EBA Engineering Consultants Ltd.

GRANULAR RESOURCE INVESTIGATION
SOURCE 222
DEMPSTER HIGHWAY #8, km 222
CARIBOU CREEK, NWT

0101-11413

SEPTEMBER, 1995

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SUBMITTED TO:

Indian and Northern Affairs Canada
Hull, Quebec

PREPARED BY:

EBA Engineering Consultants Ltd.
Edmonton, Alberta

0101-11413

September, 1995

EXECUTIVE SUMMARY

The Inuvik area obtains the majority of its granular material by processing bedrock from local quarries. The material produced is generally quite coarse with a deficiency of fine-grained material. This necessitates a source of blend sand to mix with the processed rock to produce a more acceptable gradation.

The Inuvik area has a shortage of proven sand resources on Crown land that Indian and Northern Affairs Canada (INAC) resource managers can recommend to possible users. However, in the summer of 1993, the local INAC staff completed a study which identified two adjacent hills that were believed to contain large volumes of well-drained sand. These hills are situated approximately 50 km south of Inuvik adjacent to the Dempster Highway (NWT Highway No. 8) at km post 222.

A geotechnical investigation was completed for INAC at the potential borrow site during March of 1994. The purpose of the investigation was to delineate the potential borrow material for use as a blend sand. The investigation comprised five sampled boreholes, which were sampled to a maximum penetration of 8.4 metres.

The subsurface material at the site generally consists of glacial sand and silt till. Natural moisture conditions were observed to be generally moist to wet. Excess ground ice was encountered within the permafrost, thus the moisture condition upon thawing is expected to be wet to saturated with some free water produced.

On the basis of our assessment of material quality, this site is not considered favourable for development for the indicated purpose. The economics of developing the deposit, based on the recovered subsurface information and giving consideration to its distance from Inuvik, should be compared with the cost of a possible crushed quarried rock alternative.

General comments and recommendations are provided with regard to pit development, material processing, and pit restoration in the event that the identified source is developed.

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1.0 INTRODUCTION

The Inuvik area obtains the majority of its granular material by processing bedrock from local quarries. The material produced is generally quite coarse with a deficiency of fine-grained material. This necessitates a source of blend sand to mix with the processed rock to produce a more acceptable gradation.

The Inuvik area has a shortage of proven sand resources on Crown land that resource managers can recommend to possible users. However, in 1993, local INAC staff identified two adjacent hills that were believed to contain large volumes of well-drained sand. These hills are situated approximately 50 km south of Inuvik, directly adjacent to the east side of the Dempster Highway (NWT Highway No. 8) at km post 222. Mr. M. Collie, of INAC's Inuvik District office, and Mr. S. Traynor, of INAC Headquarters, visited the site during the summer of 1993, and recommended geotechnical drilling to evaluate the granular resources available at this location.

EBA Engineering Consultants Ltd. (EBA) of Edmonton, Alberta was retained to evaluate the quality, quantity and geological development constraints of the identified potential source. The project was authorized by Contract No. A7134-3-048/01-ST. The designated Scientific Authority is Mr. R.J. Gowan, P.Geol., Geotechnical Advisor for the Natural Resources and Environment branch of INAC.

This report presents the results of the field investigation and laboratory testing program and evaluates the site as a potential source of fine-grained granular material.

2.0 BORROW INVESTIGATION PROGRAM

The borrow investigation program was designed to minimize the field time with drilling and sampling equipment. Preliminary office study and site reconnaissance were undertaken before equipment was mobilized and the drilling and sampling program was completed as part of a larger geophysical, geological and geotechnical field program undertaken by INAC between March 4 and April 1, 1994. The various components of the borrow investigation program are discussed in detail in the following sections.

2.1 PRELIMINARY OFFICE STUDY

Although the site was identified by INAC in advance of this study, considerable preparatory work was undertaken. The preliminary office study included airphoto interpretation, a review of information provided by local INAC staff and available geological maps, and a cursory search of published geologic reports. The airphoto interpretation was conducted using 1:7,500 airphotos that were obtained from the Government of NWT, Surveys and Mapping Division. The airphotos were photographed in July of 1993.

The overall field program plan, which included the proposed Source 222 borrow site, was reviewed, and discussed with INAC at a meeting held on February 14 and 15, 1994. Following the meeting, a detailed work scope and execution plan was prepared for the field investigation.

2.2 SITE RECONNAISSANCE

Ground and helicopter reconnaissance activities were undertaken on March 5 and 6, 1994, respectively. The ground reconnaissance included an on site examination of the surface conditions and proposed borehole locations. The helicopter reconnaissance was conducted in conjunction with that required for other portions of the field program. It was designed to check proposed borehole locations and to assess potential drill rig access routes locations although responsibility for clearing access to the site and boreholes rested with INAC's Inuvik office.

2.3 DRILLING AND SAMPLING PROGRAM

A drilling program was carried out on March 28 and 29, 1994. Mr. S. Traynor represented INAC in the field during this portion of the program. A total of five boreholes, numbered 11413-28 to 11413-32, inclusive, were drilled at the site. The drill rig and crew were contracted directly to INAC by Midnight Sun Drilling Co. Ltd. of Whitehorse, Yukon. Drilling and sampling operations were conducted using a CME750 (model), top drive, rotary drill rig mounted on an all-terrain rubber tire carrier. A D-6 cat was used to provide ancillary support to clear snow and light brush.

Boreholes were drilled using either a permafrost (CRREL) core barrel or solid flight augers. The penetration depth ranged between 5.0 and 8.4 m. Soil samples were retained from the solid flight auger cuttings where sample recovery was considered representative. Permafrost soil samples were obtained from the CRREL core barrel, which was used in two of the five boreholes. Borehole logs are presented in Appendix A.

2.4 LABORATORY TESTING PROGRAM

All soil samples retained during the drilling and sampling program were delivered to EBA's Edmonton laboratory for testing. The laboratory testing included natural moisture content and grain size distribution analysis. All laboratory testing was conducted in accordance with ASTM and CSA procedures and specifications. Test results are presented on the borehole logs where appropriate, and are tabulated on the laboratory test summary presented in Appendix B.

3.0 SITE DESCRIPTION

3.1 LOCATION

The subject site is located approximately 50 km south of Inuvik, NWT. The site is adjacent to km 222 of the Dempster Highway (NWT Highway No. 8) and is immediately north of Caribou Creek. The geographic coordinates are 68° 05.4'N latitude and 133° 29.2'W longitude. The corresponding UTM coordinates are shown on the site plan presented in Figure 1 and on the borehole logs presented in Appendix A.

The site is located in a region where permafrost is continuous and mean annual air temperatures are typically -9°C. Average annual ground temperatures in the permafrost are anticipated to be in the order of -4 to -6°C.

3.2 SURFACE CONDITIONS

The ground surface was snow covered at the time of the site investigation. The terrain conditions at the site are dominated by two adjacent hills. Caribou Creek provides the southern site boundary, along which a south-facing exposed bank exists. A topographic depression, oriented in a general east-west direction, lies between the two hills. This natural depression was previously used to access a borrow pit to the east of the two hills. Local relief in the immediate vicinity of the site is approximately 20 to 30 m.

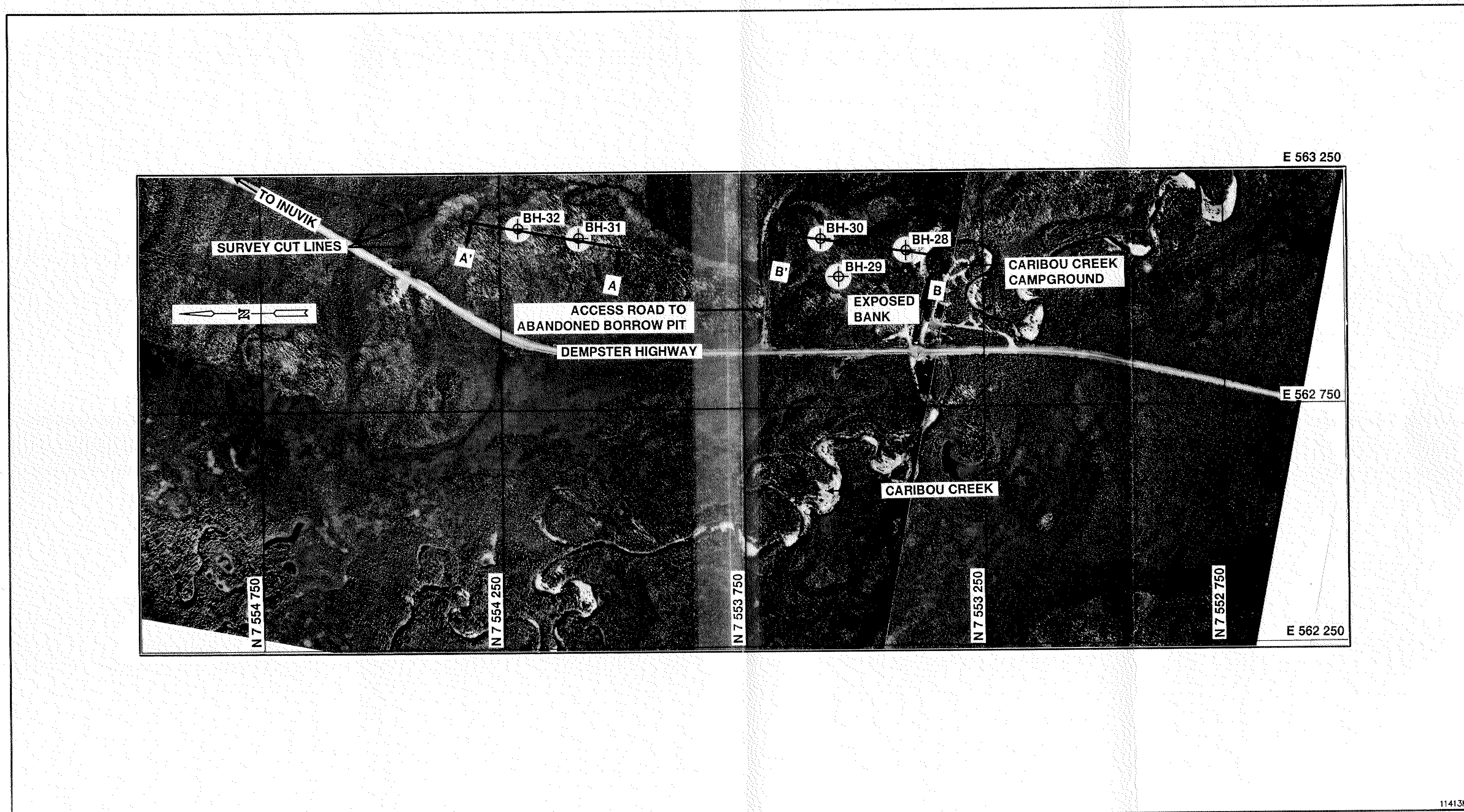


FIGURE 1 SITE PLAN AND BOREHOLE LOCATIONS

The site was basically undeveloped at the time of the investigation. Survey cut lines, which were probably used during the original construction of the Dempster Highway, are still evident. The southwest corner of the site (on the north side of Caribou Creek) appears to be used as part of the Caribou Creek campground, which is located on the southside of the creek. Ground cover generally consisted of thin organics, sparse willows and immature birch shrubs. Tree coverage across the site consists of spruce and occasional birch. The surface vegetation is shown in photographs that are presented in Figure 2.

3.3 SUBSURFACE CONDITIONS

The subsurface soil layers at this site generally consist of till. However, the gradation of the soil encountered is highly variable. This is common for glacial deposits. Figure 3 presents two stratigraphic cross-sections of the site.

The soil stratigraphy encountered at this site generally consists of surficial organic cover which is underlain by glacial sand and silt till. Within the till, interbedded lenses of sand, silt, and clay were encountered. Detailed descriptions that include colour and textural variations are presented on the borehole logs in Appendix A.

Frozen soil was encountered throughout the entire depth that the boreholes were advanced during drilling. Ground ice, including stratified ice lenses of varying thickness, were identified within the well-bonded permafrost. The active layer thickness is estimated to vary between 1 and 2 metres.

