a

* *to be avoided where possible*

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SYSTEM INTERNATIONAL CONVERSIONS

AREA

1 km^2	= 3.861 x 10^{-1} mi^2	1 km^2 = 100 hectares
1 km^2	= 2.471 x 10^{+2} acre	
1 m^2	= 1.196 yd^2	
1 m^2	= 1.076 x 10^{+1} ft^2	
1 mm^2	= 1.550 x 10^{-3} in^2	see note 1

DENSITY

1 Mg/m^3	= 6.243 x 10^{+1} lb$_m$/ft^3	see note 2
1 kg/m^3	= 6.243 x 10^{-2} lb$_m$/ft^3	

FORCE

1 N	= 2.248 x 10^{-1} lb$_f$	

HEAT

ENERGY (E)		
1 kJ	= 9.478 x 10^{-1} BTU (IST)	1 BTU = 252 cal
1 J	= 2.388 x 10^{-1} cal (IST)	
HEAT FLUX (Q)		
1 W/m^2	= 3.170 x 10^{-1} BTU/(ft^2 · hr)	
SPECIFIC HEAT CAPACITY (c)		
1 kJ/(kg · C°)	= 2.388 x 10^{-1} BTU/(lb$_m$ · F°)	
THERMAL CONDUCTIVITY (k)		
W/(m · C°)	= 5.778 x 10^{-1} BTU/(ft · hr · F°)	
COEFFICIENT OF HEAT TRANSFER (c_s)		
1 W/(m^2 · C°)	= 1.761 x 10^{-1} BTU/(ft^2 · hr · F°)	see note 3

LENGTH

1 km	= 6.214 x 10^{-1} mi (statute)	
1 m	= 1.094 yd	
1 m	= 3.281 ft	
1 mm	= 3.937 x 10^{-2} in	

MASS

1 Mg	= 1.102 T	1 T = 2000 lb$_m$
1 Mg	= 2.205 x 10^3 lb$_m$	Mg is equivilant to tonne
1 kg	= 2.205 lb$_m$	

POWER

1 W	= 1.341 x 10^{-3} HP	1 HP = 550 ft · lb$_f$/s

PRESSURE, STRESS or ELASTIC MODULI

1 MPa	= 1.044 x 10^{+1} T$_f$/ft^2 [TSF]	see note 4
1 kPa	= 1.044 x 10^{-2} T$_f$/ft^2 [TSF]	
1 kPa	= 1.450 x 10^{-1} lb$_f$/in^2 [psi]	
1 kPa	= 3.346 x 10^{-1} ft of water	hydrostatic pressure of water at 1 ft. depth
1 Pa	= 2.089 x 10^{-2} lb$_f$/ft^2 [psf]	

TEMPERATURE

°C	= (°F · 32)/1.8	0°C = 273.15° K
C°	= 1.8 F°	1 C° = 1 K°

TIME

1 Ms	= 3.171 x 10^{-2} yr	for one year equal to 365 days
1 ks	= 1.157 x 10^{-2} day	
1 s	= 3.171 x 10^{-8} yr	

VISCOSITY

DYNAMIC (η)		
1 Pa · s	= 1.000 x 10^{+3} centipoise	
KINEMATIC (ν)		
1 mm^2/s	= 1.000 cenistoke	

VOLUME

1 m^3	= 8.107 x 10^{-4} acre · ft	
1 m^3	= 1.308 yd^3	
1 m^3	= 3.531 x 10^{+1} ft^3	
1 m^3	= 2.200 x 10^{+2} gal (Imperial)	1 m^3 = 1000 L
1 cm^3	= 3.520 x 10^{-2} fl oz	see note 1
1 cm^3	= 6.102 x 10^{-2} in^3	

VOLUME RATE OF FLOW

1 m^3/s	= 1.901 x 10^{-1} mgpd (Imperial)	
1 m^3/s	= 3.531 x 10^{+1} ft^3/s	

COEFFICIENTS

VOLUME COMPRESSIBILITY OR SWELLING (m_v or m_s)		
1 m^2/MN;	= 9.579 x 10^{-2} ft^2/T$_f$	
CONSOLIDATION OR SWELLING (c_v or c_s)		
1 m^2/yr	= 1.076 x 10^{+1} ft^2/yr	
1 m^2/yr	= 2.949 x 10^{-2} ft^2/day	
1 m^2/yr	= 3.171 x 10^{-4} cm^2/s	
HYDRAULIC CONDUCTIVITY (k)		
1 m/s	= 2.835 x 10^{+5} ft/day	see note 5

NOTES:

1. *The use of cm^2 and cm^3 for area and volume is permissible.*
2. *To convert mass density (ρ) to weight per unit volume use:*
   $F = ma_g$
   i.e. $\rho \mathrm{Mg/m^3} \times 9.807\ \mathrm{m/s^2} = 9.807\rho \frac{\mathrm{Mg \cdot m}}{\mathrm{s^2 \cdot m^3}} = 9.807\rho \frac{\mathrm{kN}}{\mathrm{m^3}}$
   kg$_f$/m^3 is not a valid SI density unit.
3. *The inverse of the 'coefficient of heat transfer' is 'thermal resistance' or the 'R' value.*
4. *kg$_f$/m^2 is not a valid SI stress unit.*
5. *Hydraulic conductivity is a proportionality coefficient defined in Darcy's Law:* $v = k_w \frac{\partial h}{\partial s}$, *where v = velocity of flow*
   $\frac{\partial h}{\partial s}$ = *hydraulic gradient*
6. *All conversion factors have been rounded to four significant figures.*

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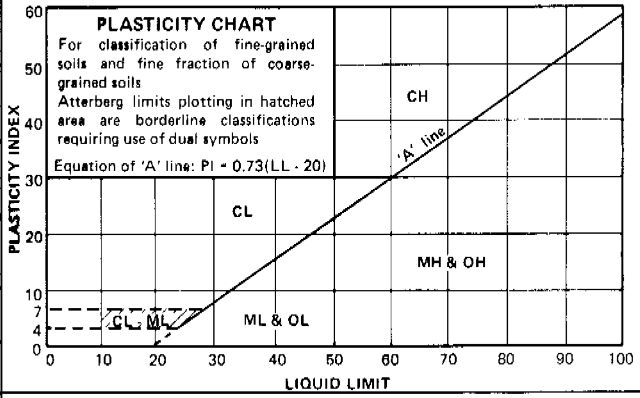
UNIFIED SOIL CLASSIFICATION†

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES	CLASSIFICATION CRITERIA		
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve*	**GRAVELS** 50% or more of coarse fraction retained on No. 4 sieve	**CLEAN GRAVELS**	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% pass No. 200 sieve GW, GP, SW, SP More than 12% pass No. 200 sieve GM, GC, SM, SC 5% to 12% pass No. 200 sieve Borderline classification requiring use of dual symbols	$C_u = D_{60}/D_{10}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below 'A' line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7	
	SANDS More than 50% of coarse fraction passes No. 4 sieve	**CLEAN SANDS**	SW	Well-graded sands and gravelly sands, little or no fines		$C_u = D_{60}/D_{10}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP	Poorly-graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW	
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures		Atterberg limits plot below 'A' line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7	
FINE-GRAINED SOILS 50% or more passes No. 200 sieve*	**SILTS AND CLAYS** Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands			
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	SILTS AND CLAYS Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
			CH	Inorganic clay of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity			
HIGHLY ORGANIC SOILS			PT	Peat, muck and other highly organic soils	*Based on the material passing the 3 in. (75 mm) sieve †ASTM Designation D 2487, for identification procedure see D 2488		

GROUND ICE DESCRIPTION

ICE NOT VISIBLE

GROUP SYMBOLS	SYMBOLS	SUBGROUP DESCRIPTION	
N	Nf	Poorly-bonded or friable	▨
	Nbn	No excess ice, well-bonded	▨
	Nbe	Excess ice, well-bonded	▨

VISIBLE ICE LESS THAN 50% BY VOLUME

GROUP SYMBOLS	SYMBOLS	SUBGROUP DESCRIPTION	
V	Vx	Individual ice crystals or inclusions	▨
	Vc	Ice coatings on particles	▨
	Vr	Random or irregularly oriented ice formations	▨
	Vs	Stratified or distinctly oriented ice formations	▨

VISIBLE ICE GREATER THAN 50% BY VOLUME

ICE	ICE + Soil Type	Ice with soil inclusions	■
	ICE	Ice without soil inclusions (greater than 25 mm (1 in.) thick)	■

NOTE:

1. *Dual symbols are used to indicate borderline or mixed ice classifications*
2. *Visual estimates of ice contents indicated on borehole logs ± 5%*
3. *This system of ground ice description has been modified from NRC Technical Memo 79, Guide to the Field Description of Permafrost for Engineering Purposes*

LEGEND

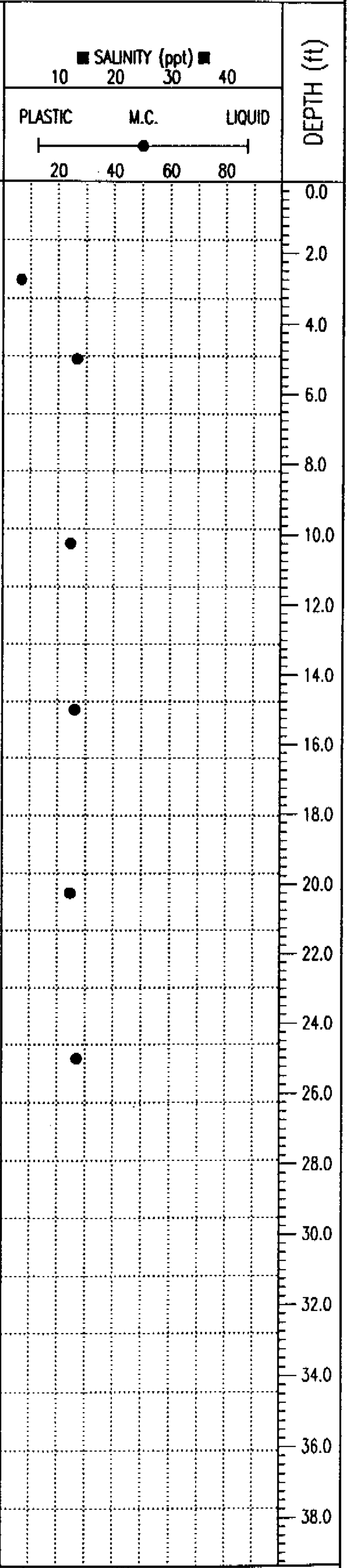
Soil ▨ Ice ■

RESOURCE TARGET 6C-1

GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-24
TARGET "6C-1"	DRILL: CME750 c/w CRREL CORE BARREL	PROJECT NO: 0101-11413
RICHARDS ISLAND, N.W.T.	UTM ZONE: 8 N7726194.3 E530745.6	ELEVATION: 14.30 (m)

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

DEPTH (m)	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMPERATURE (C)	SAMPLE TYPE	SAMPLE NO
0.0	ORGANIC ROOT MAT SAND (SM) - some silt, some clay, trace of gravel, homogeneous, fine grained, uniform, damp when thawed, non plastic, light olive grey	Nf			
1.0		Nbe, well bonded		▯	1
	- wet when thawed	Vs trace		▯	2
2.0		Vr Vs<5%, Ice lenses to 3mm thick.			
3.0	- thick laminae, even, non parallel			▯	3
4.0				▯	4
5.0	- curved, non parallel				
6.0		Nbe		▯	5
7.0				▯	6
7.7	END OF BOREHOLE (7.7 metres)				



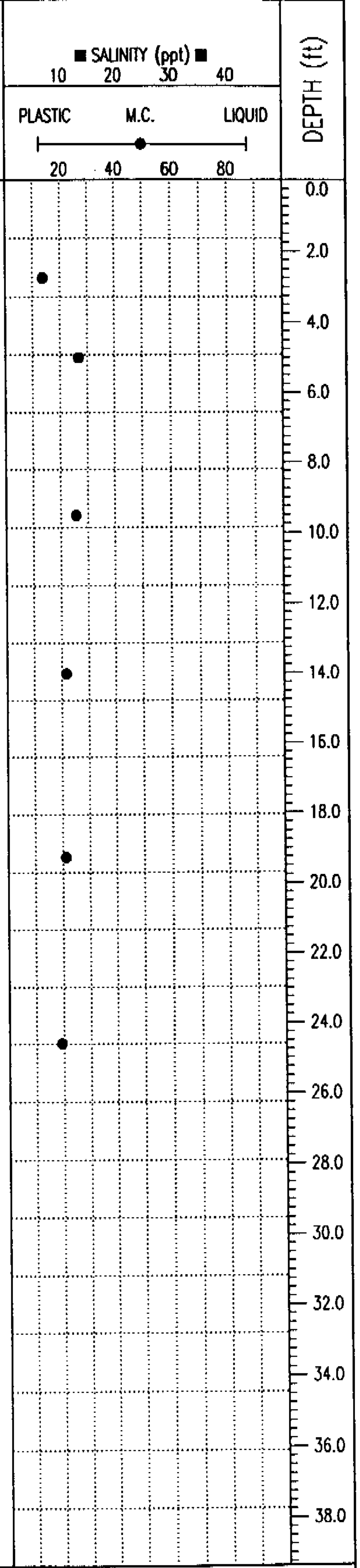
EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV	COMPLETION DEPTH: 7.7 m
	REVIEWED BY: MAV	COMPLETE: 94/03/24
	Fig. No: 11413-24	Page 1 of 1

94/07/05 12:42PM

GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-25
TARGET "6C-1"	DRILL: CME750 c/w CRREL CORE BARREL	PROJECT NO: 0101-11413
RICHARDS ISLAND, N.W.T.	UTM ZONE: 8 N7726331.2 E531124.9	ELEVATION: 10.10 (m)

SAMPLE TYPE ■ DISTURBED ◿ NO RECOVERY ☒ SPT ☰ A-CASING ▯▯ SHELBY TUBE ▮▮ CORE

DEPTH (m)	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMPERATURE (C)	SAMPLE TYPE	SAMPLE NO
0.0	ORGANIC ROOT MAT – (300mm thick)	Nf			
	SAND (SM) – silty, some clay, trace of gravel, homogeneous, fine grained, uniform, brown	Nbn		▮▮	1
1.0	SAND (SP/SM) – trace of silt and clay, homogeneous, fine grained, uniform, massive, wet when thawed, non plastic, dark olive grey	Nbe Vr trace		▮▮	2
2.0					
		Nbe		▮▮	3
3.0	– thickly bedded, curved, parallel, continuous				
4.0				▮▮	4
5.0					
6.0				▮▮	5
7.0					
		Nbn		▮▮	6
	END OF BOREHOLE (7.6 metres)				
8.0					
9.0					
10.0					
11.0					
12.0					



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EDMONTON, ALBERTA

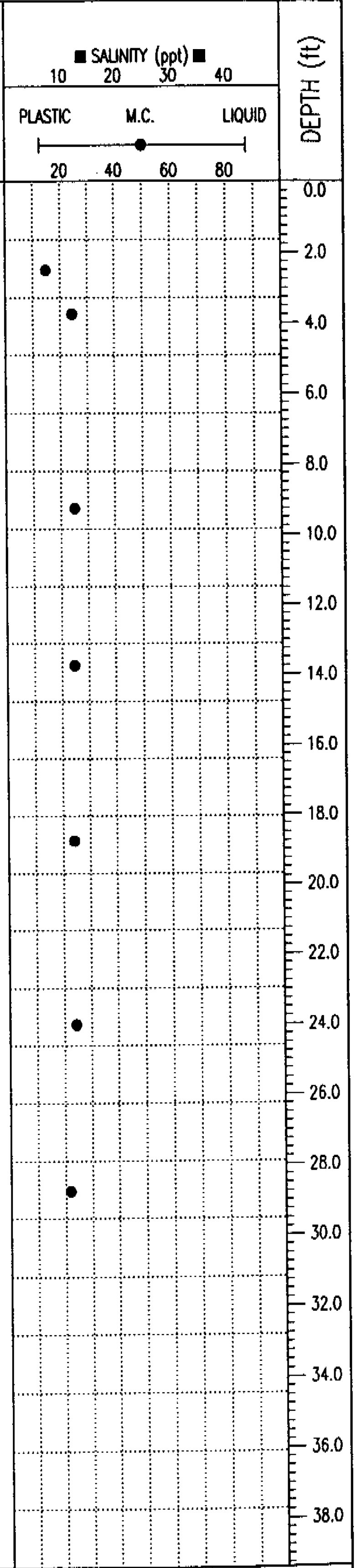
LOGGED BY: MAV	COMPLETION DEPTH: 7.6 m
REVIEWED BY: MAV	COMPLETE: 94/03/24
Fig. No: 11413-25	Page 1 of 1