Figure 4 presents a diagnostic profile of moisture content versus depth. The moisture contents that were measured on 30 samples ranged between 7 and 33 percent. The average moisture content was 21 percent.

Particle size analyses were conducted on 15 samples. The fines content (less than 75 microns) varied from as low as 4 percent to as high as 96 percent. Figure 5 presents diagnostic profiles of the percentages of fines, sand and gravel, that were measured for the 15 samples. The average fines content for these samples is 26 percent. A composite gradation curve envelope, as well as gradation limits for a general sand fill material are presented in Figure 6. Individual gradation curves are presented with the particle size test results in Appendix B.

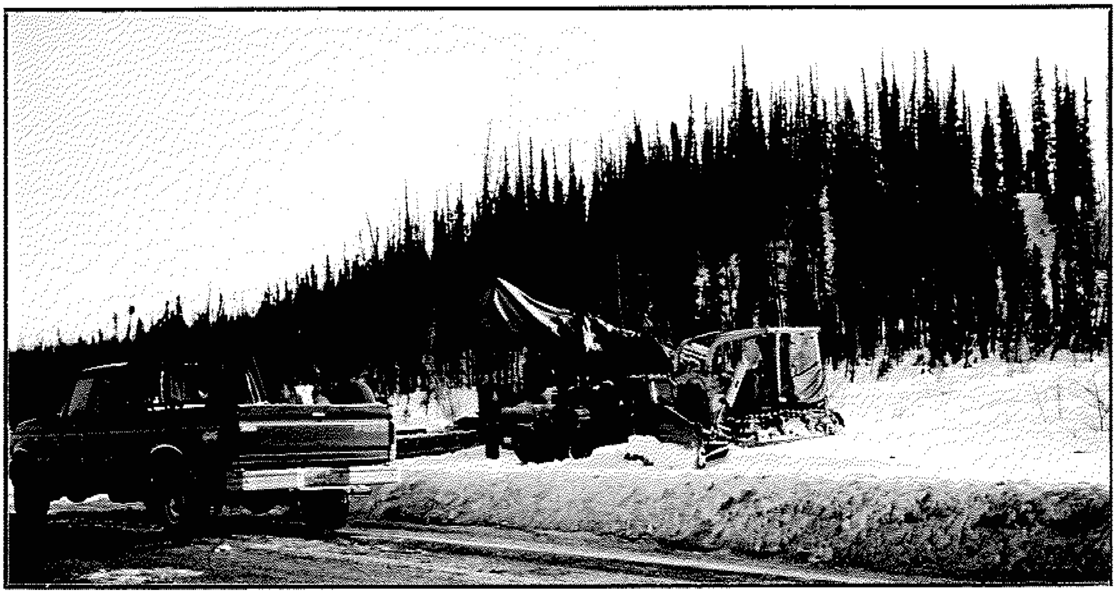


Photo 1
View from the Dempster Highway looking northeast towards the north hill.

Photo 2
View from the Dempster Highway looking southeast towards the south hill.