94/07/05 12:43PM

GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-26
TARGET "6C-1"	DRILL: CME750 c/w CRREL CORE BARREL	PROJECT NO: 0101-11413
RICHARDS ISLAND, N.W.T.	UTM ZONE: 8 N7725687.9 E531390.9	ELEVATION: 22.90 (m)

SAMPLE TYPE ■ DISTURBED ◿ NO RECOVERY ☒ SPT ☰ A-CASING ▯ SHELBY TUBE ▮ CORE

DEPTH (m)	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMPERATURE (C)	SAMPLE TYPE	SAMPLE NO
0.0	SAND (SM) - silty, trace of gravel, damp when thawed, non plastic, dark brown	Nf			
				▮	1
1.0	SAND (SM) - some silt to silty, homogeneous, fine grained, uniform, wet when thawed, non plastic, dark olive grey	Nbe		▮	2
2.0		Vr 5%			
		Nbe		▮	3
3.0	SAND (SM) - trace of silt and clay, thinly bedded, curved, saturated when thawed	Vr<5%			
4.0				▮	4
		Nbe			
				▮	5
				▮	6
	END OF BOREHOLE (8.8 metres)	Nbn		▮	7



EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV	COMPLETION DEPTH: 8.8 m
	REVIEWED BY: MAV	COMPLETE: 94/03/24
	Fig. No: 11413-26	Page 1 of 1

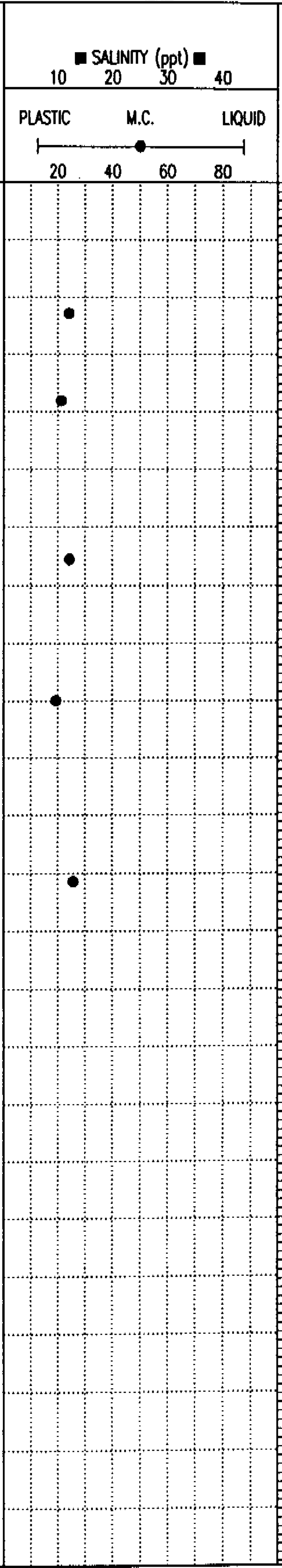
94/07/05 12:45PM

RESOURCE TARGET 6C-2

GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-20
TARGET "6C-2"	DRILL: CME750 c/w HW CASING	PROJECT NO: 0101-11413
RICHARDS ISLAND, N.W.T.	UTM ZONE: 8 N7723136.1 E532145.4	ELEVATION: 24.80 (m)

SAMPLE TYPE ■ DISTURBED ▨ NO RECOVERY ☒ SPT ☰ A-CASING ‖ SHELBY TUBE ▯ CORE

DEPTH (m)	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMPERATURE (C)	SAMPLE TYPE	SAMPLE NO	DEPTH (ft)
0.0	ORGANIC ROOT MAT AND PEAT – dark orangish brown	Nf				0.0
	SAND (SP/SM) – trace of silt, fine grained, uniform, non plastic, olive grey – massive, wet when thawed					2.0
1.0		Nbe		▯	1	4.0
2.0				▯	2	6.0
						8.0
3.0	SAND (SM) – some silt, fine grained, uniform, wet when thawed, non plastic			▯	3	10.0
4.0						12.0
				▯	4	14.0
5.0						16.0
		Vx<5%				18.0
6.0				▯	5	20.0
	END OF BOREHOLE (6.1 metres)					22.0
7.0						24.0
8.0						26.0
						28.0
9.0						30.0
10.0						32.0
						34.0
11.0						36.0
						38.0
12.0						



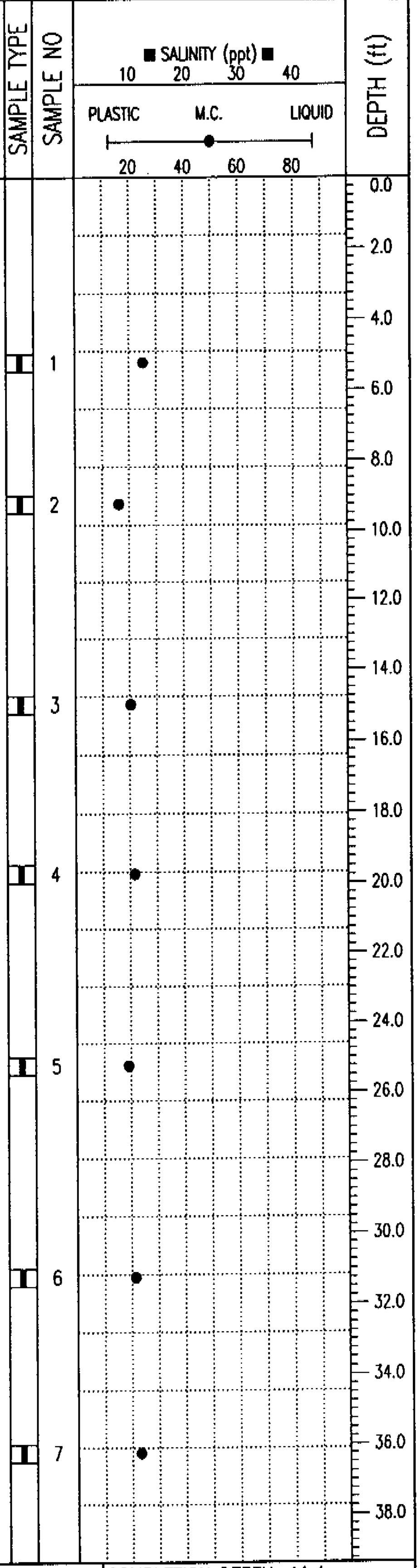
EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV	COMPLETION DEPTH: 6.1 m
	REVIEWED BY: MAV	COMPLETE: 94/03/22
	Fig. No: 11413-20	Page 1 of 1

94/07/05 12:35PM

GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-21
TARGET "6C-2"	DRILL: CME750 c/w CRREL CORE BARREL	PROJECT NO: 0101-11413
RICHARDS ISLAND, N.W.T.	UTM ZONE: 8 N7723017.1 E532307.6	ELEVATION: 23.70 (m)

SAMPLE TYPE ■ DISTURBED ◿ NO RECOVERY ☒ SPT ☰ A-CASING ▯ SHELBY TUBE ▮ CORE

DEPTH (m)	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	SAMPLE NO
0.0	ORGANIC ROOT MAT SAND (SP) - trace of silt, homogeneous, fine grained, uniform, damp, non plastic, brown - trace of fibrous organics, massive, wet when thawed	Nf	
		Vr 5-10% Nbe, well bonded	
			1
		Nbn	2
		Vx trace	
	SAND (SP/SM) - trace to some silt	Nbn	3
			4
		Vr trace	
			5
		Nbn	
			6
			7
	END OF BOREHOLE (11.1 metres)		



EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV	COMPLETION DEPTH: 11.1 m
	REVIEWED BY: MAV	COMPLETE: 94/03/23
	Fig. No: 11413-21	Page 1 of 1

94/07/05 12:36PM

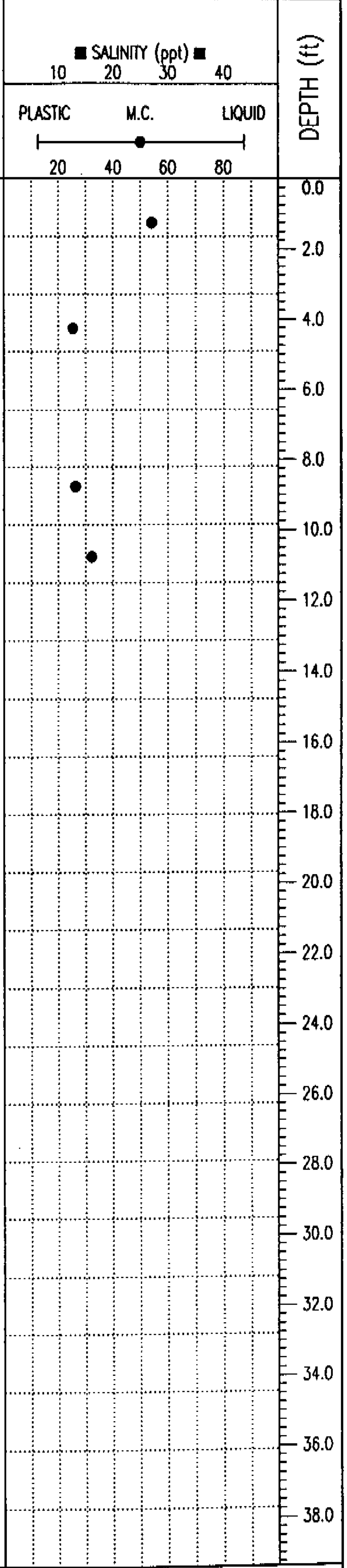
GRANULAR RESOURCE EVALUATION
TARGET "6C-2"
RICHARDS ISLAND, N.W.T.

INDIAN AND NORTHERN AFFAIRS CANADA
DRILL: CME750 c/w CRREL CORE BARREL
UTM ZONE: 8 N7722988 E531705.5

BOREHOLE NO: 11413-22
PROJECT NO: 0101-11413
ELEVATION: 23.40 (m)

SAMPLE TYPE ■ DISTURBED ▨ NO RECOVERY ☒ SPT ☰ A-CASING ▯ SHELBY TUBE ▮ CORE

DEPTH (m)	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMPERATURE (C)	SAMPLE TYPE	SAMPLE NO
0.0	PEAT (PT) AND ORGANIC SILT – very dark brown to black			▮	1
	SAND (SM) AND SILT – clayey, trace of gravel, fine grained, uniform, dark olive grey	Vs 40%			
1.0		Nbe		▮	2
2.0	– wet when thawed, very dark grey	Vs		▮	3
3.0	SAND (SM) AND SILT (TILL) – clayey, trace of fine grained gravel, saturated when thawed, very dark brownish grey	Nbe		▮	4
4.0	END OF BOREHOLE (3.5 metres)				
5.0					
6.0					
7.0					
8.0					
9.0					
10.0					
11.0					
12.0					



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EDMONTON, ALBERTA

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REVIEWED BY: MAV
Fig. No: 11413-22

COMPLETION DEPTH: 3.5 m
COMPLETE: 94/03/23
Page 1 of 1

94/07/05 12:38PM

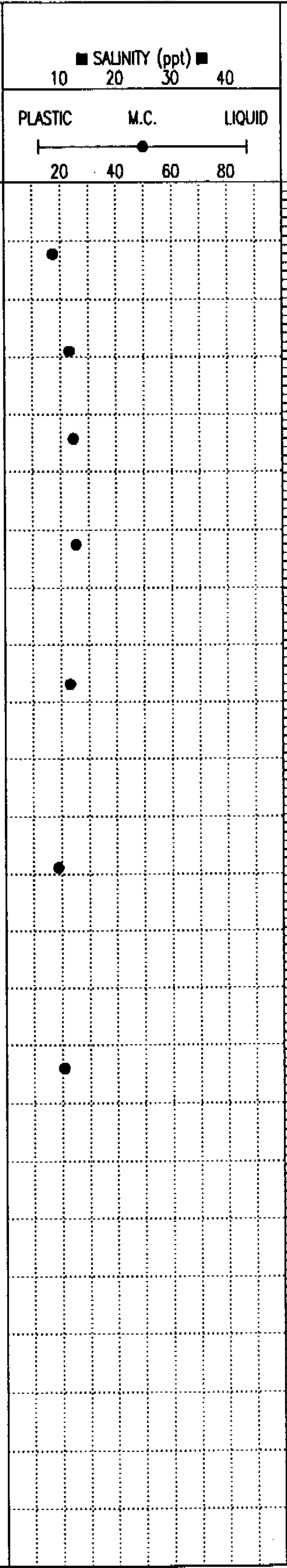
GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-23
TARGET "6C-2"	DRILL: CME750 c/w CRREL CORE BARREL	PROJECT NO: 0101-11413
RICHARDS ISLAND, N.W.T.	UTM ZONE: 8 N7722379.4 E531181.4	ELEVATION: 18.00 (m)

SAMPLE TYPE ■ DISTURBED ◿ NO RECOVERY ☒ SPT ☰ A-CASING ▯ SHELBY TUBE ▯ CORE

SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMPERATURE (C)	SAMPLE NO
SAND (SM) – some silt, trace of gravel, fine grained, uniform, moist when thawed, non plastic, olive brown	Nf		
			1
	Nbn		
– homogeneous, massive, wet when thawed, dark olive grey			
			2
	Nbe		
			3
SAND (SP/SM) – trace of silt and coarse fibrous organics, wet when thawed, non plastic			
			4
	Vx 30mm Nbe		
			5
	Vr 25%, vertical ice lense 20mm thick.		
			6
	Vx 5%		
			7
END OF BOREHOLE (7.8 metres)			

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

DEPTH (ft): 0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0, 24.0, 26.0, 28.0, 30.0, 32.0, 34.0, 36.0, 38.0



EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV	COMPLETION DEPTH: 7.8 m
	REVIEWED BY: MAV	COMPLETE: 94/03/23
	Fig. No: 11413-23	Page 1 of 1

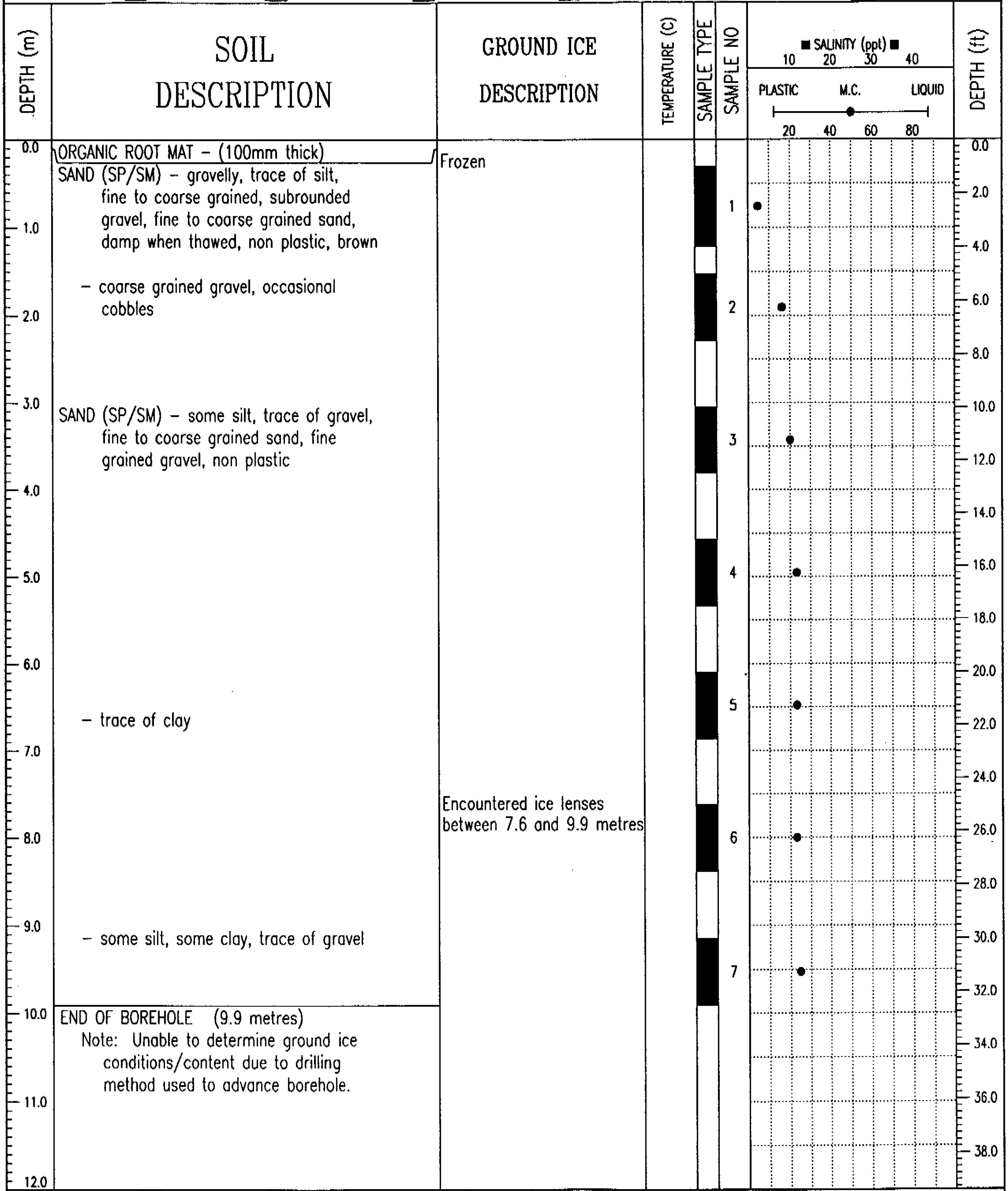
94/07/05 12:40PM

RESOURCE TARGET 4B-1

GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-27
TARGET "4B-1"	DRILL: CME750 c/w SOLID FLIGHT AUGERS	PROJECT NO: 0101-11413
RICHARDS ISLAND, N.W.T.	UTM ZONE: 8 N7704050.7 E538232	ELEVATION: 22.80 (m)

SAMPLE TYPE ■ DISTURBED ▨ NO RECOVERY ☒ SPT ☰ A-CASING ‖ SHELBY TUBE ▮ CORE

DEPTH (m)	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	SAMPLE NO
0.0	ORGANIC ROOT MAT – (100mm thick)	Frozen	
	SAND (SP/SM) – gravelly, trace of silt, fine to coarse grained, subrounded gravel, fine to coarse grained sand, damp when thawed, non plastic, brown		1
	– coarse grained gravel, occasional cobbles		2
3.0	SAND (SP/SM) – some silt, trace of gravel, fine to coarse grained sand, fine grained gravel, non plastic		3
			4
	– trace of clay		5
		Encountered ice lenses between 7.6 and 9.9 metres	6
	– some silt, some clay, trace of gravel		7
10.0	END OF BOREHOLE (9.9 metres) Note: Unable to determine ground ice conditions/content due to drilling method used to advance borehole.		



EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV	COMPLETION DEPTH: 9.9 m
	REVIEWED BY: MAV	COMPLETE: 94/03/26
	Fig. No: 11413-27	Page 1 of 1

94/07/05 12:47PM

APPENDIX C

SUMMARY OF LABORATORY TESTING AND PARTICLE SIZE ANALYSIS

LABORATORY TEST SUMMARY

Borehole	Sample Number	Sample Interval		Moisture Content	Salinity	Liquid Limit	Plastic Limit	Plasticity Index	USC Classification	Clay	Silt	Sand	Gravel
		from (m)	to (m)	(%)	(ppt)					(%)	(%)	(%)	(%)
11413-20	1	1.07	1.22	24.2					SP/SM	-	7.9	92.1	0.0
11413-20	2	1.83	1.98	21.3									
11413-20	3	3.20	3.35	24.4					SM	-	13.4	86.6	0.0
11413-20	4	4.42	4.57	19.4									
11413-20	5	5.99	6.15	25.8									
11413-21	1	1.52	1.68	25.3					SP	-	2.9	97.1	0.0
11413-21	2	2.74	2.90	16.2									
11413-21	3	4.50	4.65	20.5					SP/SM	-	10.0	90.0	0.0
11413-21	4	5.94	6.10	21.8									
11413-21	5	7.62	7.77	19.2									
11413-21	6	9.45	9.60	21.5									
11413-21	7	10.97	11.13	23.3									
11413-22	1	0.31	0.46	54.2									
11413-22	2	1.22	1.37	25.5						24.9	36.2	38.2	0.7
11413-22	3	2.59	2.74	26.4									
11413-22	4	3.20	3.35	32.3						23.8	35.6	39.5	1.1
11413-23	1	0.31	0.91	17.5					SM	-	13.9	77.2	8.9
11413-23	2	1.37	1.52	23.2									
11413-23	3	2.13	2.29	24.6					SP/SM	-	6.9	93.1	0.0
11413-23	4	3.05	3.20	25.5									
11413-23	5	4.27	4.42	23.2									
11413-23	6	5.87	6.02	18.9									
11413-23	7	7.62	7.77	20.7									

0101-11413

6/28/94

LABORATORY TEST SUMMARY

Borehole	Sample Number	Sample Interval from (m)	to (m)	Moisture Content (%)	Salinity (ppt)	Liquid Limit	Plastic Limit	Plasticity Index	USC Classification	Clay (%)	Silt (%)	Sand (%)	Gravel (%)
11413-24	1	0.76	0.91	6.7						10.9	16.2	72.0	0.9
11413-24	2	1.45	1.60	26.8									
11413-24	3	3.05	3.20	24.6						9.8	11.2	79.0	0.0
11413-24	4	4.50	4.65	26.3									
11413-24	5	6.10	6.25	24.7									
11413-24	6	7.54	7.70	27.1									
11413-25	1	0.76	0.91	13.8						12.1	22.5	64.7	0.7
11413-25	2	1.45	1.60	26.9					SP/SM	2.7	4.8	92.5	0.0
11413-25	3	2.82	2.97	25.7									
11413-25	4	4.19	4.34	21.7									
11413-25	5	5.79	5.94	21.2									
11413-25	6	7.42	7.57	19.3									
11413-26	1	0.61	0.91	14.8						-	21.4	71.2	7.4
11413-26	2	1.07	1.22	24.5									
11413-26	3	2.74	2.90	25.1					SM	4.4	9.0	86.6	0.0
11413-26	4	4.12	4.27	24.7									
11413-26	5	5.64	5.79	24.1									
11413-26	6	7.24	7.39	24.4									
11413-26	7	8.69	8.84	21.9									
11413-27	1	0.31	1.22	4.7					SP/SM	-	5.3	60.9	33.8
11413-27	2	1.52	2.29	16.2									
11413-27	3	3.05	3.81	20.1					SW/SM	-	10.0	84.2	5.8
11413-27	4	4.57	5.33	23.2									
11413-27	5	6.10	6.86	23.3					SM	5.3	14.5	78.2	2.0
11413-27	6	7.62	8.38	23.1									
11413-27	7	9.14	9.91	24.8						14.1	17.8	63.9	4.2

EBA File No. 0101-94-11413

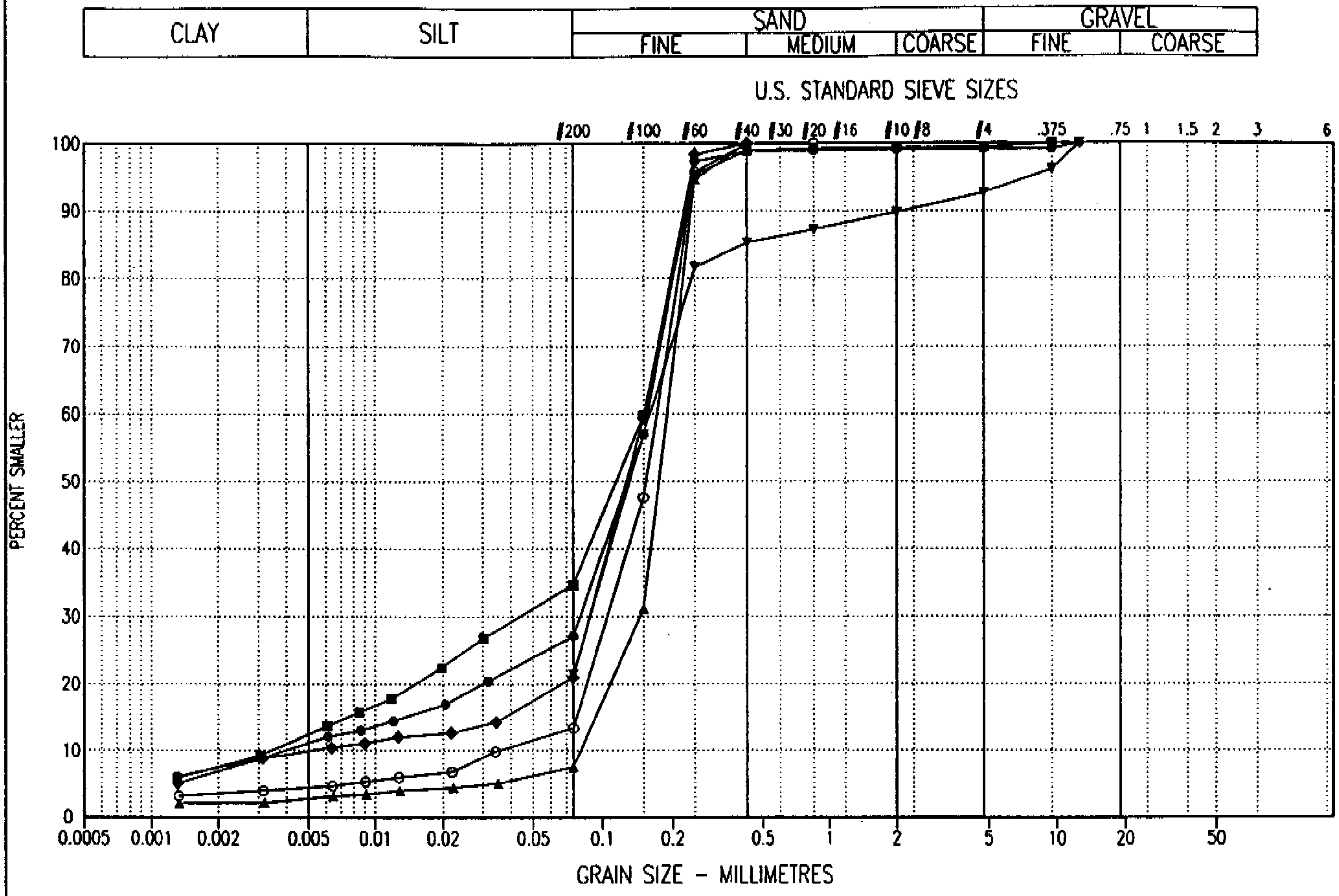
PARTICLE SIZE DISTRIBUTION ANALYSIS SUMMARY

Borehole Number	Depth		Percent Passing																		
	from (m)	to (m)	50 mm (%)	25 mm (%)	19 mm (%)	12.5 mm (%)	9.5 mm (%)	4.75 mm (%)	2 mm (%)	0.85 mm (%)	0.425 mm (%)	0.25 mm (%)	0.15 mm (%)	0.75 mm (%)	0.03 mm (%)	0.02 mm (%)	0.01 mm (%)	0.009 mm (%)	0.006 mm (%)	0.003 mm (%)	0.001 mm (%)
11413-20	1.10	1.20	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.0	71.6	7.9							
11413-20	3.20	3.40	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	98.1	66.4	13.5							
11413-21	1.50	1.70	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6	21.5	4.7	2.9							
11413-21	4.50	4.70	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	88.8	39.5	10.0							
11413-22	1.20	1.40	100.0	100.0	100.0	100.0	100.0	99.3	99.0	98.6	97.8	95.2	81.1	61.2	50.3	43.4	35.8	31.7	27.7	19.8	13.5
11413-22	3.20	3.40	100.0	100.0	100.0	100.0	100.0	98.9	98.4	97.6	96.8	94.2	79.9	59.4	48.4	41.6	35.0	29.4	25.9	20.0	13.4
11413-23	0.30	0.90	100.0	100.0	100.0	100.0	98.3	91.1	85.3	80.1	75.7	67.9	36.2	14.0							
11413-23	2.10	2.30	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	88.0	41.5	6.9							
11413-24	0.80	0.90	100.0	100.0	100.0	100.0	99.2	99.1	99.0	98.9	98.8	97.4	57.0	27.1	20.5	17.0	14.5	13.1	12.1	8.8	6.1
11413-24	3.00	3.20	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.4	59.4	21.0	14.3	12.7	12.1	11.1	10.5	8.9	5.1
11413-25	0.80	0.90	100.0	100.0	100.0	100.0	100.0	99.4	99.3	99.2	98.9	95.5	59.8	34.7	26.8	22.4	17.8	15.8	13.7	9.3	5.8
11413-25	1.40	1.60	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	94.7	31.2	7.6	5.1	4.4	4.0	3.5	3.2	2.2	2.1
11413-26	0.60	0.90	100.0	100.0	100.0	100.0	96.2	92.7	89.8	87.2	85.2	81.7	57.0	21.5							
11413-26	2.70	2.90	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	95.8	47.6	13.4	9.8	6.8	6.0	5.4	4.8	4.0	3.2
11413-27	0.30	1.20	100.0	90.2	87.6	80.2	75.0	66.2	58.3	48.4	36.3	14.6	8.2	5.4							
11413-27	3.00	3.80	100.0	100.0	100.0	100.0	98.7	94.2	87.0	70.7	38.7	17.5	12.9	10.1							
11413-27	6.10	6.90	100.0	100.0	100.0	100.0	100.0	98.0	95.2	90.5	75.3	45.7	30.5	19.8	15.1	11.8	9.1	7.6	6.0	4.4	2.4
11413-27	9.10	9.90	100.0	100.0	100.0	100.0	96.9	95.9	89.9	86.1	76.3	55.5	40.9	31.9	27.1	23.6	20.0	17.6	15.4	11.4	8.3

RESOURCE TARGET 6C-1

EBA Engineering

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
●——●	24	0.80 - 0.90	10.9	16.2	72.0	0.9	37.8	10.3	SM
◆——◆	24	3.00 - 3.20	9.8	11.2	79.0	0.0	28.2	10.5	SM
■——■	25	0.80 - 0.90	12.1	22.5	64.7	0.7	42.7	4.4	SM
▲——▲	25	1.40 - 1.60	2.7	4.8	92.5	0.0	2.4	1.3	SP-SM
▼——▼	26	0.60 - 0.90	21.4		71.2	7.4	3.0	1.0	SM
○——○	26	2.70 - 2.90	4.4	9.0	86.6	0.0	4.9	2.0	SM

Project: 101-11413

Date Tested: 94/04/21

BY: MH

Tested in accordance with ASTM D422 unless otherwise noted.