Figure 2 Surface Vegetation

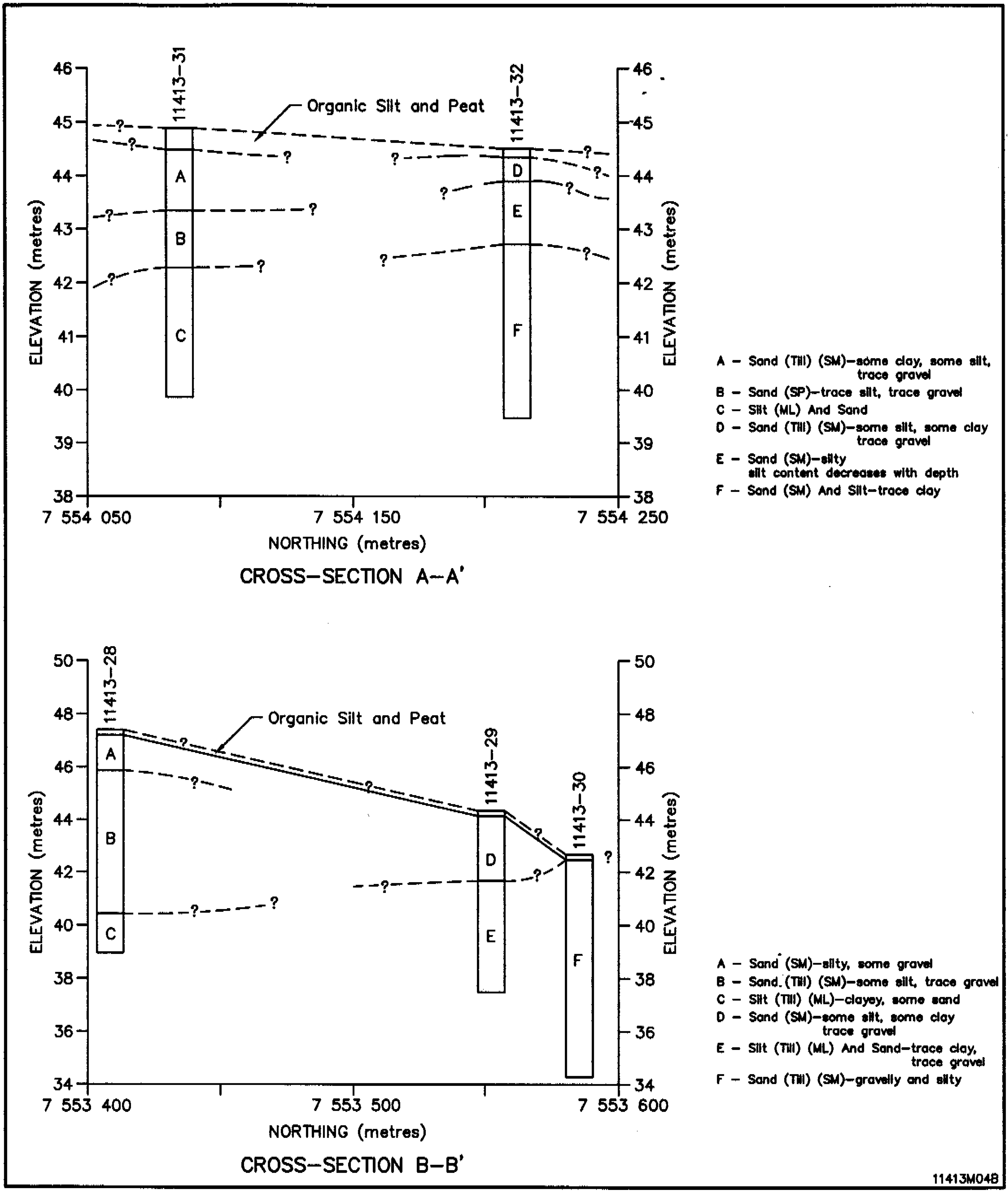


FIGURE 3 STRATIGRAPHIC CROSS-SECTIONS

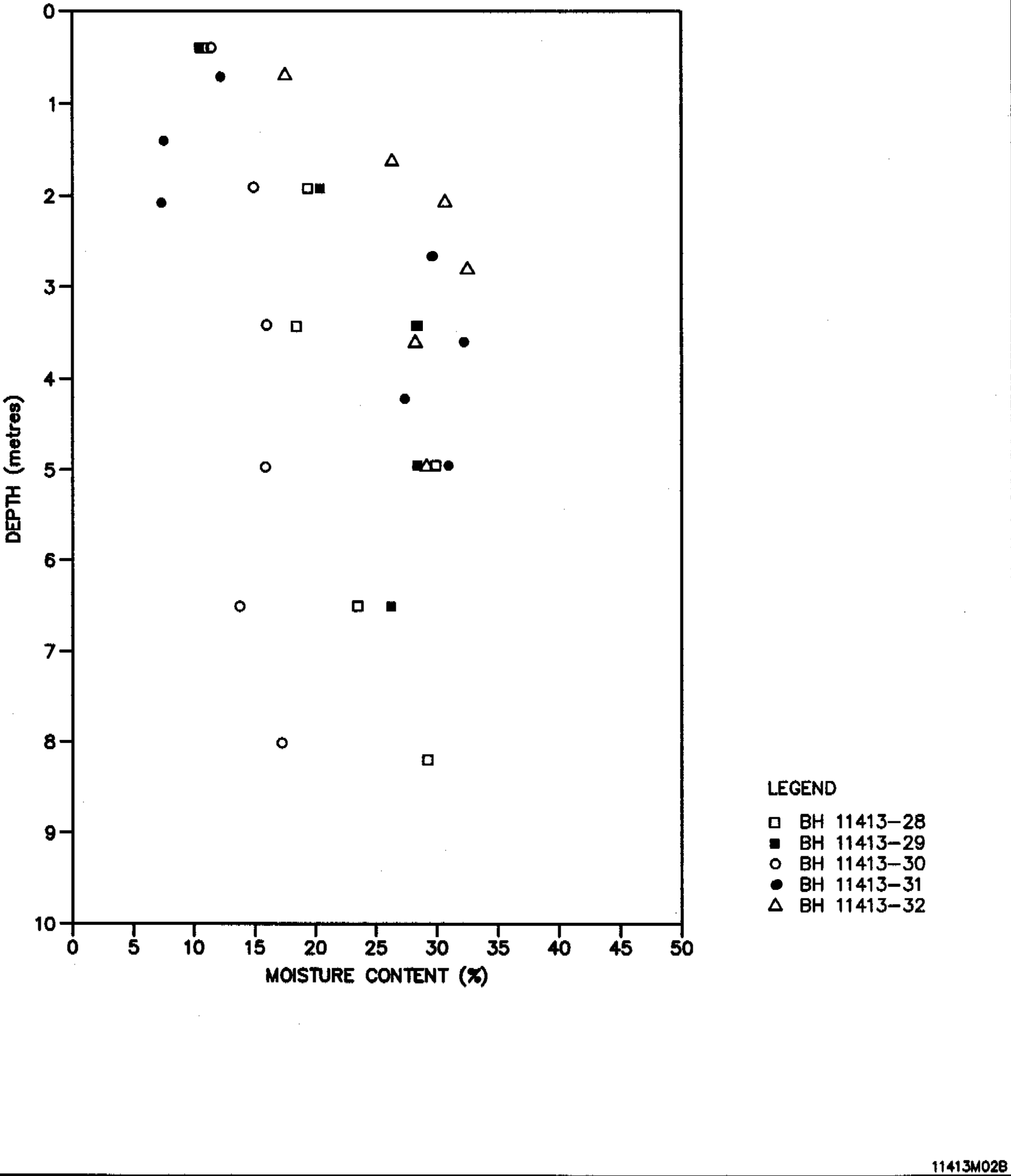


FIGURE 4 MOISTURE CONTENT VS. DEPTH

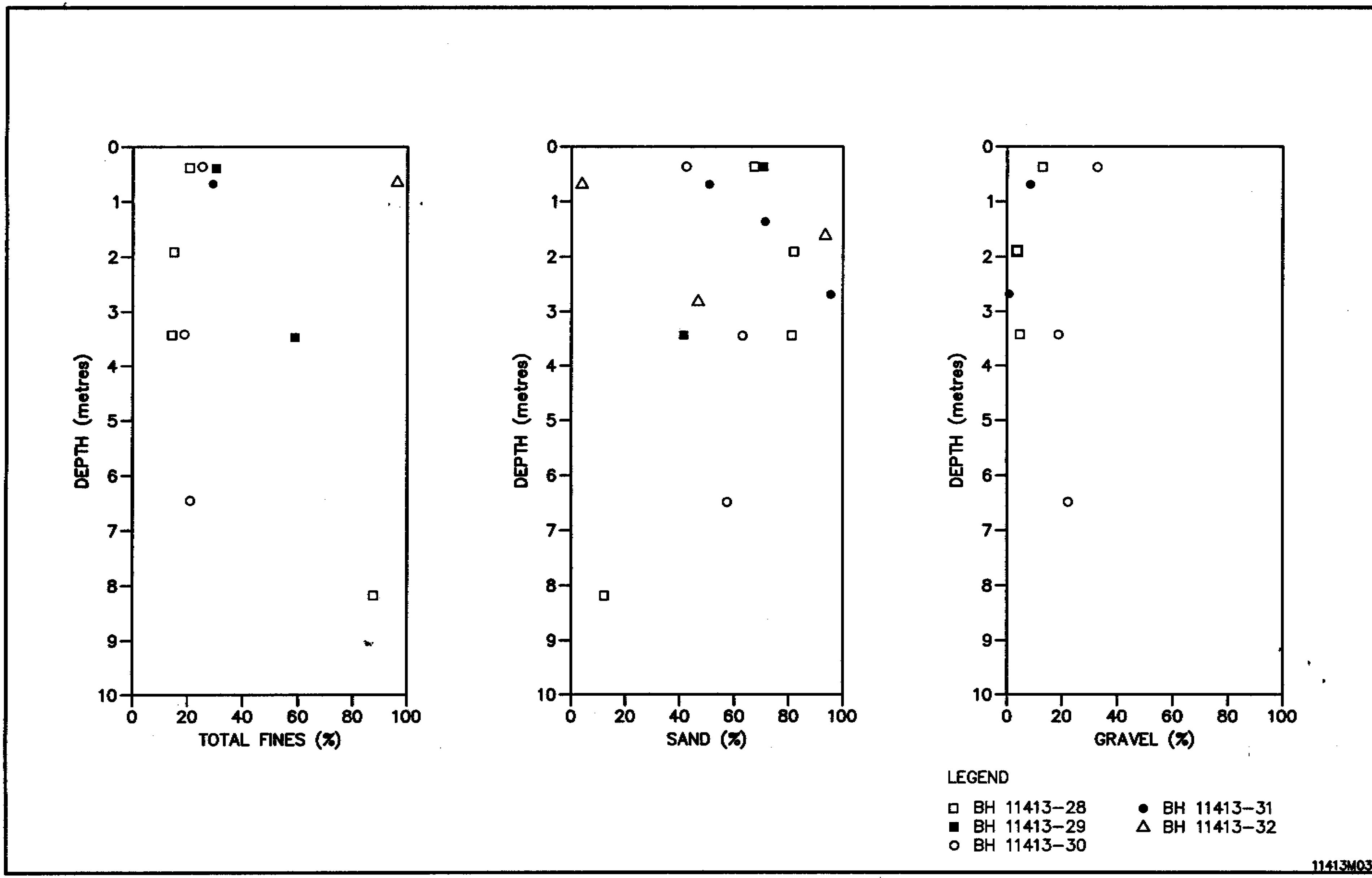
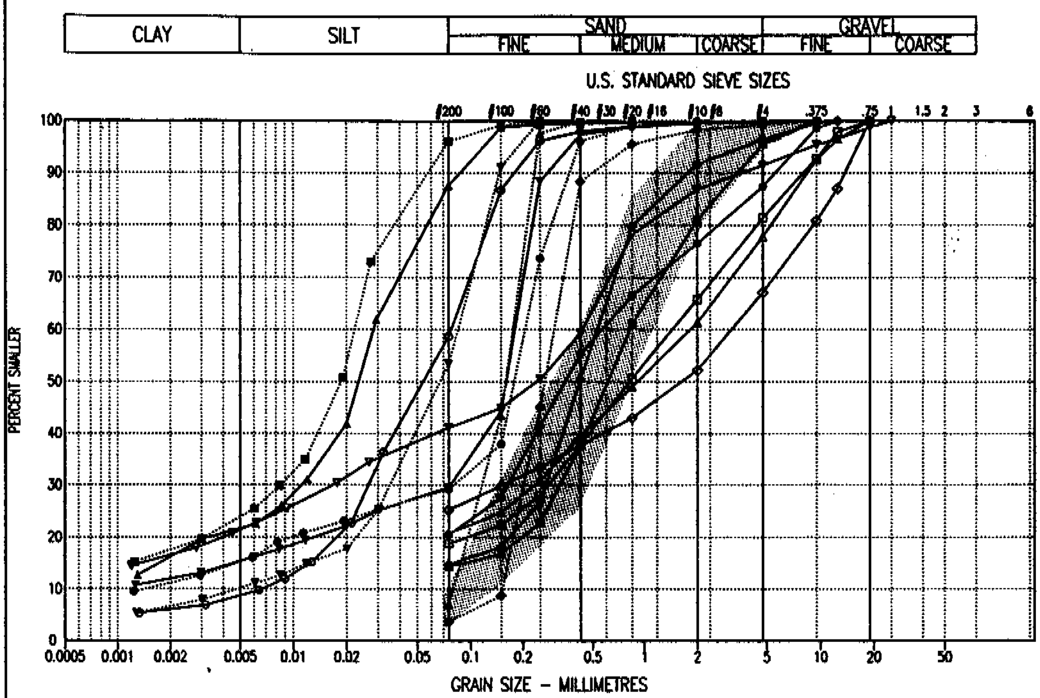


FIGURE 5 PERCENTAGES OF FINES, SAND AND GRAVEL VS. DEPTH

PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION: CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
●——●	28	0.00 – 0.80	20.5	66.8	12.7	16.5	1.3	SM
◆——◆	28	1.50 – 2.30	14.7	81.8	3.5	11.1	2.6	SM
■——■	28	3.00 – 3.80	14.3	81.2	4.5	15.8	2.6	SM
▲——▲	28	8.10 – 8.40	21.4 66.1	12.5	0.0	–	–	
▼——▼	29	0.00 – 0.80	15.1 14.4	70.4	0.1	–	–	
○——○	29	3.00 – 3.20	8.5 50.2	41.2	0.1	11.8	1.4	
◇——◇	30	0.00 – 0.80	25.2	41.9	32.9	69.8	0.1	SM
□——□	30	3.00 – 3.80	18.7	62.7	18.6	28.3	1.0	SM
△——△	30	6.10 – 6.90	20.7	57.1	22.2	35.4	0.6	SM
▽——▽	31	0.60 – 0.80	21.3 19.8	50.3	8.6	–	–	
●·······●	31	1.40 – 1.50	14.9 14.2	70.9	0.0	140.8	21.1	SC
●·······◆	31	2.50 – 2.70	3.7	95.5	0.8	2.0	0.9	SP
■·······■	32	0.60 – 0.80	23.5 72.6	3.9	0.0	–	–	
▲·······▲	32	1.50 – 1.70	7.0	93.0	0.0	2.2	1.0	SP–SM
▼·······▼	32	2.74 – 2.90	10.0 43.5	46.5	0.0	17.6	3.2	

Project: 101–11413 Date Tested: 94/04/19 BY: MH

Tested in accordance with ASTM D422 unless otherwise noted.

LEGEND

▒ – GENERAL SAND FILL GRADATION LIMITS

0101–11413

FIGURE 6 GRADING ENVELOPE

4.0 GRANULAR RESOURCE DEVELOPMENT RECOMMENDATIONS

4.1 GENERAL CONSIDERATIONS

The economics of developing granular resources from a borrow pit versus crushed quarried rock has not been considered herein; however, INAC should be aware of this issue. In conventional southern construction, the cost of gravel pit operations and material processing is usually much less than for a quarry rock source of aggregate. In the north, however, several factors may conspire to significantly increase the cost of conventional gravel pit operations to the point where rock quarries are more economical. Some of the factors include the following:

- Permafrost will restrict the schedule and the rate of excavation or require blasting for excavation;
- Thawing ground ice may make the obtained borrow material much wetter and necessitate a drying process that will make it more costly to use;
- The wetter conditions may create pit drainage problems and settling pond requirements; and
- When wet borrow material freezes in a stockpile over winter, the particles bond together and may not thaw naturally during the following year.

Therefore, a nearby outcrop of quality rock possibly can be quarried, crushed and stockpiled, in some cases, for less cost than required to develop gravel from a frozen, ice-rich, deposit. If a quarry is closer to market, then the economics of a quarry operation are further improved.

4.2 QUALITY ASSESSMENT

In evaluating the material quality of the identified potential borrow source, EBA has given consideration to the initial gradation of the native granular material as it relates to general material suitability and processing requirements. Other factors considered included the uniformity of the deposit and the percentage of fines.

The composition of the granular material varies throughout the deposit. Natural moisture conditions were observed to be generally moist to wet. Excess ground ice was encountered within the permafrost, thus the moisture condition upon thawing is expected to be wet to saturated with some free water produced.

Gradation analyses for the samples obtained indicate that the sand content ranges from 4 to 96 percent with an average of 59 percent. The fines content (material with particle size less than 75 microns) for these samples averaged 26 percent, indicating the need for washing is highly probable. Also, screening may be required to produce a high quality material for potential blending purposes in concrete or asphalt production. Due to the variability in the material encountered, it may be difficult and uneconomical to produce a quantity of material resulting in a consistent gradation that could be used for blending purposes. On the other hand, EBA has successful experience with producing blend sand from quarried rock in the Inuvik area.

4.3 SUMMARY

On the basis of the generally poor quality of the materials encountered during this site investigation, their variability, and adversely high moisture and fines contents, this site is not considered favourable for development for the indicated purpose.

Should this site still be considered for development, then the economics of developing the deposit will have to be determined based on the information obtained from the five boreholes drilled and giving consideration for the distance between the site and Inuvik.

5.0 GENERAL DEVELOPMENT GUIDELINES

5.1 GENERAL

If the source investigated is to be developed, the following general comments with regard to pit development and processing should be considered. These development guidelines have taken into consideration the current Territorial Land Use Regulations but are subject to approval by Land Use Authorities.

5.2 PIT DEVELOPMENT

5.2.1 Extraction Methods

Permafrost was encountered in all subsurface borings and can be expected throughout the deposit. Its presence will prevent excavation from vertical faces by loaders as is conventional (southern) practice. Excavation may be conducted by drill and blast, ripping or progressive thaw and strip. Each procedure has been successfully used for development of borrow sources in arctic regions using the general approaches described in the following.

EBA's previous experience with excavation of frozen materials has indicated the need to use considerably higher quantities of explosives per unit volume of materials than for rock excavation. The drill and blast method of pit development would produce blocks of frozen granular material. This material may thaw faster under some conditions, but the cost of production may be greater. Ultimately seasonal warmth is required to melt the permafrost bonded chunks. This method may be more economic for deposits of limited aerial extent.

Excavation of well-bonded frozen gravel at one typical deposit on the North Slope of Alaska under EBA's direction was accomplished using blasting techniques during the winter. Conventional air-powered drill rigs were used to drill shot holes. The holes were loaded with caps, primer and ANFO explosive (ammonium nitrate and fuel oil) and detonated twice a day. Drilling patterns and loading densities were varied during the project to compensate for changes in natural moisture content and yield materials which fell within the maximum specified chunk size. The charges were set with a delay pattern to improve fragmentation. Load factors varied from 0.8 kg of ANFO per cubic metre with 3 by 3 metre hole spacing to 1.1 kg ANFO per cubic metre with a 2.7 by 2.7 metre hole spacing.

During the summer months, combined convective and radiant heat transfer will thaw a surficial layer of granular material on the pit floor. As the material thaws, borrow can be scraped and stockpiled to continuously expose a fresh surface to thaw. The depth of thaw will primarily be a function of the moisture content (latent heat) of the frozen material. Reworking and handling during stripping also provides an opportunity for some drainage, which results in a lower moisture content in the stockpiled material, 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 5 percent to remain completely workable under winter conditions. One technique that has been found to assist in the drying of the granular materials is to use conveyors for stockpile creation. Moisture contents have been found to decrease considerably through this operation because of the exposure to warm air, the drop to the top of the pile and the subsequent rolling of the material down the faces of the stockpile.

Progressive strip and thaw operations would have to be scheduled for the period mid June to mid September.

In some instances, frozen materials have been excavated by ripping using large dozer mounted rippers. EBA's previous experience with ripping is that it is possible but seldom a desirable construction plan because of wear and tear on equipment and high consumption of cutting shoes.

5.2.2 Drainage Considerations

Drainage of the pit and stockpile areas 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 on the pit floor may initiate irregular thaw of ice-rich zones creating holes which cannot be seen by equipment operators.

Drainage management plans must be incorporated into the pit development and layout. By utilizing natural grades with culverts on pit roads and providing dedicated maintenance of the pit floor, enhanced production rates and lower operating costs can be achieved by most operators.

5.2.3 Stockpile Management

Separate stockpiles are required for produced borrow material. Overburden stripping stockpiles will be required. Processed materials should be stockpiled in such a manner as to prevent segregation and contamination. The base of the laydown area must be a smooth, uniform surface, graded to provide positive drainage from the pile. The area where the stockpiled material is placed should be outside of the excavation. Granular material can freeze in the stockpile if it is wet from thawing ground ice or if precipitation gets into the material. Developing borrow material from a frozen stockpile can be as costly as the initial excavation of it.

The processed material should be placed in layers not greater than 1.0 m thick, and it should not to be dumped or pushed over edges or faces. If dumped, it must be spread towards the centre of the pile with a dozer. The stockpile must be constructed in a neat and regular shape with sideslopes not to exceed 1.5H:1V. To further assist with the thawing and draining of frozen material, the stockpile should be turned over regularly.

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

5.3 MATERIAL PROCESSING

5.3.1 Extraction Consideration

If general fill material should be produced from the source, it may be necessary to screen off any oversize encountered prior to use as a general fill material. In areas where a greater total thickness of fill is required, it may be possible to use the pit run material for general fill. Alternatively, any oversize material or reject material may possibly be used during pit reclamation.

Concrete/asphalt aggregate and blend sand material will require either screening and/or crushing of material that has been allowed to thaw and drain prior to use.

5.3.2 Screening, Crushing, Washing

Limited screening may be required if there are oversize fractions that need to be removed from the material being processed to meet certain end-use purposes. It is not likely that crushing will be required.

The fines content (sub 75 micron particle size) for the samples tested was found to average 26 percent (see Figure 5). On that basis, it would appear that washing may be necessary. Therefore, some effort to select cleaner material in an attempt to reduce the amount of fines requiring washing may be beneficial. Further gradation analyses would be required to optimize the development if the source be opened.

5.4 PIT RESTORATION PROCEDURES

Restoration of the pit areas will consist of three major components:

- Disposal of rejected materials;
- Backfilling of pits and stabilization of the pit walls; and
- Drainage and erosion control.

Disposal of all combustible debris may be accomplished by burning. Ashes may be disposed of by burial, with any available soils in the pit area. All discarded machinery and parts, scrap metal, and other non-combustible material must be removed from the site. All combustible waste petroleum products should be incinerated or removed from the site.

Rejected material (i.e. oversize, cobbles, and processed material that fails to meet specification) may be disposed of in the excavation. The sideslope of the pit area should be dressed to a final slope 1.5H:1V or as designated by Land Use Authorities. The slopes and surrounding areas should be free of waste material piles and left in a neat, trimmed, and tidy condition.

All obstructions to material drainage caused by construction should be removed and the surrounding area restored to its original conditions. Grading should be such that water is prevented from channelling and downcutting.

6.0 CLOSURE

This report has been prepared based on findings from literature review, airphoto interpretation, field reconnaissance, subsurface exploration, and laboratory testing. Analyses to assess the suitability of materials incorporates interpretation, extrapolation, and assumptions; particularly, as related to the anticipated gradation of the processed materials. The data as presented should, therefore, be used in appropriate context. Further information concerning the use of this report is found in the General Conditions in Appendix A.

Respectfully submitted,
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APPENDIX A

BOREHOLE LOGS

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.

This report is not to be reproduced in part or in whole without consent in writing from EBA Engineering Consultants Ltd. (EBA). Additional copies of the report, if required, may be obtained upon request. Isolated information, logs of borings, or profiles are not to be reproduced, copied or transferred.

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	°	$1° = (\pi/180)$ 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*

SYSTEM INTERNATIONAL CONVERSIONS

AREA

1 km²	$= 3.861 \times 10^{-1}$ mi²	1 km² = 100 hectares
1 km²	$= 2.471 \times 10^{+2}$ acre	
1 m²	= 1.196 yd²	
1 m²	$= 1.076 \times 10^{+1}$ ft²	
1 mm²	$= 1.550 \times 10^{-3}$ in²	see note 1

DENSITY

1 Mg/m³	$= 6.243 \times 10^{+1}$ lb_m/ft^3	see note 2
1 kg/m³	$= 6.243 \times 10^{-2}$ lb_m/ft^3	

FORCE

1 N	$= 2.248 \times 10^{-1}$ lb_f	

HEAT

ENERGY (E)

1 kJ	$= 9.478 \times 10^{-1}$ BTU (IST)	1 BTU = 252 cal
1 J	$= 2.388 \times 10^{-1}$ cal (IST)	

HEAT FLUX (Q)

1 W/m²	$= 3.170 \times 10^{-1}$ BTU/(ft² · hr)	

SPECIFIC HEAT CAPACITY (c)

1 kJ/(kg · C°)	$= 2.388 \times 10^{-1}$ BTU/(lb_m · F°)	

THERMAL CONDUCTIVITY (k)

W/(m · C°)	$= 5.778 \times 10^{-1}$ BTU/(ft · hr · F°)	

COEFFICIENT OF HEAT TRANSFER (c_s)

1 W/(m² · C°)	$= 1.761 \times 10^{-1}$ BTU/(ft² · hr · F°)	see note 3

LENGTH

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

MASS

1 Mg	= 1.102 T	1 T = 2000 lb_m
1 Mg	$= 2.205 \times 10^{3}$ lb_m	Mg is equivilant to tonne
1 kg	= 2.205 lb_m	

POWER

1 W	$= 1.341 \times 10^{-3}$ HP	1 HP = 550 ft · lb_f/s

PRESSURE, STRESS or ELASTIC MODULI

1 MPa	$= 1.044 \times 10^{+1}$ T_f/ft^2 [TSF]	see note 4
1 kPa	$= 1.044 \times 10^{-2}$ T_f/ft^2 [TSF]	
1 kPa	$= 1.450 \times 10^{-1}$ lb_f/in^2 [psi]	
1 kPa	$= 3.346 \times 10^{-1}$ ft of water	hydrostatic pressure of water at 1 ft. depth
1 Pa	$= 2.089 \times 10^{-2}$ 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	$= 3.171 \times 10^{-2}$ yr	for one year equal to 365 days
1 ks	$= 1.157 \times 10^{-2}$ day	
1 s	$= 3.171 \times 10^{-8}$ yr	

VISCOSITY

DYNAMIC (η)

1 Pa · s	$= 1.000 \times 10^{+3}$ centipoise	

KINEMATIC (ν)

1 mm²/s	= 1.000 cenistoke	

VOLUME

1 m³	$= 8.107 \times 10^{-4}$ acre · ft	
1 m³	= 1.308 yd³	
1 m³	$= 3.531 \times 10^{+1}$ ft³	
1 m³	$= 2.200 \times 10^{+2}$ gal (Imperial)	1 m³ = 1000 L
1 cm³	$= 3.520 \times 10^{-2}$ fl oz	see note 1
1 cm³	$= 6.102 \times 10^{-2}$ in³	

VOLUME RATE OF FLOW

1 m³/s	$= 1.901 \times 10^{-1}$ mgpd (Imperial)	
1 m³/s	$= 3.531 \times 10^{+1}$ ft³/s	

COEFFICIENTS

VOLUME COMPRESSIBILITY OR SWELLING (m_v or m_s)

1 m²/MN;	$= 9.579 \times 10^{-2}$ ft^2/T_f	

CONSOLIDATION OR SWELLING (c_v or c_s)

1 m²/yr	$= 1.076 \times 10^{+1}$ ft²/yr	
1 m²/yr	$= 2.949 \times 10^{-2}$ ft²/day	
1 m²/yr	$= 3.171 \times 10^{-4}$ cm²/s	

HYDRAULIC CONDUCTIVITY (k)

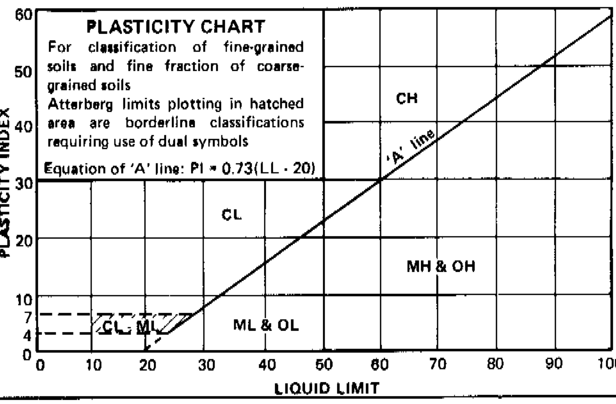
1 m/s	$= 2.835 \times 10^{+5}$ ft/day	see note 5

NOTES:

1. *The use of cm² and cm³ for area and volume is permissible.*
2. *To convert mass density (ρ) to weight per unit volume use:*
   $F = ma_g$
   i.e. $\rho Mg/m^3 \times 9.807\ m/s^2 = 9.807\rho \frac{Mg \cdot m}{s^2 \cdot m^3} = 9.807\rho \frac{kN}{m^3}$
   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.*

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	Plasticity chart (see below)		
			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

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

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

GROUP SYMBOLS	SYMBOLS	SUBGROUP DESCRIPTION
ICE	ICE + Soil Type	Ice with soil inclusions
	ICE	Ice without soil inclusions (greater than 25 mm (1 in.) thick)

GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-28
SOURCE 222, HIGHWAY #8	DRILL: CME750 c/w SOLID FLIGHT AUGERS	PROJECT NO: 0101-11413
CARIBOU CREEK, N.W.T.	UTM ZONE: 8 N7553409.6 E563077.6	ELEVATION: 47.40 (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	SALINITY (ppt) 10 20 30 40 / PLASTIC M.C. LIQUID 20 40 60 80	DEPTH (ft)
0.0	ORGANIC ROOT MAT – (150mm thick)	Frozen					0.0
	SAND (SM) – silty, some fine gravel, well graded, non plastic, brown			Disturbed	1	●	
1.0							2.0
	SAND (TILL) (SM) – some silt, trace of gravel, iron oxide staining evident, non plastic, dark olive grey			Disturbed	2	●	4.0 / 6.0
2.0							8.0
3.0				Disturbed	3	●	10.0 / 12.0
4.0							14.0
5.0	– saturated when thawed			Disturbed	4	●	16.0 / 18.0
6.0							

EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV	COMPLETION DEPTH: 8.4 m
	REVIEWED BY: DCC	COMPLETE: 94/03/28
	Fig. No: 11413-28	Page 1 of 2

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GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-28
SOURCE 222, HIGHWAY #8	DRILL: CME750 c/w SOLID FLIGHT AUGERS	PROJECT NO: 0101-11413
CARIBOU CREEK, N.W.T.	UTM ZONE: 8 N7553409.6 E563077.6	ELEVATION: 47.40 (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	SALINITY (ppt) 10 20 30 40 / PLASTIC M.C. LIQUID 20 40 60 80	DEPTH (ft)
6.0	SAND (TILL) (SM) – (continued)	Frozen		Disturbed	5	M.C. point	20.0, 22.0
7.0	SILT (TILL) (ML) – clayey, some sand, wet to saturated when thawed, dark olive grey	Ice evident in auger cuttings.					24.0
8.0	– saturated when thawed			Disturbed	6	M.C. point	26.0
	END OF BOREHOLE (8.4 metres) Note: Unable to determine ground ice conditions/content due to drilling method used to advance borehole.						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: 8.4 m
	REVIEWED BY: DCC	COMPLETE: 94/03/28
	Fig. No: 11413-28	Page 2 of 2