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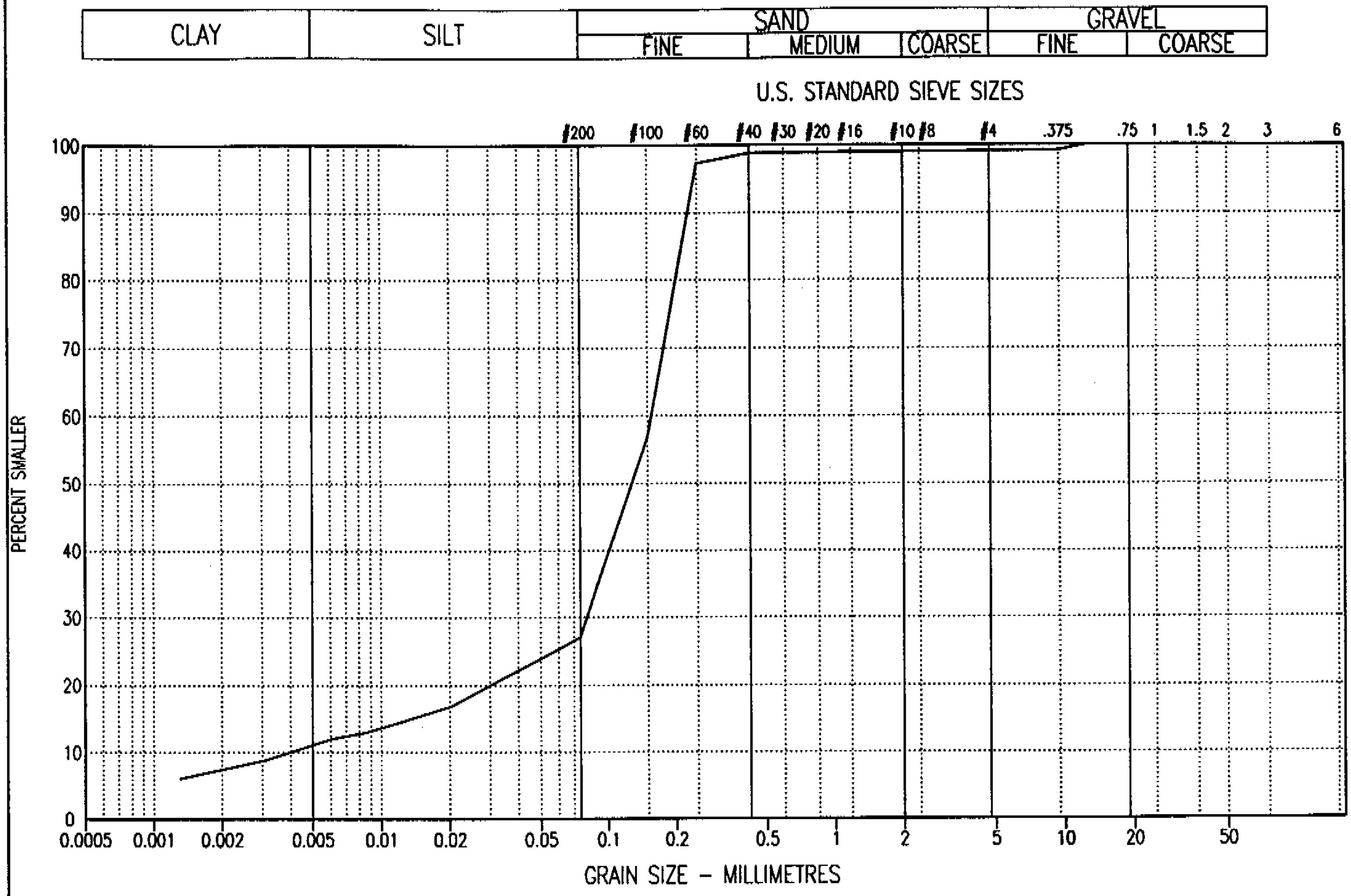
The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
——	24	0.80 - 0.90	10.9	16.2	72.0	0.9	37.8	10.3	

Project: 101-11413

Date Tested: 94/04/21

BY: MH

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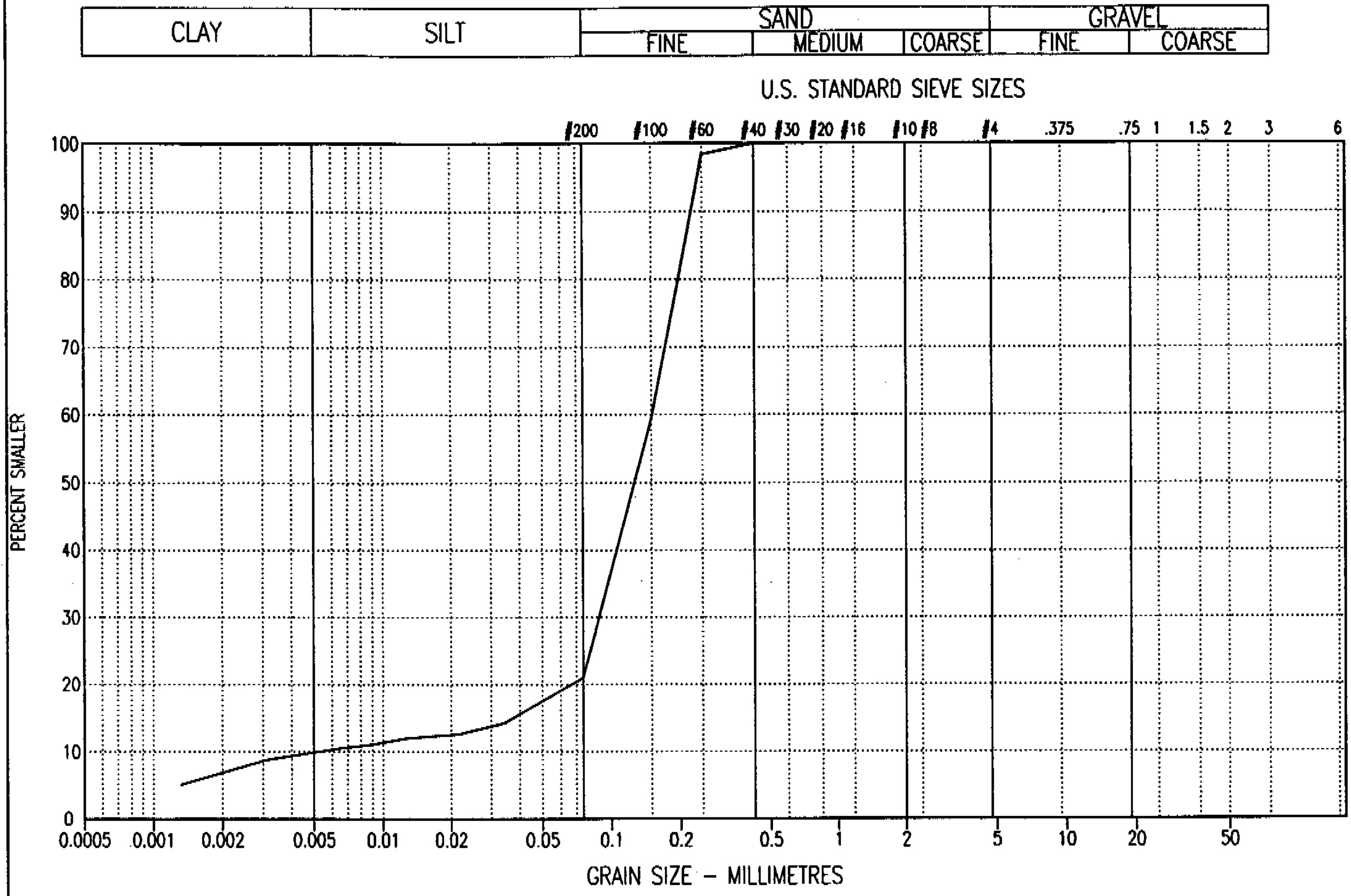
EBA Engineering

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
———	24	3.00 - 3.20	9.8	11.2	79.0	0.0	28.2	10.5	

Project: 101-11413

Date Tested: 94/05/09

BY: IS

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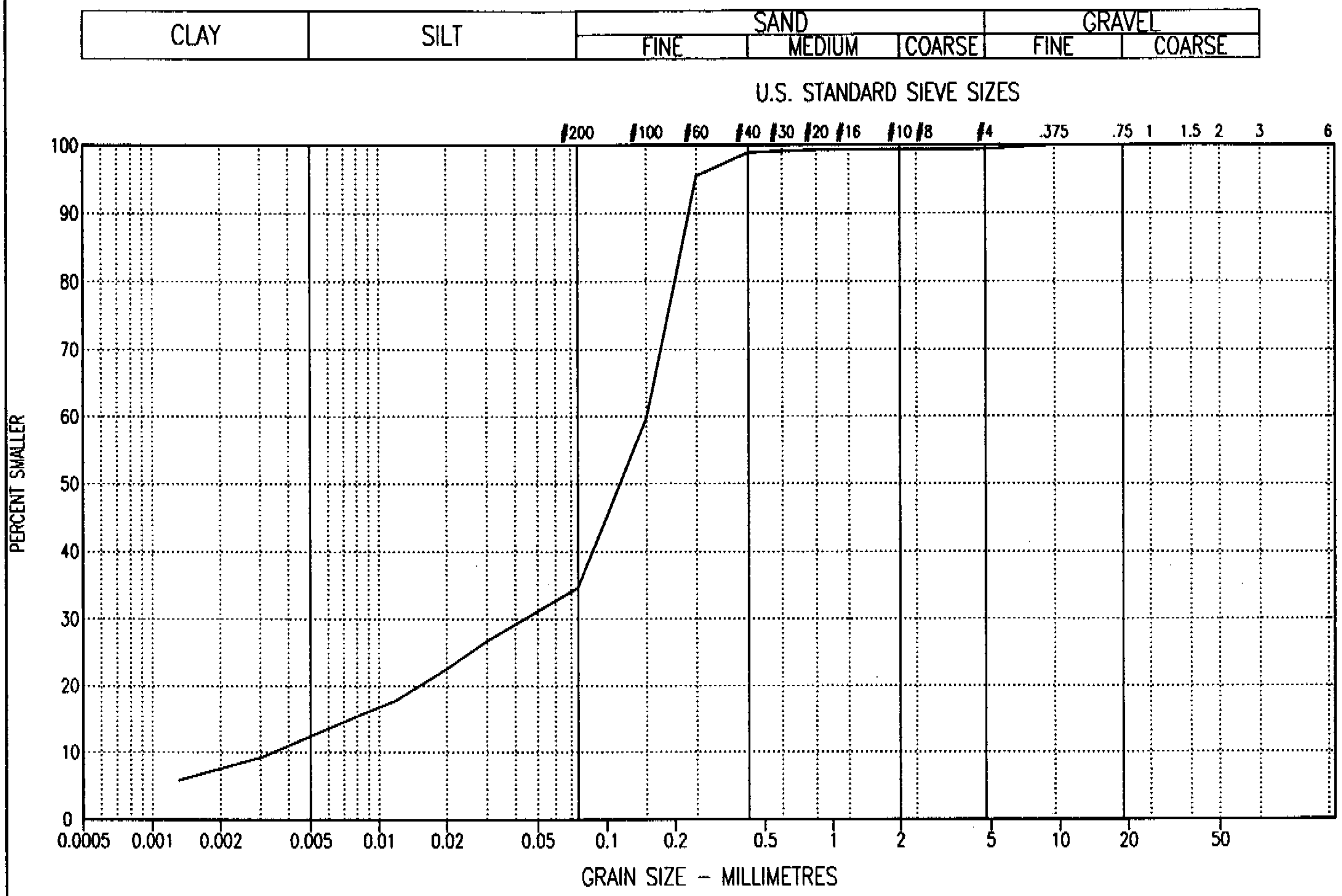
EBA Engineering

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
———	25	0.80 - 0.90	12.1	22.5	64.7	0.7	42.7	4.4	

Project: 101-11413

Date Tested: 94/04/21

BY: MH

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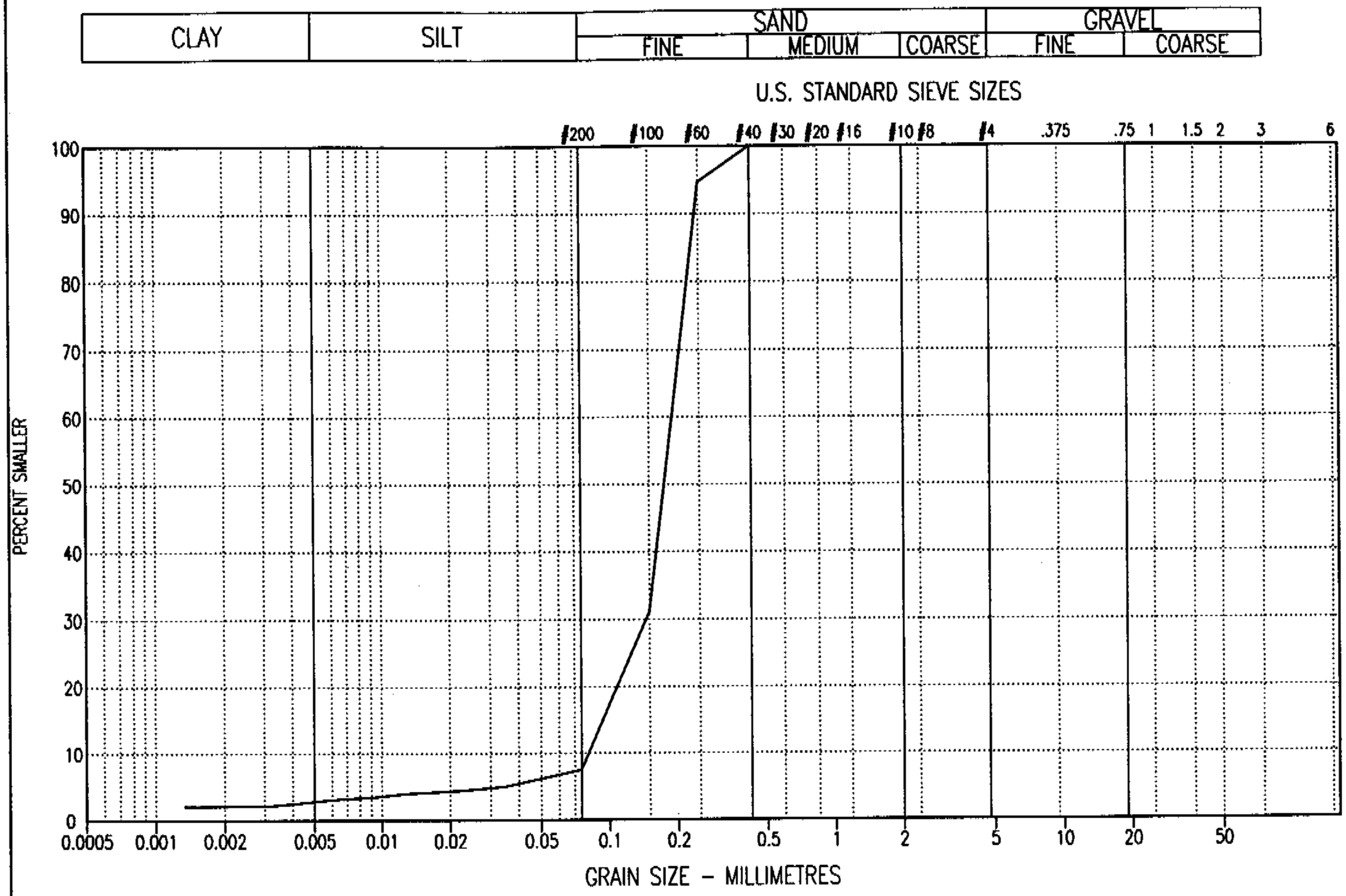
EBA Engineering

PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
——	25	1.40 – 1.60	2.7	4.8	92.5	0.0	2.4	1.3	SP/SM

Project: 101-11413

Date Tested: 94/04/21

BY: MH

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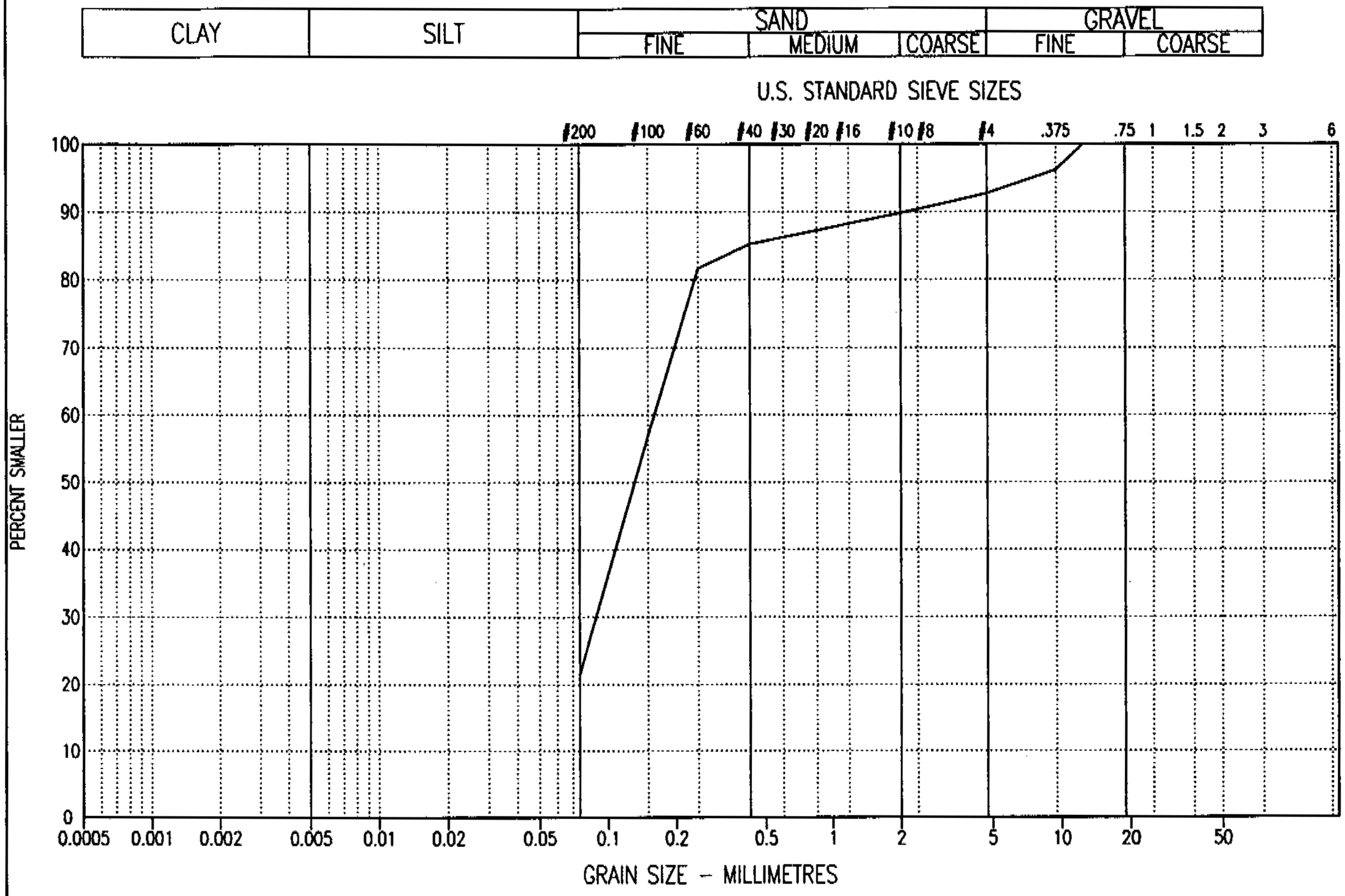
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
—	26	0.6 - 0.9	21.4	71.2	7.4	4.6	1.5	