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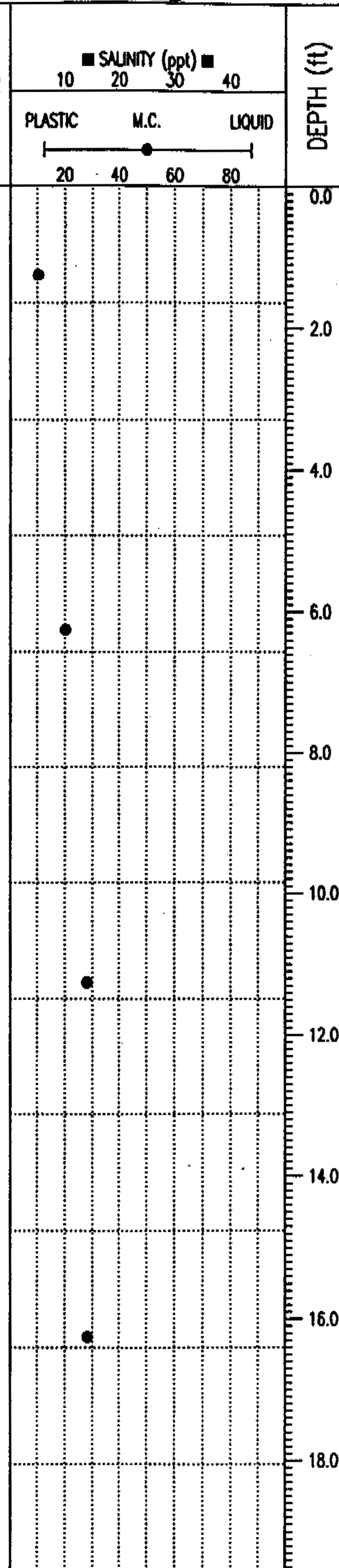
GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-29
SOURCE 222, HIGHWAY #8	DRILL: CME750 c/w SOLID FLIGHT AUGERS	PROJECT NO: 0101-11413
CARIBOU CREEK, N.W.T.	UTM ZONE: 8 N7553553.4 E563023.8	ELEVATION: 44.40 (m)

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	ORGANIC ROOT MAT – (100mm thick)	Frozen			
	SAND (SM) – some silt, some clay, fine grained, uniform, damp to moist when thawed, non plastic, brown			Disturbed	1
	– damp to moist when thawed				
1.0					
	– trace to some gravel, moist to wet			Disturbed	2
2.0					
	SILT (TILL) (ML) AND SAND – trace of clay and gravel, iron oxide staining evident, wet to saturated when thawed, non plastic, dark olive grey				
3.0					
	– wet to saturated when thawed			Disturbed	3
4.0					
5.0	– saturated when thawed			Disturbed	4
6.0					



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EDMONTON, ALBERTA

LOGGED BY: MAV	COMPLETION DEPTH: 6.9 m
REVIEWED BY: DCC	COMPLETE: 94/03/28
Fig. No: 11413-29	Page 1 of 2

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GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-29
SOURCE 222, HIGHWAY #8	DRILL: CME750 c/w SOLID FLIGHT AUGERS	PROJECT NO: 0101-11413
CARIBOU CREEK, N.W.T.	UTM ZONE: 8 N7553553.4 E563023.8	ELEVATION: 44.40 (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	SALINITY (ppt) 10 20 30 40 / PLASTIC M.C. LIQUID 20 40 60 80	DEPTH (ft)
6.0	SILT (TILL) (ML) AND SAND - (continued)	Frozen		Disturbed	5	M.C. ≈ 15	20.0
							22.0
7.0	END OF BOREHOLE (6.9 metres)						
							24.0
8.0	Note: Unable to determine ground ice conditions/content due to drilling method used to advance borehole.						26.0
							28.0
9.0							
							30.0
							32.0
10.0							
							34.0
11.0							36.0
							38.0
12.0							

EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV	COMPLETION DEPTH: 6.9 m
	REVIEWED BY: DCC	COMPLETE: 94/03/28
	Fig. No: 11413-29	Page 2 of 2

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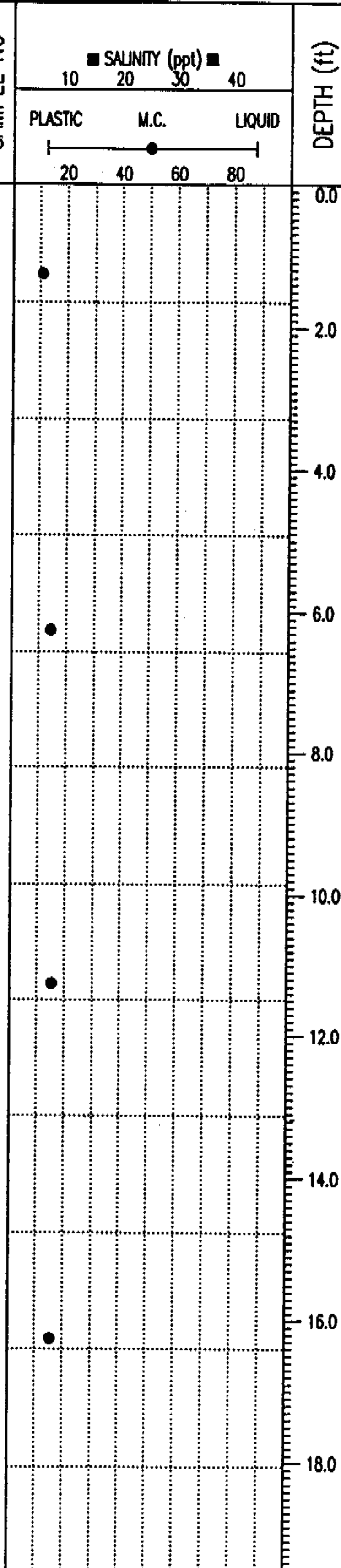
GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-30
SOURCE 222, HIGHWAY #8	DRILL: CME750 c/w SOLID FLIGHT AUGERS	PROJECT NO: 0101-11413
CARIBOU CREEK, N.W.T.	UTM ZONE: 8 N7553586.2 E563104.9	ELEVATION: 42.70 (m)

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	SAND (TILL) (SM) – gravelly, silty, well graded, gravel sizes to 25mm diameter, moist when thawed, non plastic, brown	Frozen		Disturbed	1	0.0
2.0				Disturbed	2	6.0
3.0	– some fine gravel, some silt, well graded, gravel fraction is subangular to angular, moist when thawed, non plastic			Disturbed	3	10.0
4.5		Ice fragments evident in auger cuttings.				
5.0				Disturbed	4	16.0
6.0						



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EDMONTON, ALBERTA

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REVIEWED BY: DCC	COMPLETE: 94/03/28
Fig. No: 11413-30	Page 1 of 2

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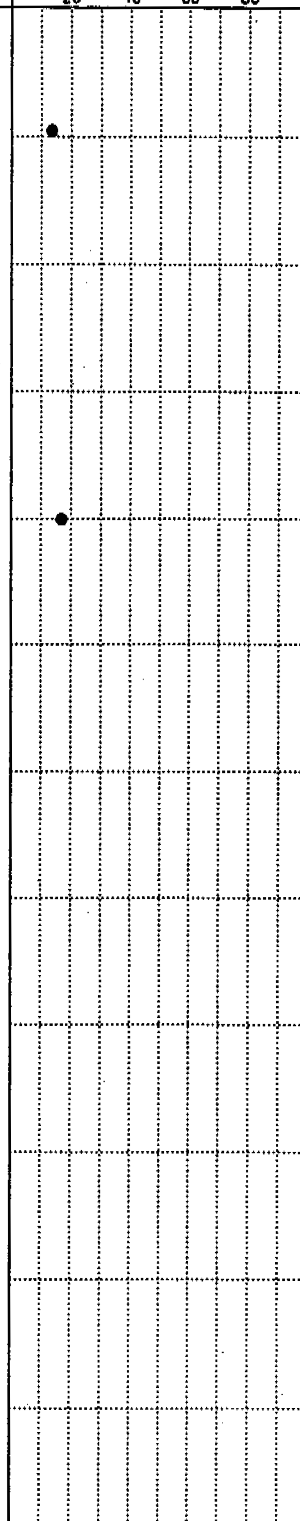
GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-30
SOURCE 222, HIGHWAY #8	DRILL: CME750 c/w SOLID FLIGHT AUGERS	PROJECT NO: 0101-11413
CARIBOU CREEK, N.W.T.	UTM ZONE: 8 N7553586.2 E563104.9	ELEVATION: 42.70 (m)

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

DEPTH (m)	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	TEMPERATURE (C)	SAMPLE TYPE	SAMPLE NO	■ SALINITY (ppt) ■ 10 20 30 40 / PLASTIC M.C. LIQUID 20 40 60 80	DEPTH (ft)
6.0	SAND (TILL) (SM) - (continued)	Frozen					20.0
	- silty, gravelly			Disturbed	5		
							22.0
7.0							
							24.0
8.0	- wet when thawed			Disturbed	6		26.0
	END OF BOREHOLE (8.4 metres)						
	Note: Unable to determine ground ice conditions/content due to drilling method used to advance borehole.						28.0
9.0							30.0
							32.0
10.0							34.0
11.0							36.0
							38.0
12.0							



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	REVIEWED BY: DCC	COMPLETE: 94/03/28
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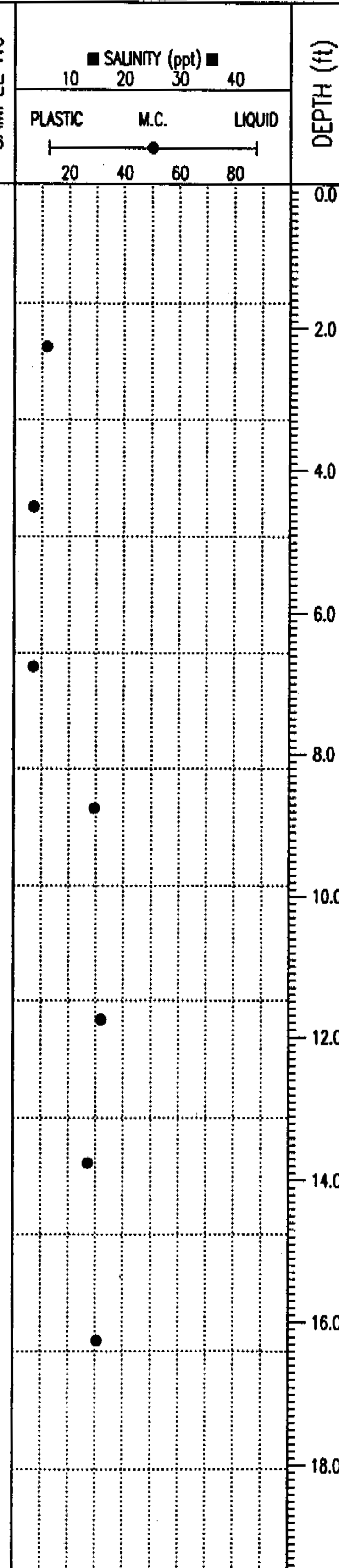
GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-31
SOURCE 222, HIGHWAY #8	DRILL: CME750 c/w CRREL CORE BARREL	PROJECT NO: 0101-11413
CARIBOU CREEK, N.W.T.	UTM ZONE: 8 N7554084.8 E563124.3	ELEVATION: 44.90 (m)

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	ORGANIC SILT (OL) AND PEAT	Ice lenses throughout			
	SAND (TILL) (SM) – some clay, some silt, trace of fibrous organics, trace of coal fragments, trace of fine gravel, well graded, iron oxide staining throughout, subangular to angular gravel, non plastic, orangey brown	Nbn		CORE	1
1.0		Nf		CORE	2
	SAND (SM) – some silt, some clay, very thin 3mm thick black organic lenses throughout, fine grained, uniform, damp when thawed, non plastic, dark brown	Vs trace			
2.0				CORE	3
	SAND (TILL) (SM) – some gravel, some silt, trace of fibrous organics and coal fragments	Nbe			
	SAND (SP/SM) – trace of silt, trace of coal fragments, trace of coarse subrounded gravel particles disseminated throughout, iron oxide staining evident, smooth, non plastic, brownish grey			CORE	4
3.0				CORE	5
	– black coal particles disseminated throughout, thin laminae, even, non parallel, mottled olive and olive grey	Nbe			
4.0	SILT (ML) – some sand to sandy, very thin laminae, curved, non plastic, grey	Vs trace		CORE	6
	SILT (ML) AND SAND – fine grained, uniform, thin laminae, even, non parallel, saturated when thawed, non plastic, grey	Nbe, Vx trace		CORE	7
5.0	END OF BOREHOLE (5.0 metres)				
6.0					



EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV	COMPLETION DEPTH: 5.0 m
	REVIEWED BY: DCC	COMPLETE: 94/03/29
	Fig. No: 11413-31	Page 1 of 1

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GRANULAR RESOURCE EVALUATION	INDIAN AND NORTHERN AFFAIRS CANADA	BOREHOLE NO: 11413-32
SOURCE 222, HIGHWAY #8	DRILL: CME750 c/w CRREL CORE BARREL	PROJECT NO: 0101-11413
CARIBOU CREEK, N.W.T.	UTM ZONE: 8 N7554212.3 E563155.5	ELEVATION: 44.50 (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	SALINITY (ppt) 10 20 30 40 / PLASTIC M.C. LIQUID 20 40 60 80	DEPTH (ft)
0.0	ORGANIC ROOT MAT AND PEAT - (150mm thick)	Frozen Ice lenses throughout Nbn Vs 10%					0.0
	SAND (TILL) (SM) - some silt, trace of gravel and organics, iron oxide staining throughout, orange						
	SILT (TILL) (ML) - clayey, trace of fine grained sand, non to low plastic, olive brown			CORE	1		2.0
1.0	SAND (SM) - silty, trace of coal fragments, iron staining evident, thin laminae, even, non parallel, non plastic, mottled olive and olive grey - trace of silt, very thin interbedded black organic lenses <1mm thick, appears to be coal			CORE	2		4.0
2.0				CORE	3		6.0
	SAND (SM) AND SILT - some clay			CORE	4		8.0
3.0	- silt content increases with depth, very thin laminae, even, parallel, continuous, mottled lenses olive grey and grey - thin laminae, curved, non parallel, grey			CORE	5		10.0 12.0
4.0							14.0
5.0	END OF BOREHOLE (5.0 metres)			CORE	6		16.0
6.0							18.0

EBA ENGINEERING CONSULTANTS LTD. EDMONTON, ALBERTA	LOGGED BY: MAV REVIEWED BY: DCC Fig. No: 11413-32	COMPLETION DEPTH: 5.0 m COMPLETE: 94/03/29 Page 1 of 1

94/05/20 11:58AM

APPENDIX B

SUMMARY OF LABORATORY TESTING AND PARTICLE SIZE ANALYSIS

LABORATORY TEST SUMMARY

Borehole	Sample Number	Sample Interval from (m)	to (m)	Moisture Content (%)	USC Classification	Clay (%)	Silt (%)	Sand (%)	Gravel (%)
11413-28	1	0.00	0.76	10.6	SM	-	20.5	66.8	12.7
11413-28	2	1.52	2.29	19.3	SM	-	14.7	81.8	3.5
11413-28	3	3.05	3.81	18.3	SM	-	14.3	81.2	4.5
11413-28	4	4.57	5.33	29.7					
11413-28	5	6.10	6.86	23.4					
11413-28	6	7.93	8.41	29.2		21.4	66.1	12.5	0.0
11413-29	1	0.00	0.76	10.4		15.1	14.4	70.4	0.1
11413-29	2	1.52	2.29	20.3					
11413-29	3	3.05	3.81	28.1		8.5	50.2	41.2	0.1
11413-29	4	4.57	5.33	28.3					
11413-29	5	6.10	6.86	26.2					
11413-30	1	0.00	0.76	11.0		-	25.2	41.9	32.9
11413-30	2	1.52	2.29	14.5					
11413-30	3	3.05	3.81	15.5	SM	-	18.7	62.7	18.6
11413-30	4	4.57	5.33	15.5					
11413-30	5	6.10	6.86	13.5	SM	-	20.7	57.1	22.2
11413-30	6	7.62	8.38	16.9					
11413-31	1	0.61	0.76	11.9		21.3	19.8	50.3	8.6
11413-31	2	1.22	1.52	7.2		14.9	14.2	70.9	0.0
11413-31	3	1.98	2.13	7.0					
11413-31	4	2.59	2.74	29.5	SP	-	3.7	95.5	0.8
11413-31	5	3.51	3.66	32.0					
11413-31	6	4.12	4.27	27.3					
11413-31	7	4.88	5.03	30.7					
11413-32	1	0.61	0.76	17.6		23.5	72.6	3.9	0.0
11413-32	2	1.52	1.68	26.5	SP/SM	-	7.0	93.0	0.0
11413-32	3	1.98	2.13	31.0					
11413-32	4	2.74	2.90	32.6		10.0	43.5	46.5	0.0
11413-32	5	3.51	3.66	28.4					
11413-32	6	4.88	5.03	29.1					

PARTICLE SIZE DISTRIBUTION ANALYSIS SUMMARY

Borehole Number	Depth		Percent Passing																	
	from (m)	to (m)	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 (%)
11413-28	0.00	0.80	100.0	100.0	100.0	98.6	87.4	76.6	66.5	55.4	41.5	27.6	20.5							
11413-28	1.50	2.30	100.0	100.0	100.0	99.5	96.5	91.7	79.8	50.6	26.7	18.2	14.8							
11413-28	3.00	3.80	100.0	100.0	100.0	100.0	95.5	81.0	61.1	37.7	22.8	16.9	14.3							
11413-28	8.10	8.40	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.6	99.4	98.8	87.6	61.9	41.9	31.1	26.0	22.5	19.7	12.7
11413-29	0.00	0.80	100.0	100.0	100.0	100.0	99.9	99.6	98.8	97.4	88.4	44.4	29.6	25.3	22.2	19.5	17.7	16.1	13.1	10.8
11413-29	3.00	3.20	100.0	100.0	100.0	100.0	99.9	99.6	99.0	98.0	96.2	86.7	58.8	36.4	22.8	15.2	12.0	9.8	7.0	5.4
11413-30	0.00	0.80	100.0	100.0	87.0	80.9	67.1	52.3	43.0	37.8	33.5	29.8	25.3							
11413-30	3.00	3.80	100.0	100.0	97.9	92.8	81.4	65.9	50.6	37.9	28.0	22.3	18.8							
11413-30	6.10	6.90	100.0	100.0	96.5	92.5	77.8	61.4	49.0	39.7	30.8	24.7	20.8							
11413-31	0.60	0.80	100.0	98.8	96.5	95.5	91.5	86.9	78.2	59.4	50.6	45.0	41.2	34.5	30.4	25.5	22.8	20.7	17.9	14.5
11413-31	1.40	1.50	100.0	100.0	100.0	100.0	100.0	100.0	99.1	96.2	73.7	38.0	29.2	25.4	23.2	20.8	19.1	16.0	12.5	9.5
11413-31	2.50	2.70	100.0	100.0	100.0	100.0	99.2	98.4	95.6	88.3	45.2	8.8	3.7							
11413-32	0.60	0.80	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.6	99.2	96.2	73.1	50.8	34.9	29.9	25.4	19.7	15.2
11413-32	1.50	1.70	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.7	43.5	7.1							
11413-32	2.74	2.90	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	91.1	53.5	25.4	17.8	14.9	12.7	11.1	7.9	5.4

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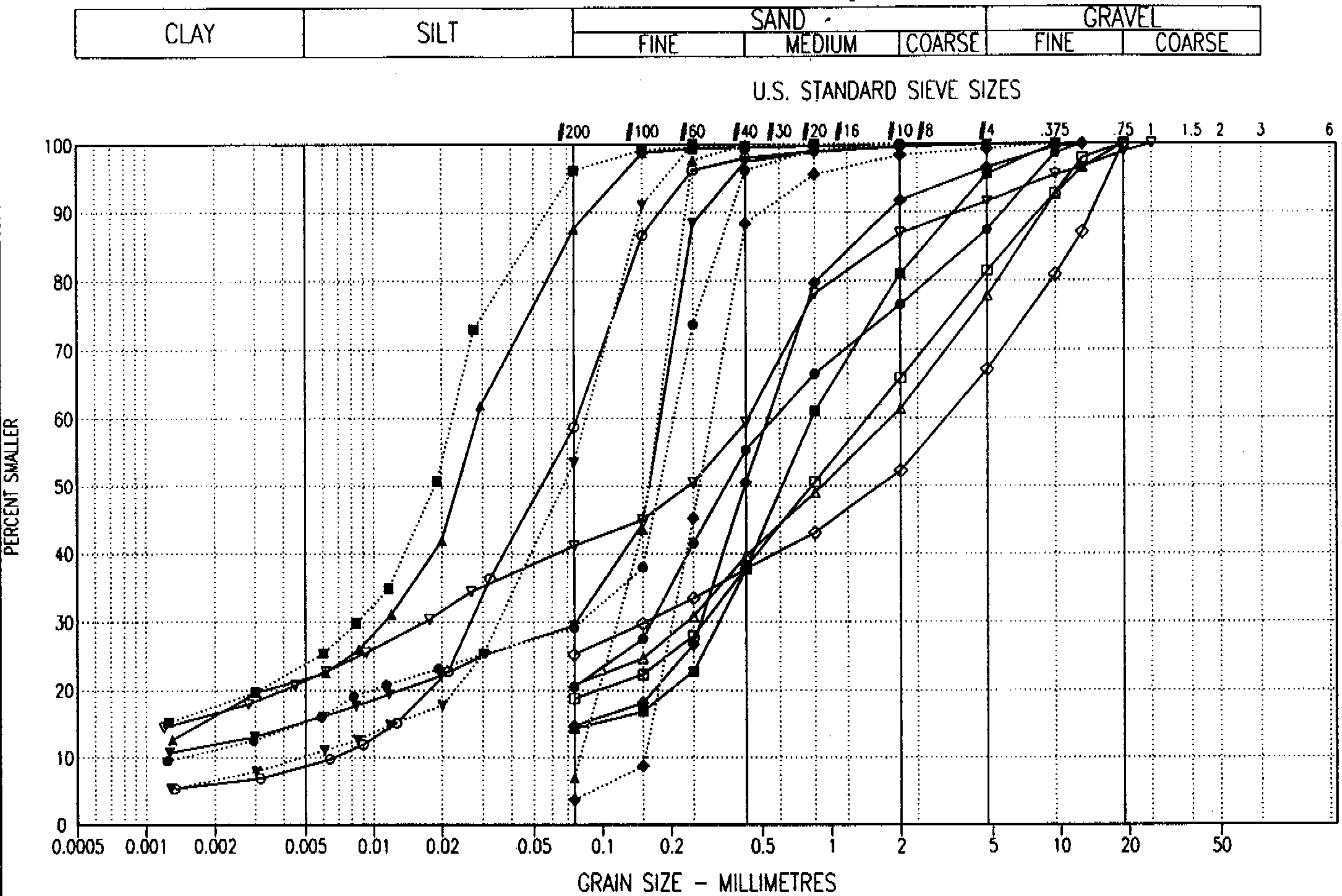
PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION: CLAY & SILT %	DESCRIPTION: SAND %	DESCRIPTION: GRAVEL %	Cu	Cc	U.S.C
●——●	28	0.00 – 0.80	20.5	66.8	12.7	16.5	1.3	SM
◆——◆	28	1.50 – 2.30	14.7	81.8	3.5	11.1	2.6	SM
■——■	28	3.00 – 3.80	14.3	81.2	4.5	15.8	2.6	SM
▲——▲	28	8.10 – 8.40	21.4 66.1	12.5	0.0	–	–	
▼——▼	29	0.00 – 0.80	15.1 14.4	70.4	0.1	–	–	
○——○	29	3.00 – 3.20	8.5 50.2	41.2	0.1	11.8	1.4	
◇——◇	30	0.00 – 0.80	25.2	41.9	32.9	69.8	0.1	SM
□——□	30	3.00 – 3.80	18.7	62.7	18.6	28.3	1.0	SM
△——△	30	6.10 – 6.90	20.7	57.1	22.2	35.4	0.6	SM
▽——▽	31	0.60 – 0.80	21.3 19.8	50.3	8.6	–	–	
●·······●	31	1.40 – 1.50	14.9 14.2	70.9	0.0	140.8	21.1	SC
◆·······◆	31	2.50 – 2.70	3.7	95.5	0.8	2.0	0.9	SP
■·······■	32	0.60 – 0.80	23.5 72.6	3.9	0.0	–	–	
▲·······▲	32	1.50 – 1.70	7.0	93.0	0.0	2.2	1.0	SP–SM
▼·······▼	32	2.74 – 2.90	10.0 43.5	46.5	0.0	17.6	3.2	

Project: 101-11413 Date Tested: 94/04/19 BY: MH

Tested in accordance with ASTM D422 unless otherwise noted.