Project: 101-11413

Date Tested: 90/04/19

BY: MH

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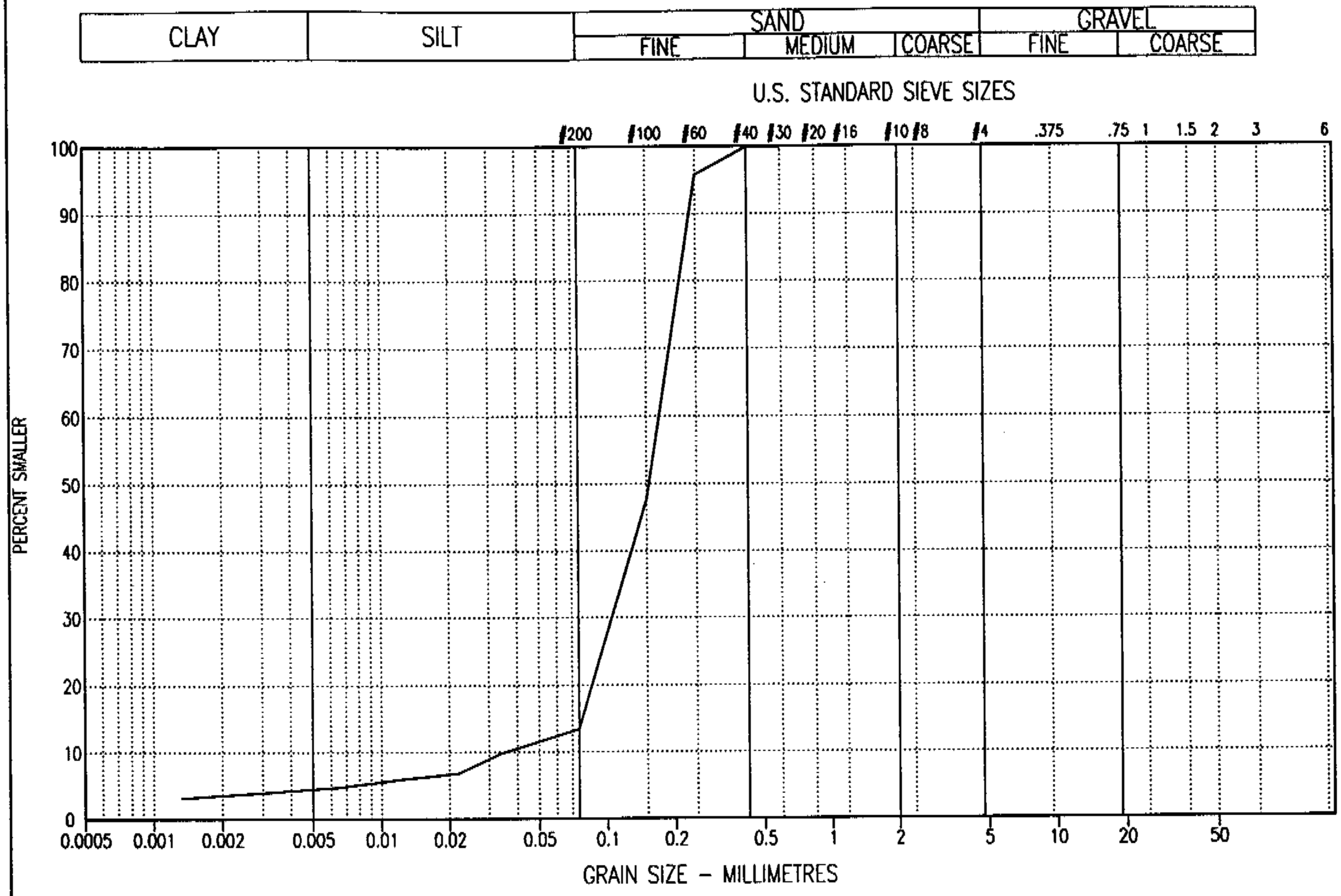
EBA Engineering

PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
——	26	2.70 – 2.90	4.4	9.0	86.6	0.0	4.9	2.0	SM

Project: 101-11413

Date Tested: 94/04/21

BY: MH

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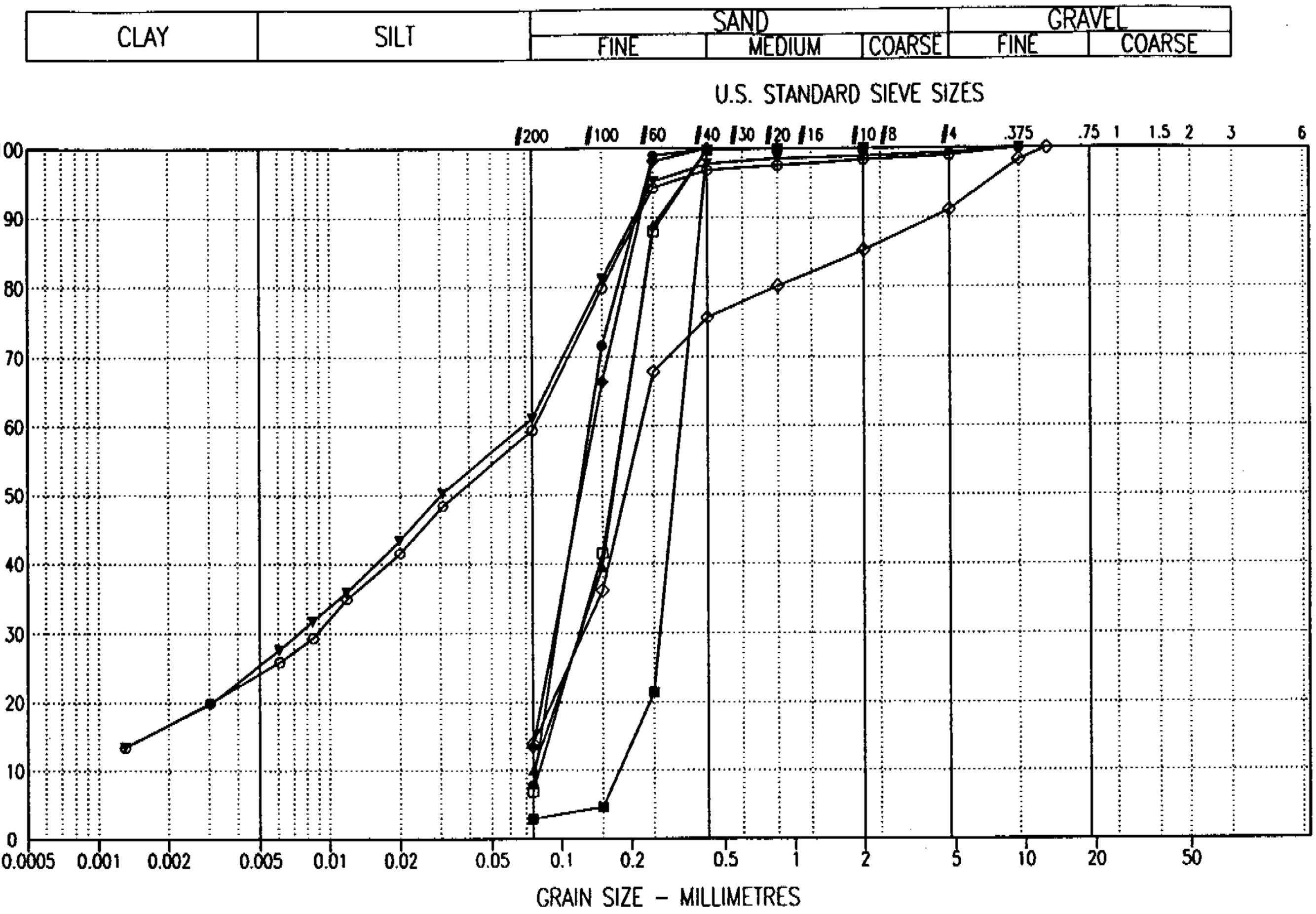
RESOURCE TARGET 6C-2

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
●—●	20	1.10 - 1.20	7.9	92.1	0.0	1.8	1.0	SP-SM
◆—◆	20	3.20 - 3.40	13.4	86.6	0.0	2.5	1.2	SM
■—■	21	1.50 - 1.70	2.9	97.1	0.0	1.9	1.2	SP
▲—▲	21	4.50 - 4.70	10.0	90.0	0.0	2.6	1.1	SP-SM
▼—▼	22	1.20 - 1.40	24.9 36.2	38.2	0.7	-	-	
○—○	22	3.20 - 3.40	23.8 35.6	39.5	1.1	-	-	
◇—◇	23	0.30 - 0.90	13.9	77.2	8.9	3.6	1.2	SM
□—□	23	2.10 - 2.30	6.9	93.1	0.0	2.3	1.0	SP-SM

Project: 101-11413

Date Tested: 94/04/08

BY: MH

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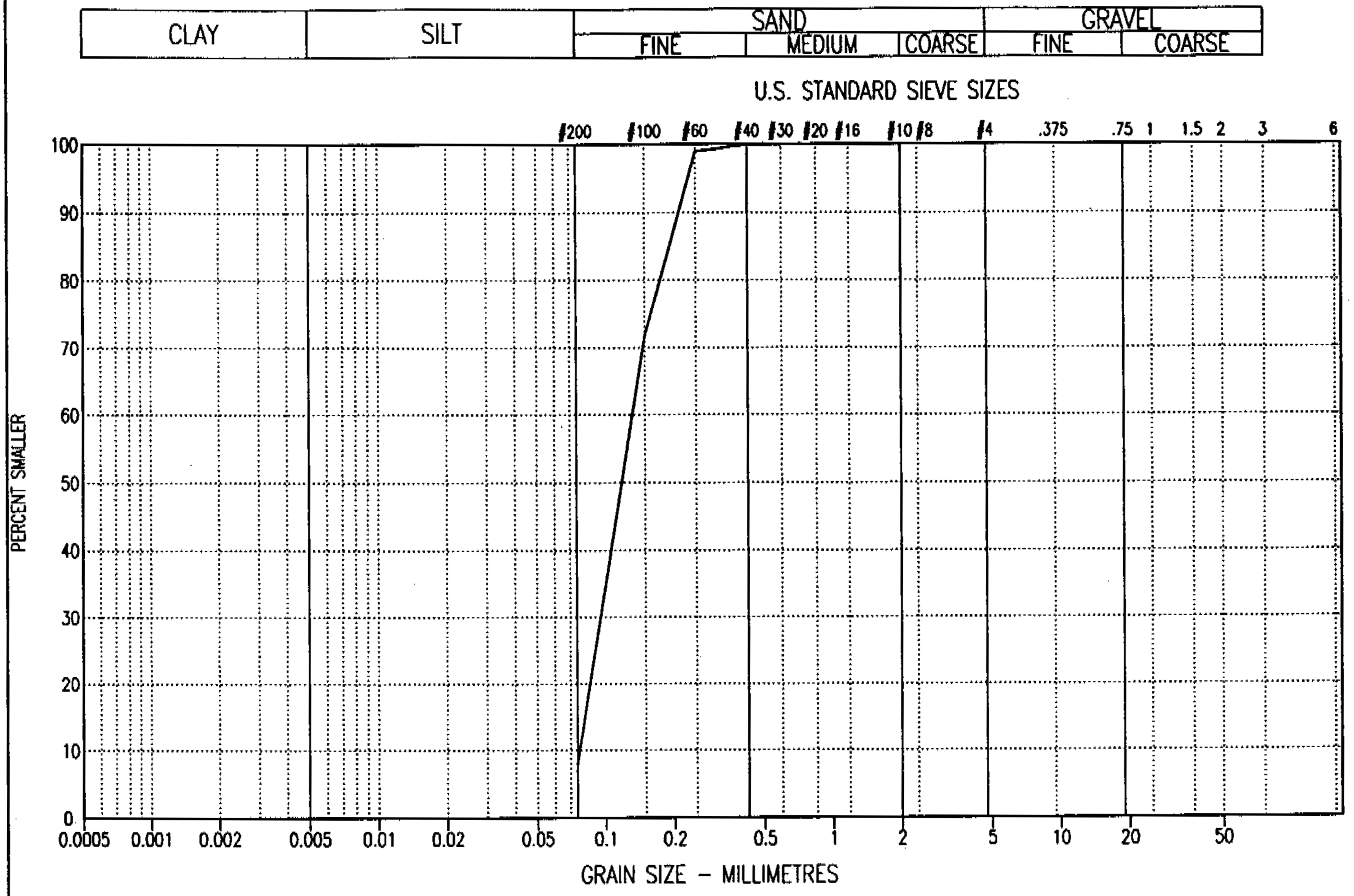
PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
——	20	1.1 – 1.2	7.9	92.1	0.0	1.8	1.0	SP/SM

Project: 101-11413

Date Tested: 94/04/08

BY: MH

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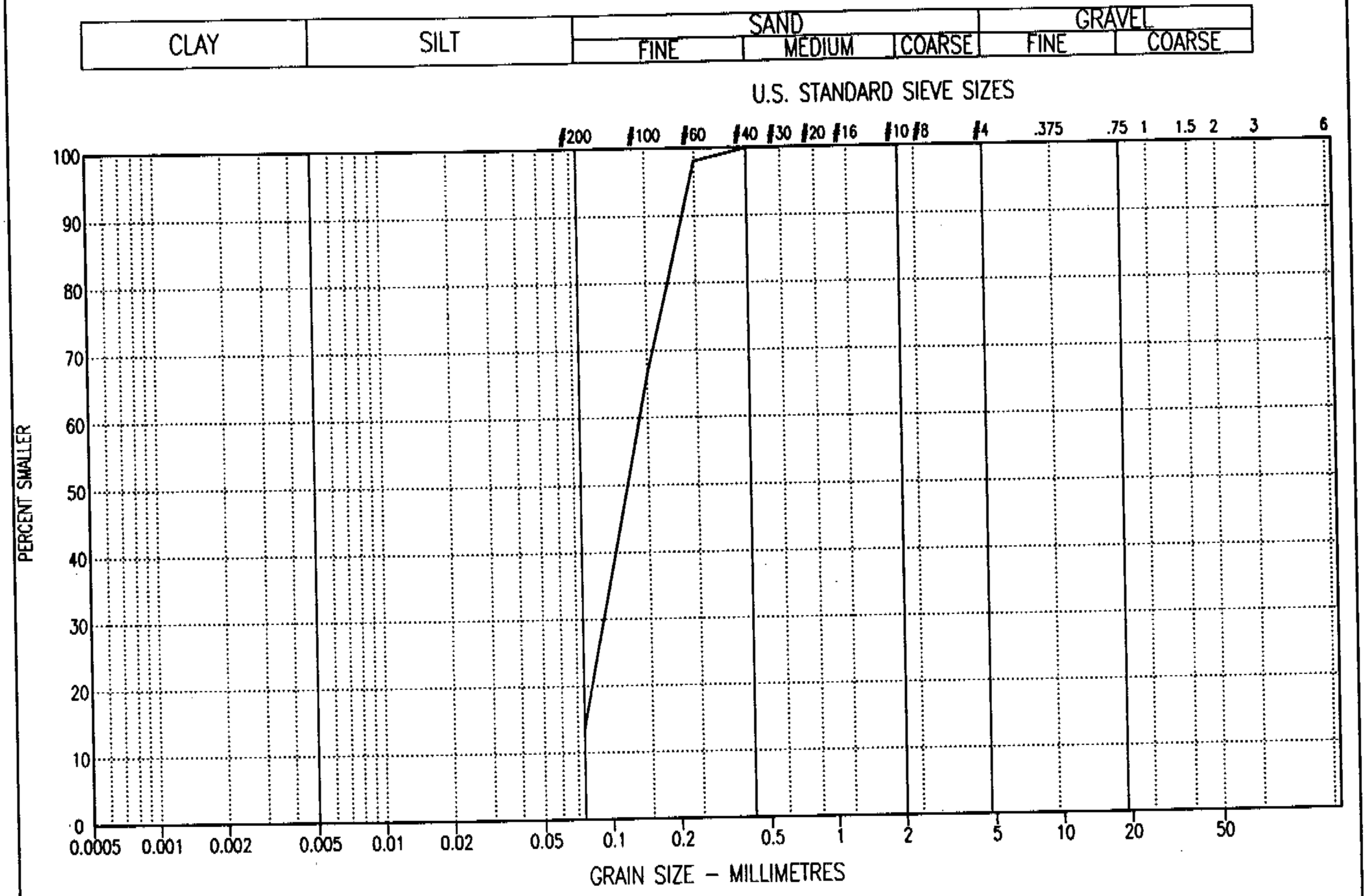
PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
——	20	3.2 – 3.4	13.4	86.6	0.0	2.5	1.2	SM