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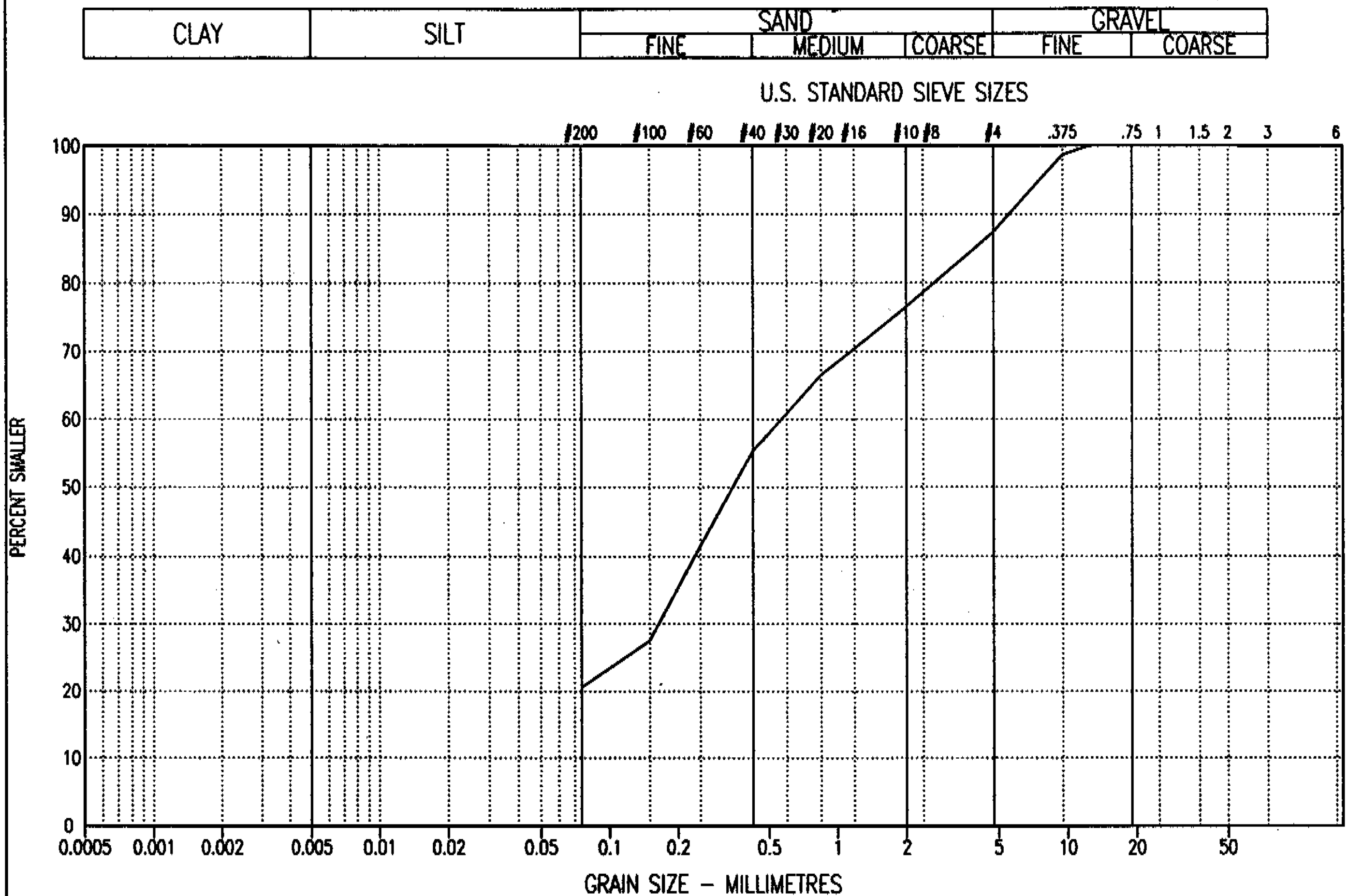
PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
——	28	0.0 – 0.8	20.5	66.8	12.7	16.5	1.3	

Project: 101-11413 Date Tested: 94/04/19 BY: MH

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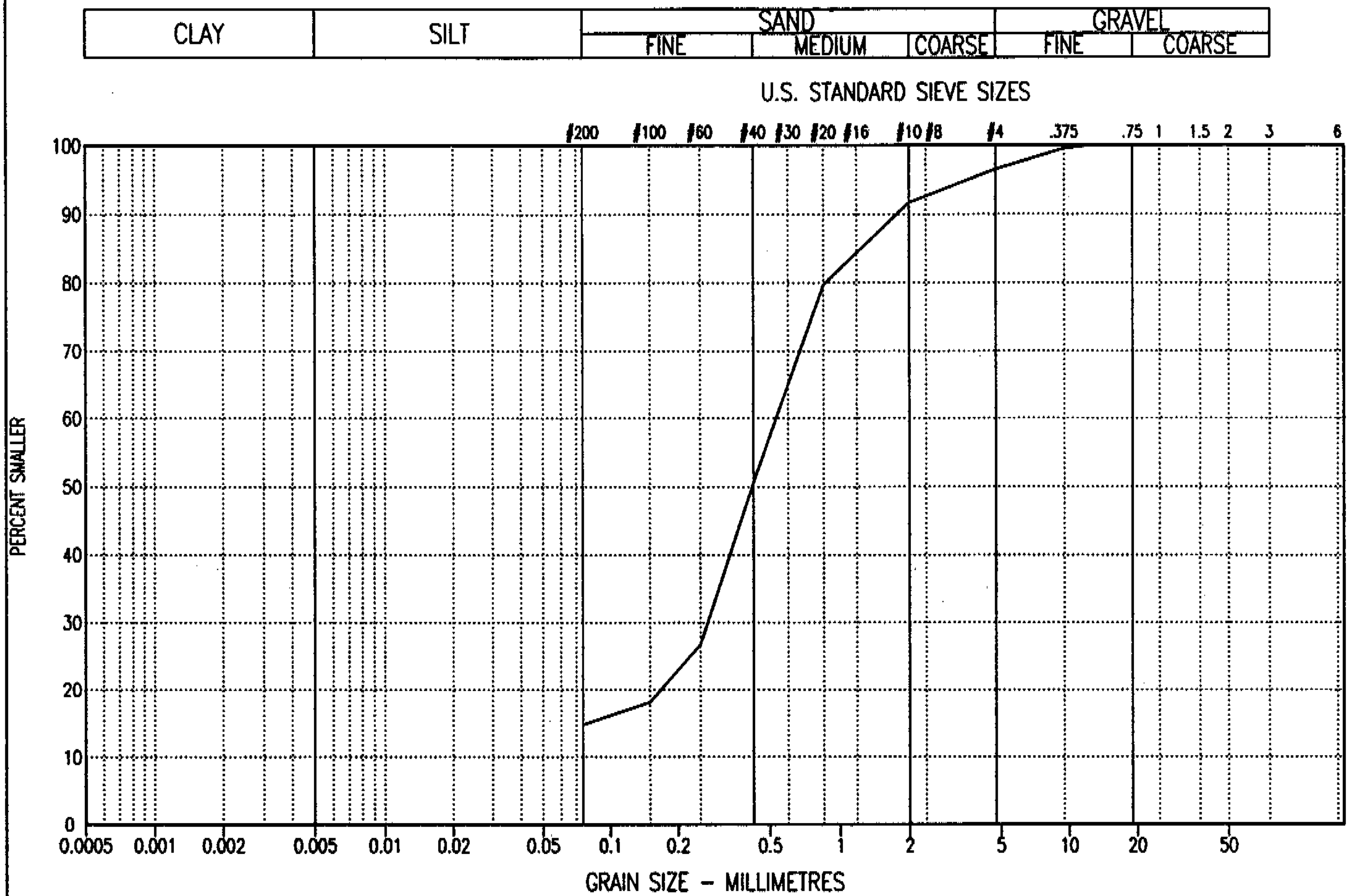
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION: CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	28	1.5 - 2.3	14.7	81.8	3.5	11.1	2.6	SM

Project: 101-11413 Date Tested: 94/04/19 BY: MH

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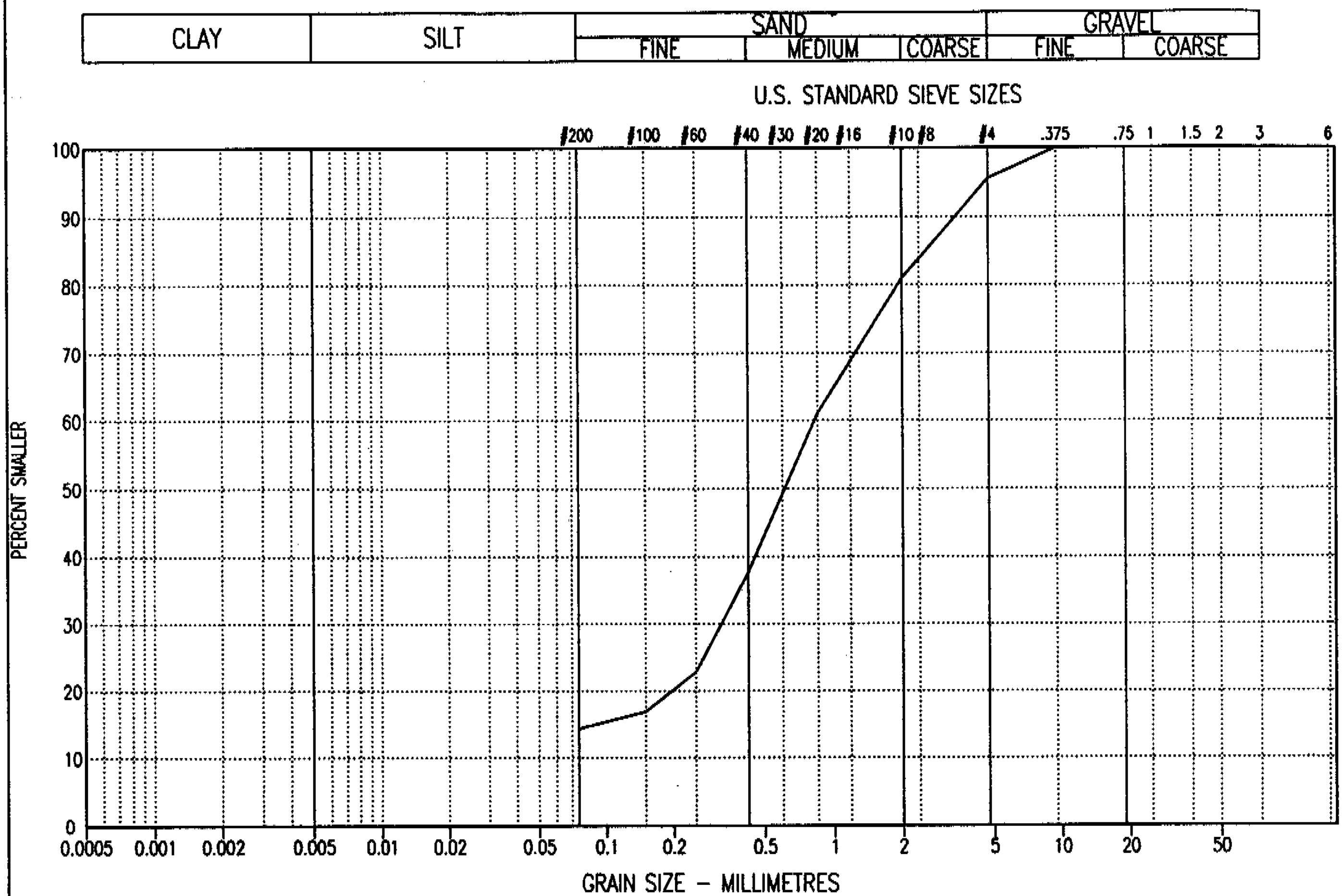
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (ft)	DESCRIPTION CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
——	28	3.0 - 3.8	14.3	81.2	4.5	15.8	2.6	SM