Project: 101-11413

Date Tested: 94/04/08

BY: MH

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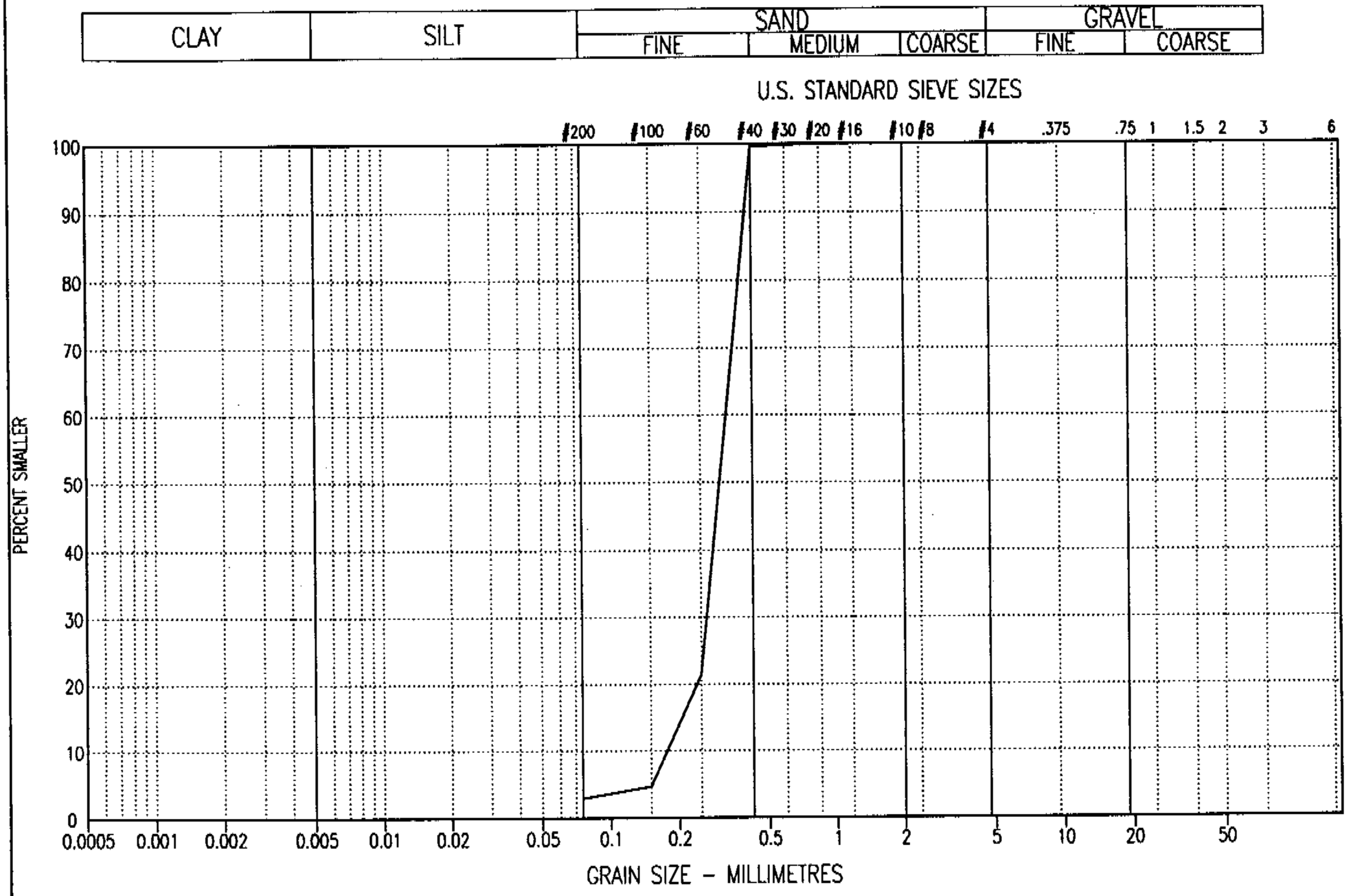
EBA Engineering

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
———	21	1.5 - 1.7	2.9	97.1	0.0	1.9	1.2	SP

Project: 101-11413

Date Tested: 94/04/11

BY: MH

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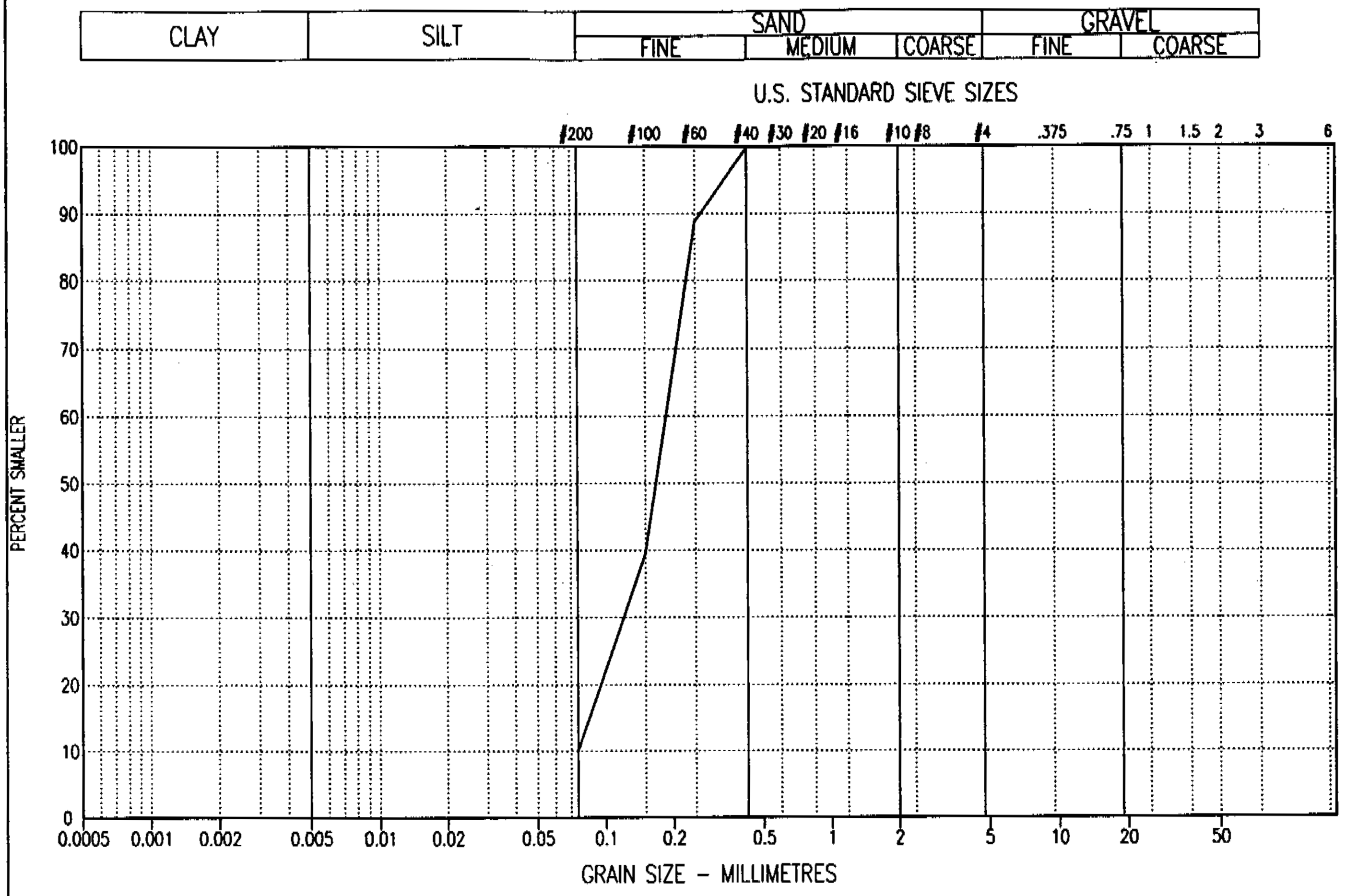
EBA Engineering

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
———	21	4.5 - 4.7	10.0	90.0	0.0	2.6	1.1	SP/SM

Project: 101-11413

Date Tested: 94/04/11

BY: MH

Tested in accordance with ASTM D422 unless otherwise noted.

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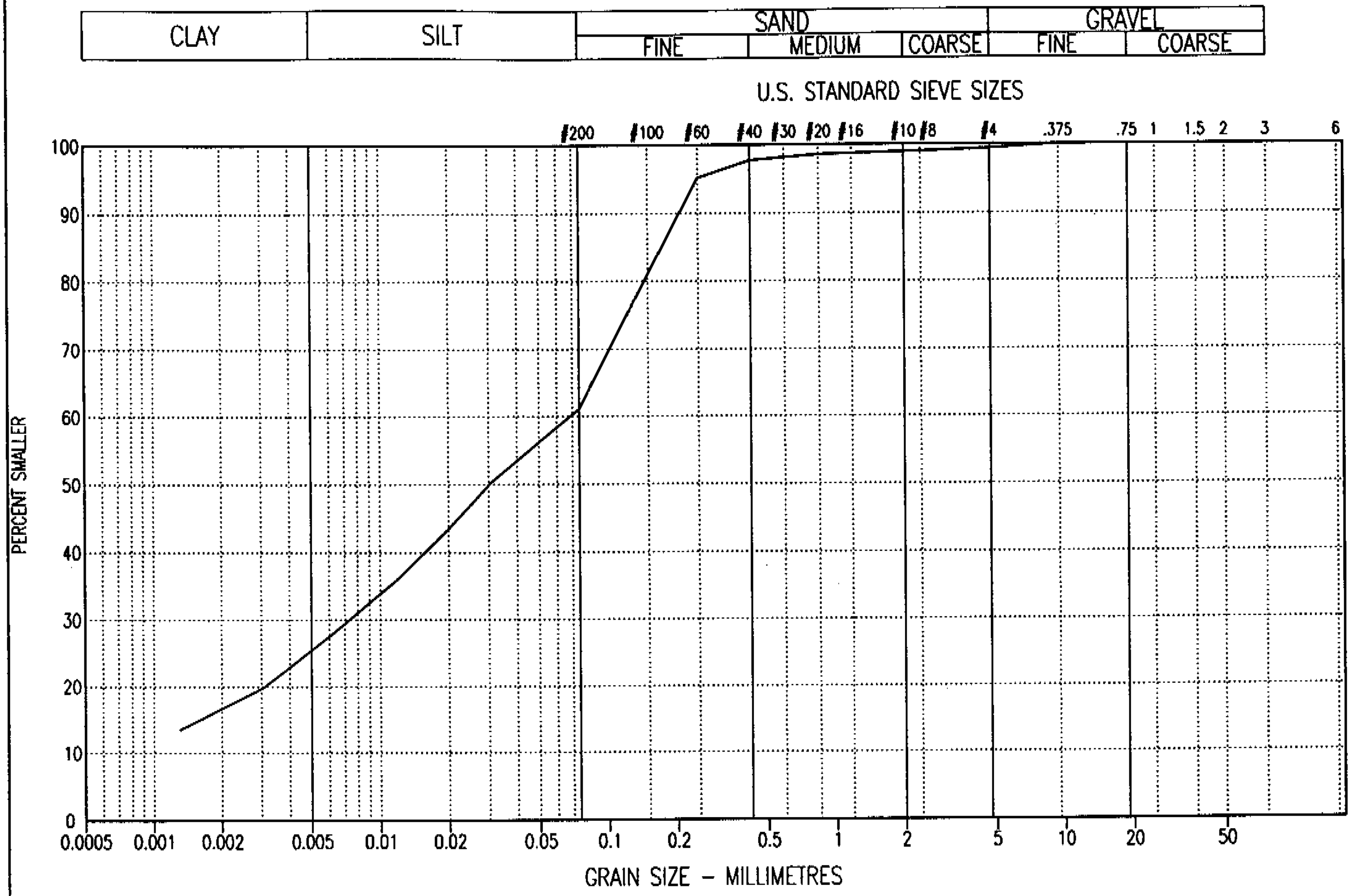

SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
——	22	1.20 - 1.40	24.9	36.2	38.2	0.7	-	-	

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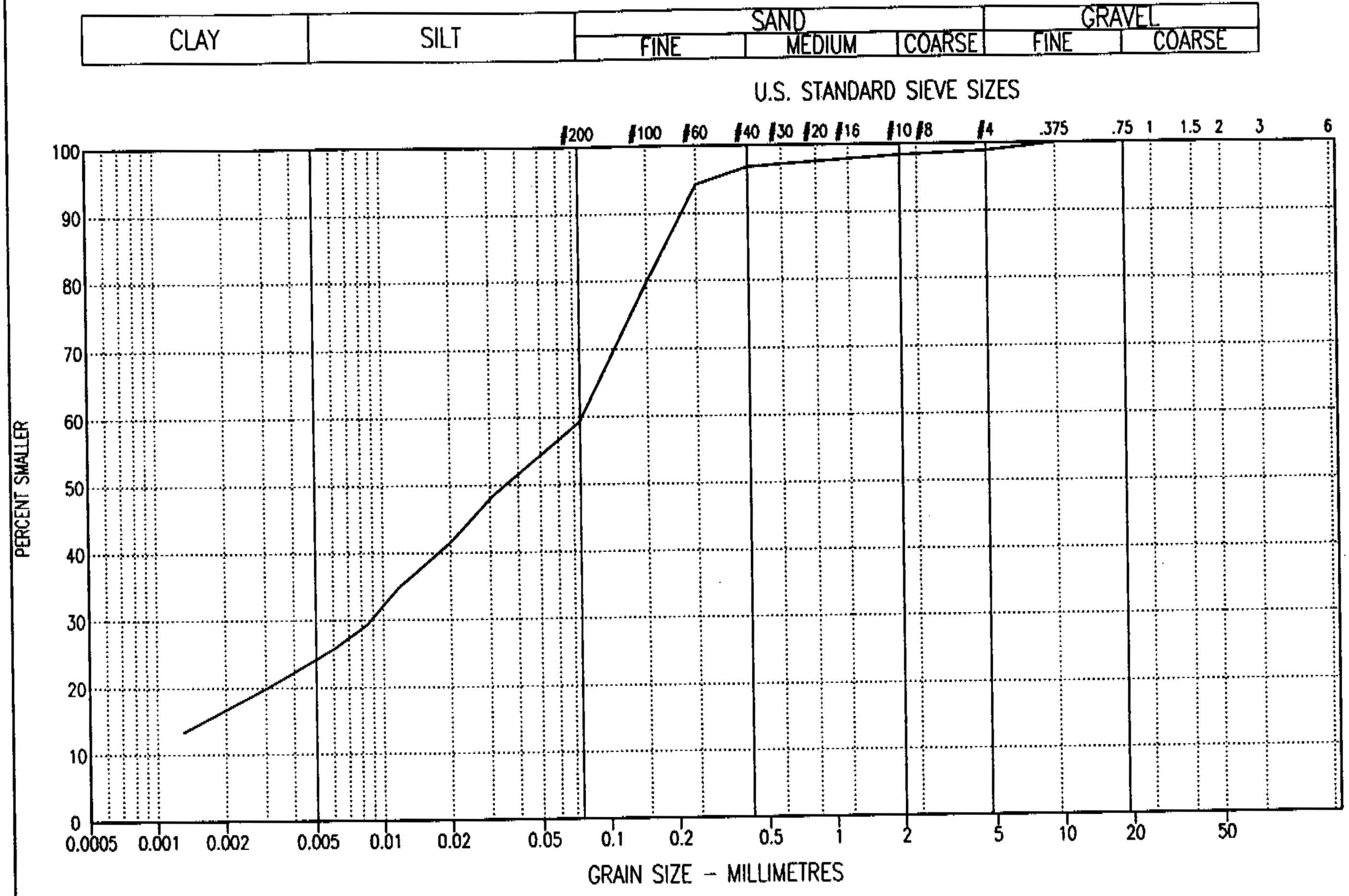

SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
———	22	3.20 - 3.40	23.8	35.6	39.5	1.1	-	-	

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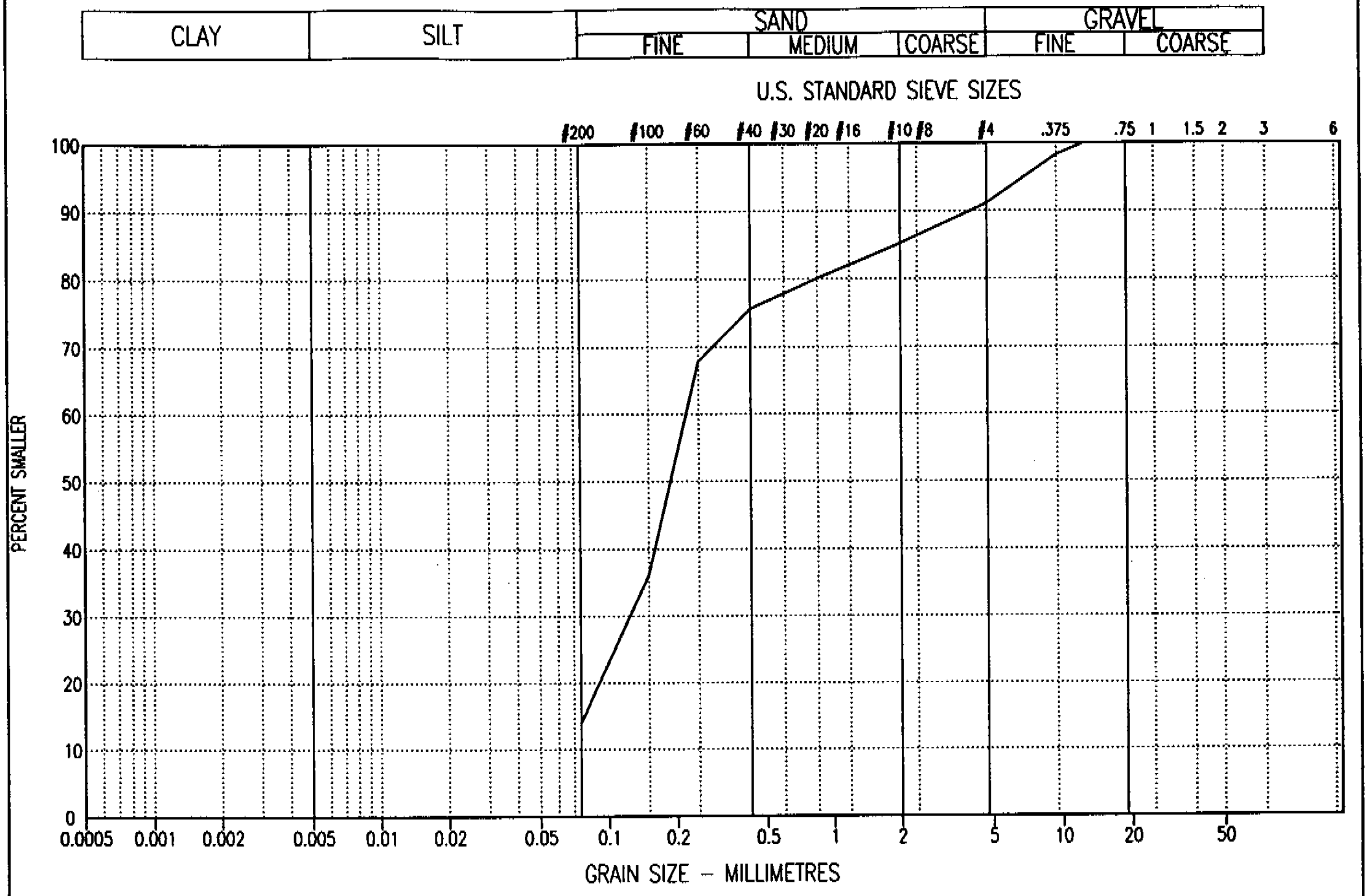

SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
——	23	0.3 – 0.9	13.9	77.2	8.9	4.2	1.4	SM

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Date Tested: 94/04/19

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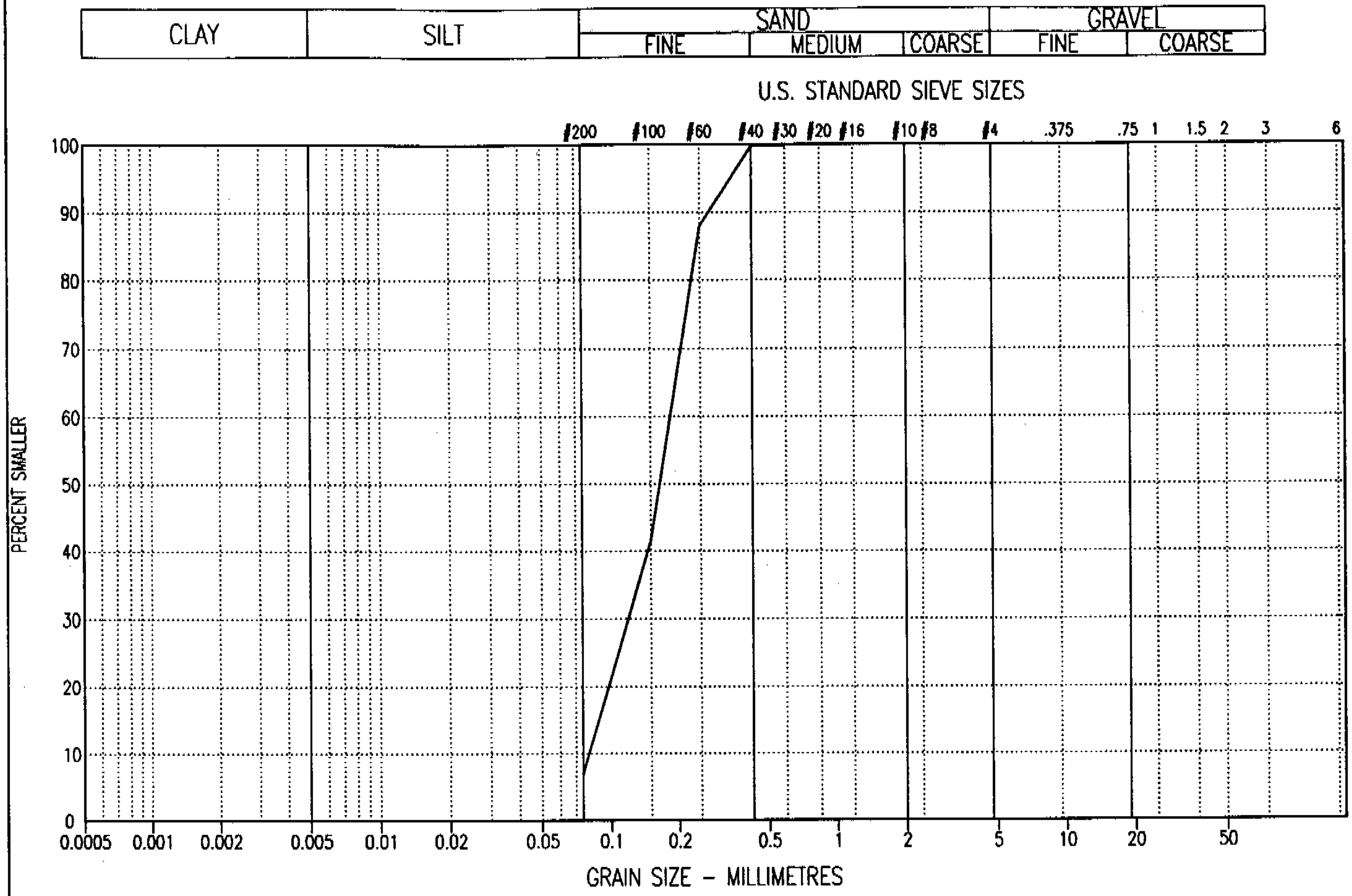

SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
———	23	2.1 - 2.3	6.9	93.1	0.0	2.3	1.0	SP/SM

Project: 101-11413

Date Tested: 94/04/19

BY: MH

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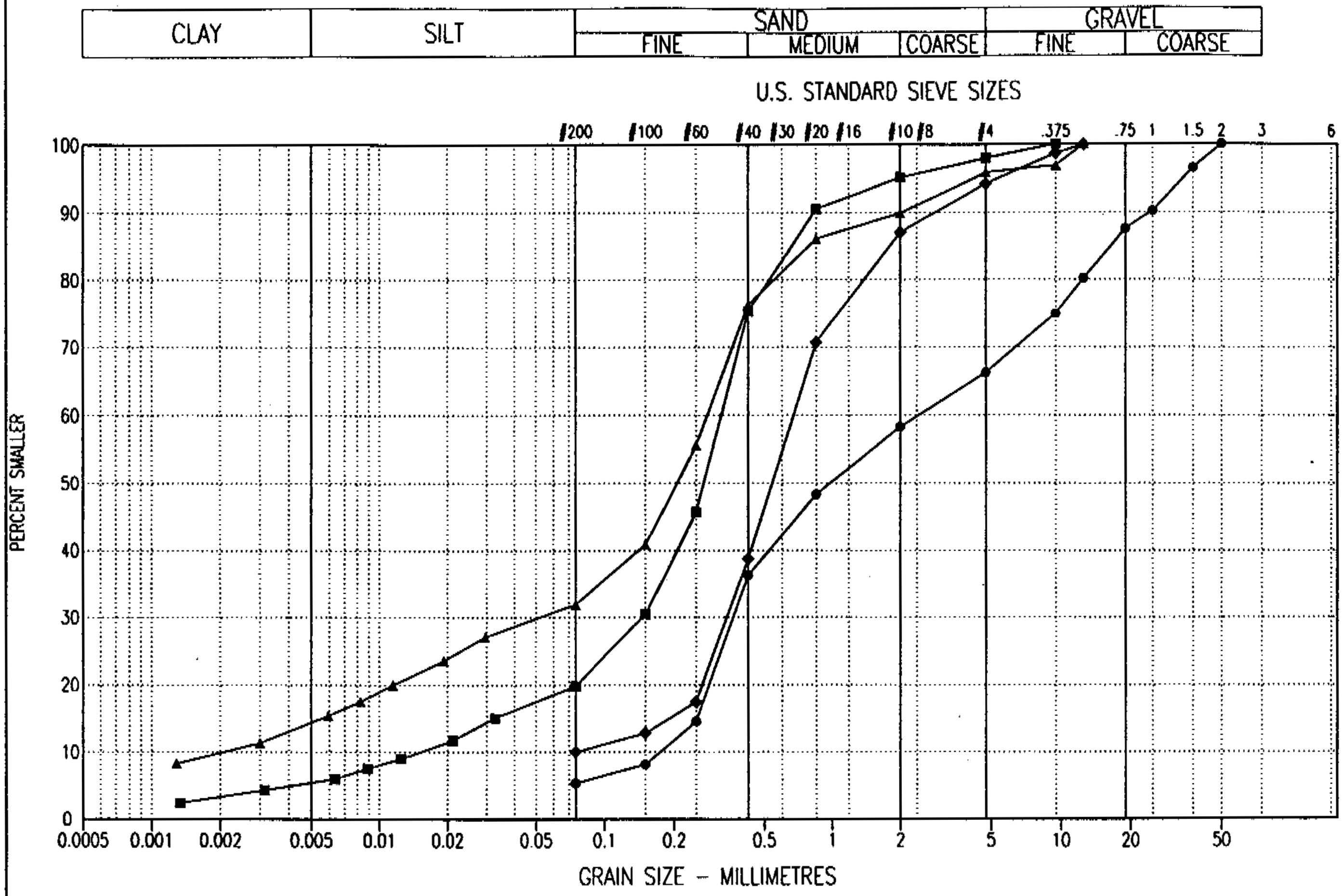
RESOURCE TARGET 4B-1

EBA Engineering

PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
●——●	27	0.30 - 1.20	5.3	60.9	33.8	14.6	0.3	SP–SM
◆——◆	27	3.00 - 3.80	10.0	84.2	5.8	9.5	2.4	SW–SM
■——■	27	6.10 - 6.90	5.3 14.5	78.2	2.0	21.7	4.2	SM
▲——▲	27	9.10 - 9.90	14.1 17.8	63.9	4.2	129.7	5.1	SM

Project: 101-11413

Date Tested: 94/04/11

BY: COC

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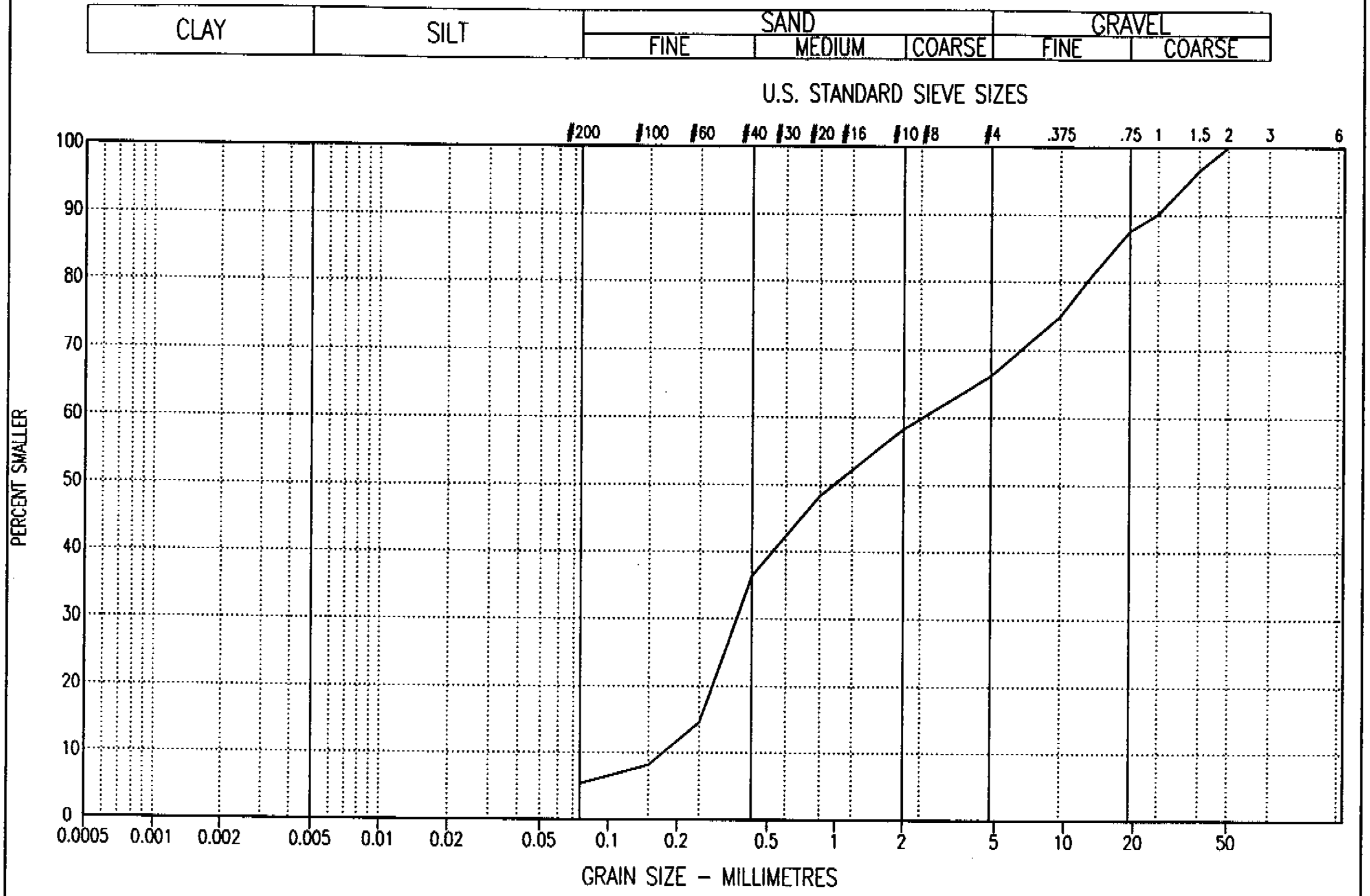

SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
—	27	0.3 - 1.2	5.3	60.9	33.8	14.6	0.3	SP/SM

Project: 101-11413

Date Tested: 94/04/11

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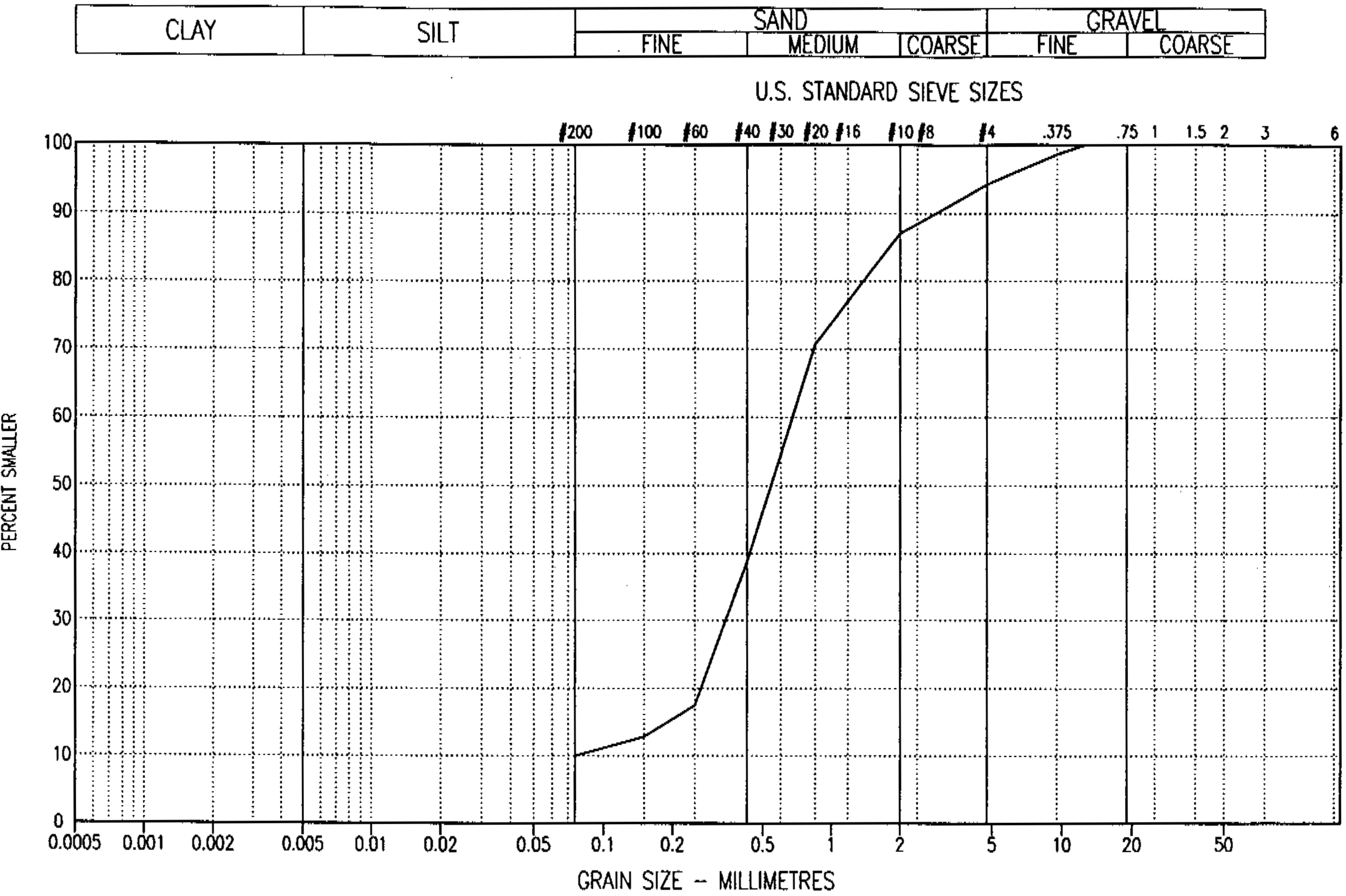

SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
——	27	3.0 - 3.8	10.0	84.2	5.8	9.5	2.4	SW/SM

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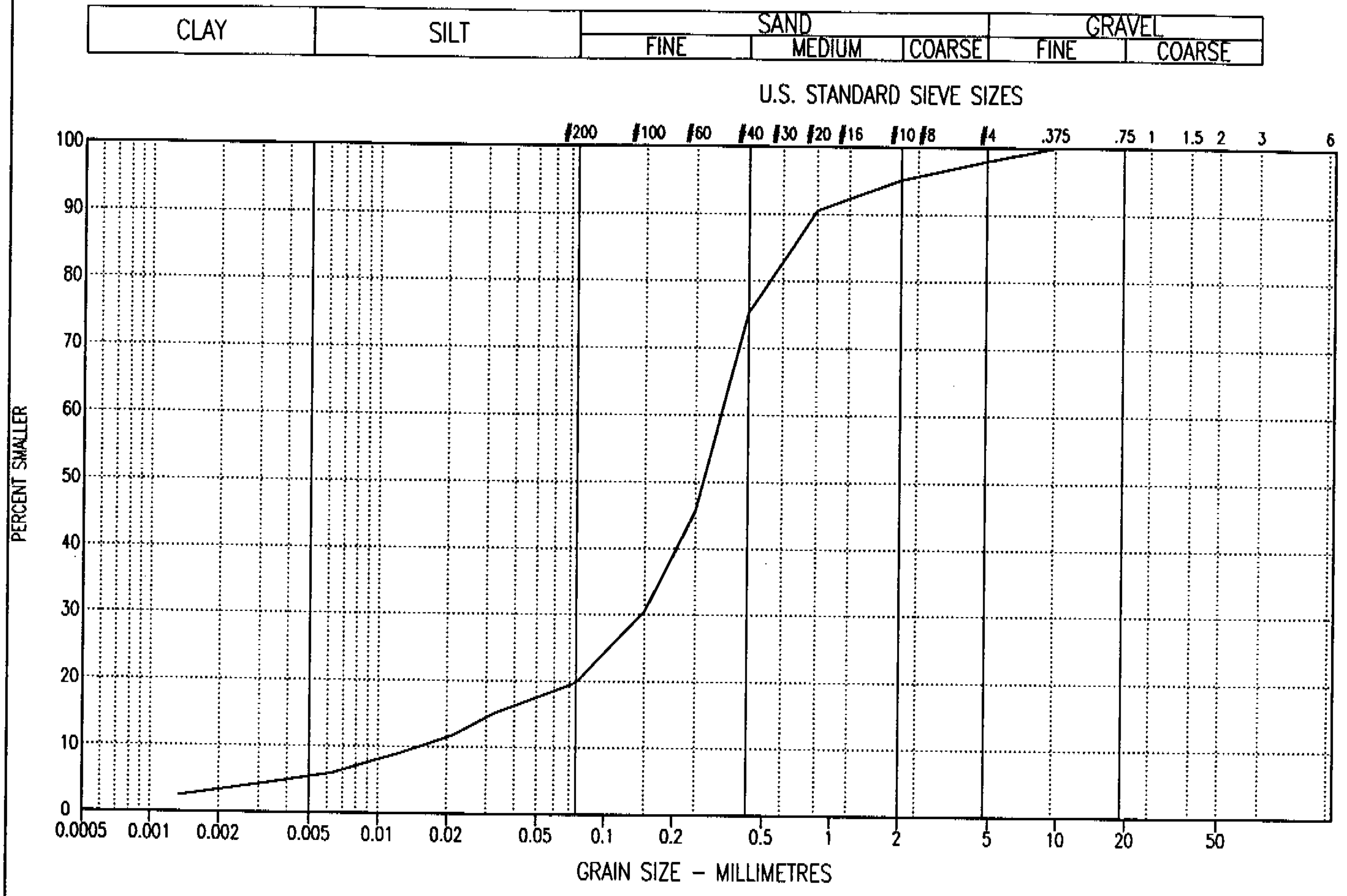

SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
——	27	6.10 - 6.90	5.3	14.5	78.2	2.0	21.7	4.2	SM

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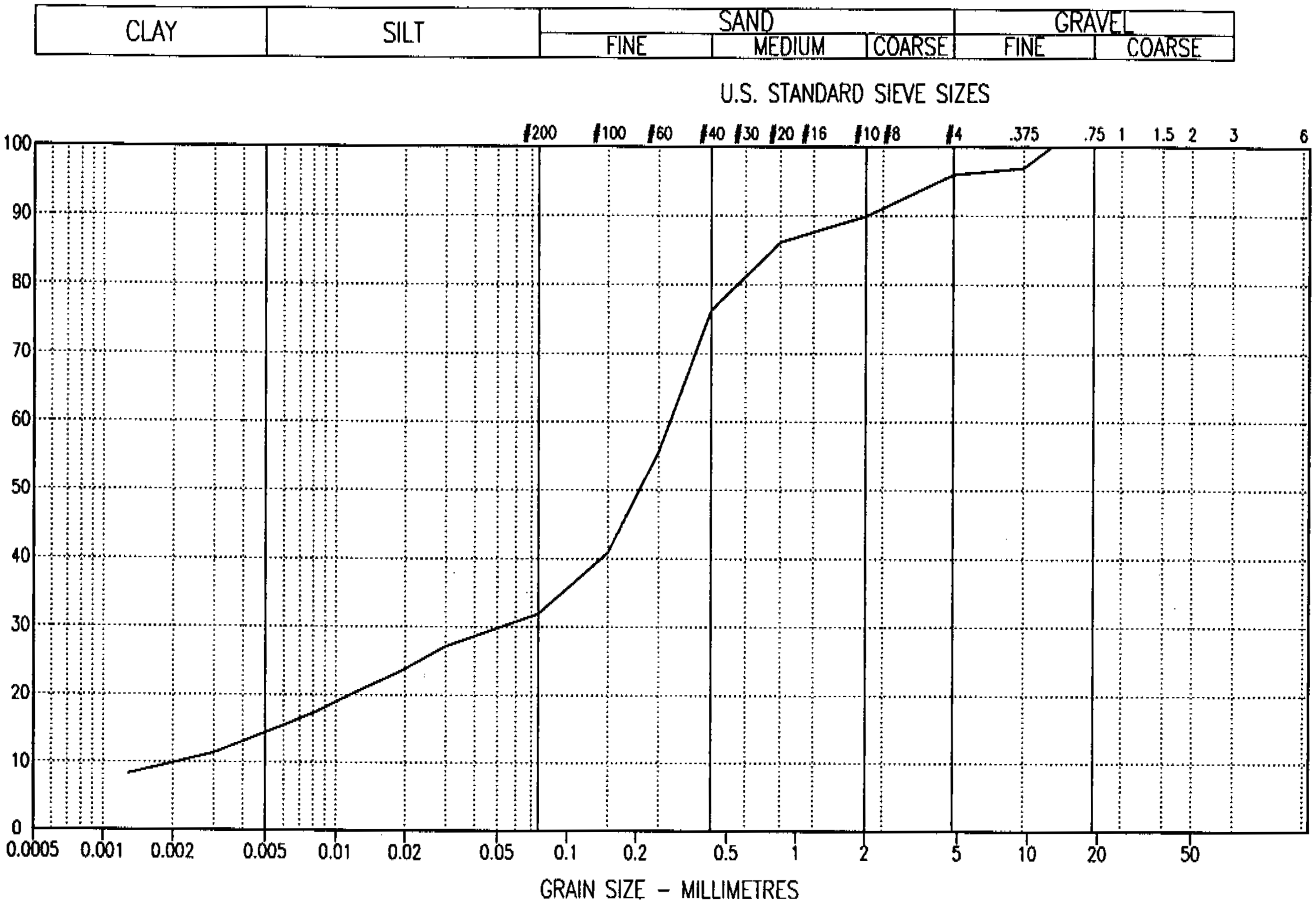

SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
——	27	9.10 - 9.90	14.1	17.8	63.9	4.2	129.7	5.1	

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SYSTEM INTERNATIONAL UNITS

QUANTITY	NAME	SYMBOL	EXPRESSED IN TERMS OF OTHER SI UNITS	EXPRESSED IN TERMS OF BASE AND SUPPLEMENTARY UNITS
SI UNITS				
length	metre	m		
mass	kilogram	kg		
time	second	s		
electric current	ampere	A		
thermodynamic temperature	kelvin	K		
amount of substance	mole	mol		
luminous intensity	candela	cd		
SI SUPPLEMENTARY UNITS				
plane angle	radian	rad		
solid angle	steradian	sr		
EXAMPLES OF SI DERIVED UNITS WITH SPECIAL NAMES				
frequency	hertz	Hz	1/s	s^{-1}
force	newton	N	$m \cdot kg/s^2$	$m \cdot kg \cdot s^{-2}$
pressure, stress	pascal	Pa	N/m^2	$m^{-1} \cdot kg \cdot s^{-2}$
energy, work, quantity of heat	joule	J	$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$
power, radiant flux	watt	W	J/s	$m^2 \cdot kg \cdot s^{-3}$
EXAMPLES OF SI DERIVED UNITS WITHOUT SPECIAL NAMES				
velocity - linear	metre per second		m/s	$m \cdot s^{-1}$
- angular	(radian per second)		rad/s	$rad \cdot s^{-1}$
acceleration - linear	(metre per second) per second		m/s^2	$m \cdot s^{-2}$
- angular	(radian per second) per second		rad/s^2	$rad \cdot s^{-2}$
concentration (of amount of substance)	mole per cubic metre		mol/m^3	$mol \cdot m^{-3}$
dynamic viscosity	pascal second		$Pa \cdot s$	$m^{-1} \cdot kg \cdot s^{-1}$
moment of force	newton metre		$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$
surface tension	newton per metre		N/m	$kg \cdot s^{-2}$
heat flux density, irradiance	watt per square metre		W/m^2	$kg \cdot s^{-3}$
heat capacity, entropy	joule per kelvin		J/K	$m^2 \cdot s^{-2}\ K^{-1}$
specific heat capacity, specific entropy	joule per kilogram kelvin		$J/(kg \cdot K)$	$m^2 \cdot s^{-2} \cdot K^{-1}$
specific energy	joule per kilogram		J/kg	$m^2 \cdot s^{-2}$
thermal conductivity	watt per metre kelvin		$W/(m \cdot K)$	$m \cdot kg \cdot s^{-3} \cdot K^{-1}$

OTHER UNITS PERMITTED FOR USE WITH SI

QUANTITY	NAME	SYMBOL	DEFINITION
time	minute	min	1 min = 60 s
	hour	h	1 h = 3,600 s
	day	d	1 d = 86,400 s
	year	a	
plane angle	degree	°	$1^\circ = (\pi/180)$ rad
	minute	′	$1' = (\pi/10{,}800)$ rad
	second	″	$1'' = (\pi/648{,}000)$ rad
area	hectare	ha	1 ha = 10,000 m^2
volume	litre	L	1,000 L = 1 m^3
temperature	degree Celsius	°C	0° C = 273.15° K temperature interval 1 C° ≡ 1 K°
mass	tonne	t	1 t = 1,000 kg = 1 Mg

MULTIPLYING FACTOR	PREFIX	SYMBOL	MULTIPLYING FACTOR	PREFIX	SYMBOL
1,000,000,000,000,000,000 = 10^{18}	exa	E	0.1 = 10^{-1}	deci*	d
1,000,000,000,000,000 = 10^{15}	peta	P	0.01 = 10^{-2}	centi*	c
1,000,000,000,000 = 10^{12}	tetra	T	0.001 = 10^{-3}	milli	m
1,000,000,000 = 10^{9}	giga	G	0.000,001 = 10^{-6}	micro	μ
1,000,000 = 10^{6}	mega	M	0.000,000,001 = 10^{-9}	nano	n
1,000 = 10^{3}	kilo	k	0.000,000,000,001 = 10^{-12}	pico	p
100 = 10^{2}	hecto*	h	0.000,000,000,000,001 = 10^{-15}	femto	f
10 = 10^{1}	deca*	da	0.000,000,000,000,000,001 = 10^{-18}	atto	a

* *to be avoided where possible*