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

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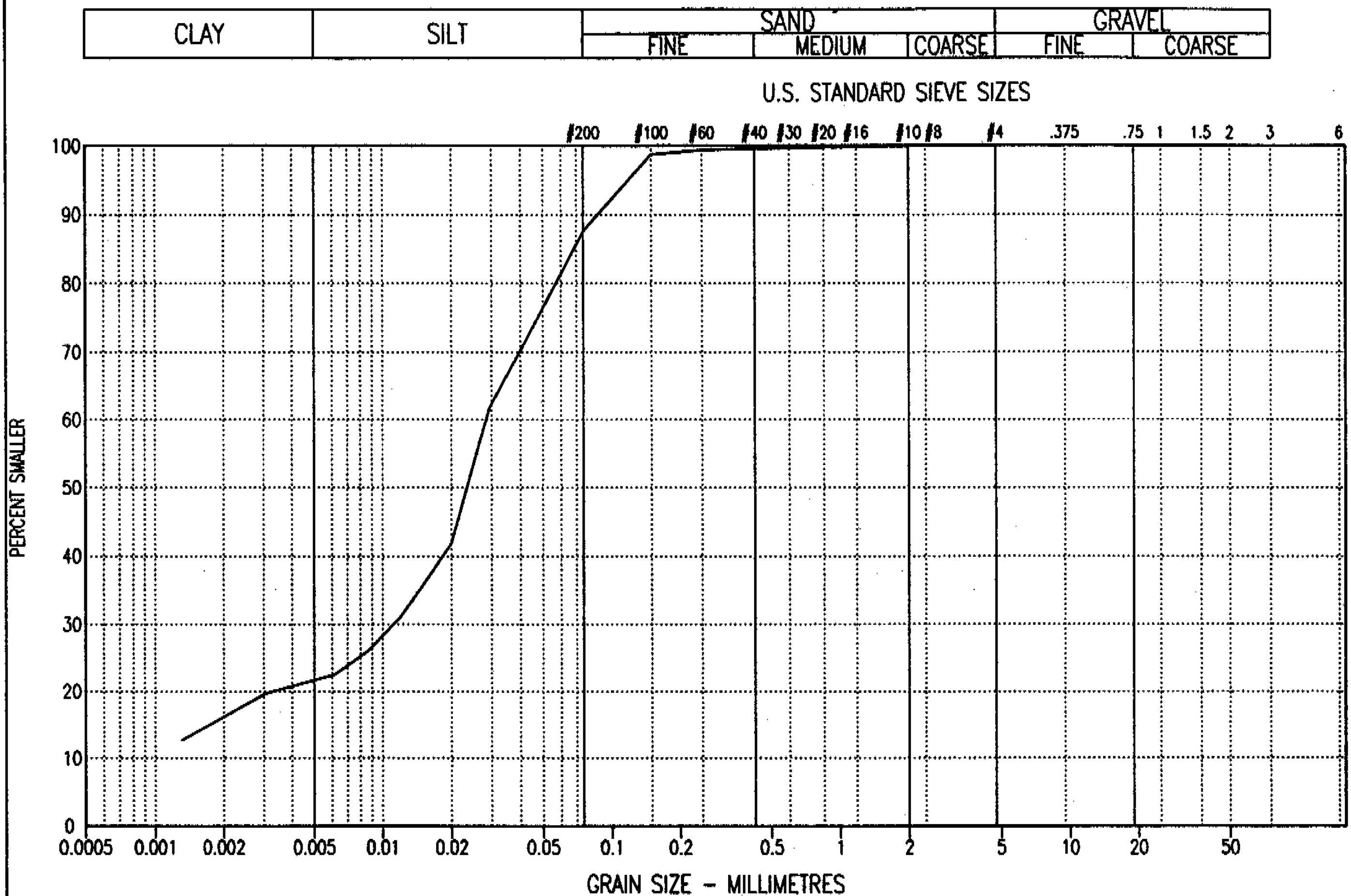
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	28	8.10 - 8.40	21.4	66.1	12.5	0.0	-	-	

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

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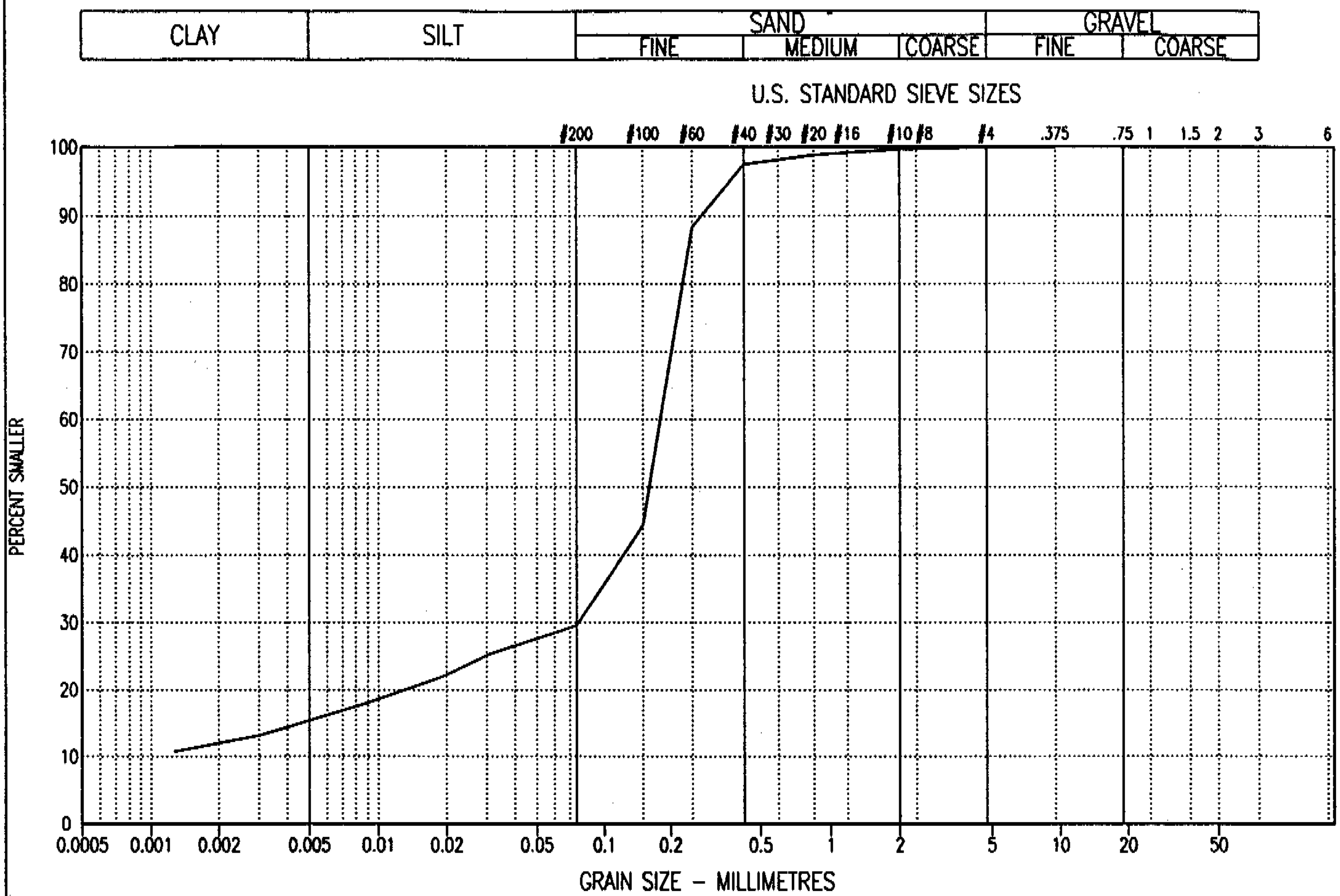
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	29	0.00 - 0.80	15.1	14.4	70.4	0.1	-	-	

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

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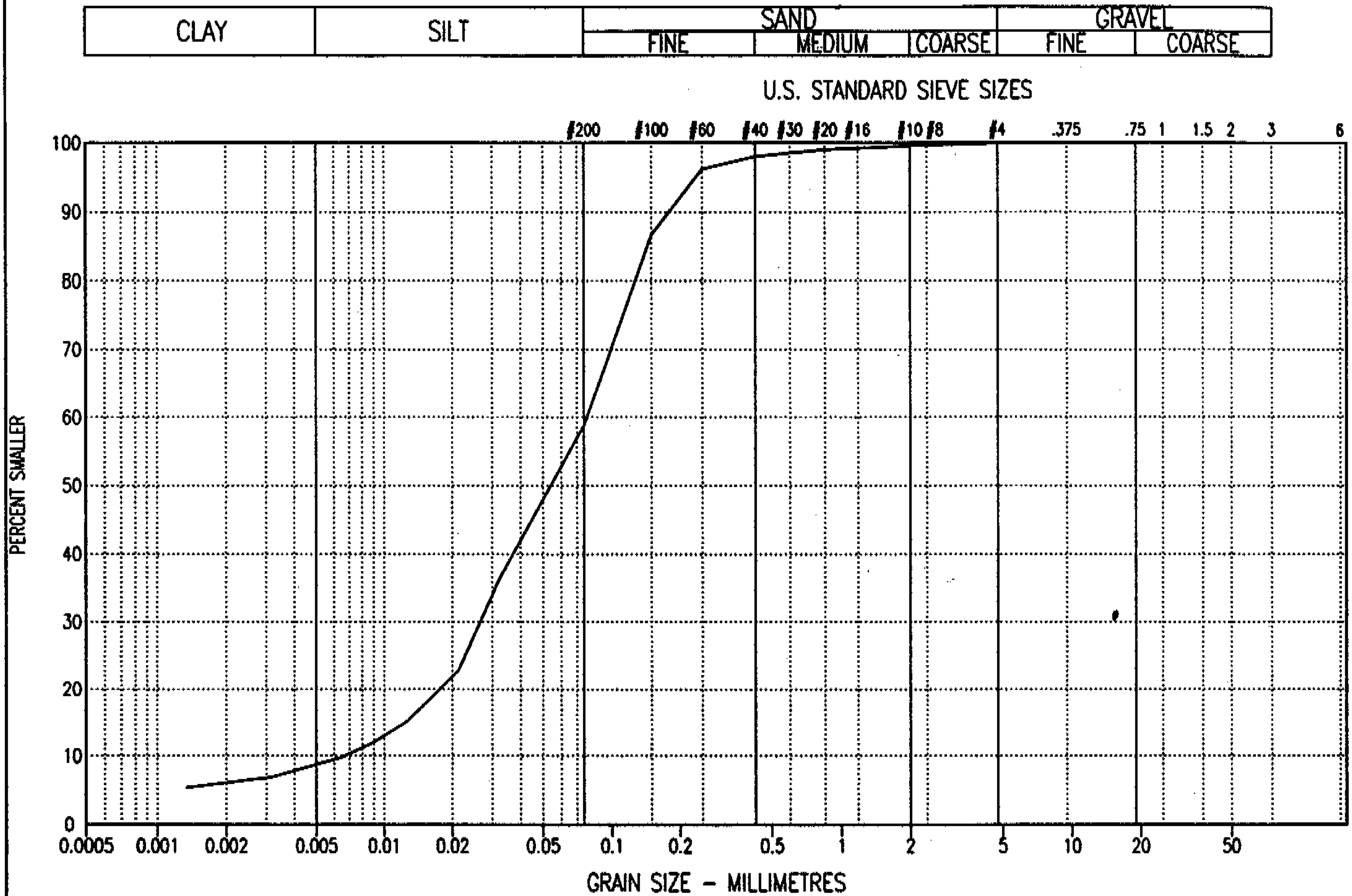
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	29	3.00 - 3.20	8.5	50.2	41.2	0.1	11.8	1.4	

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

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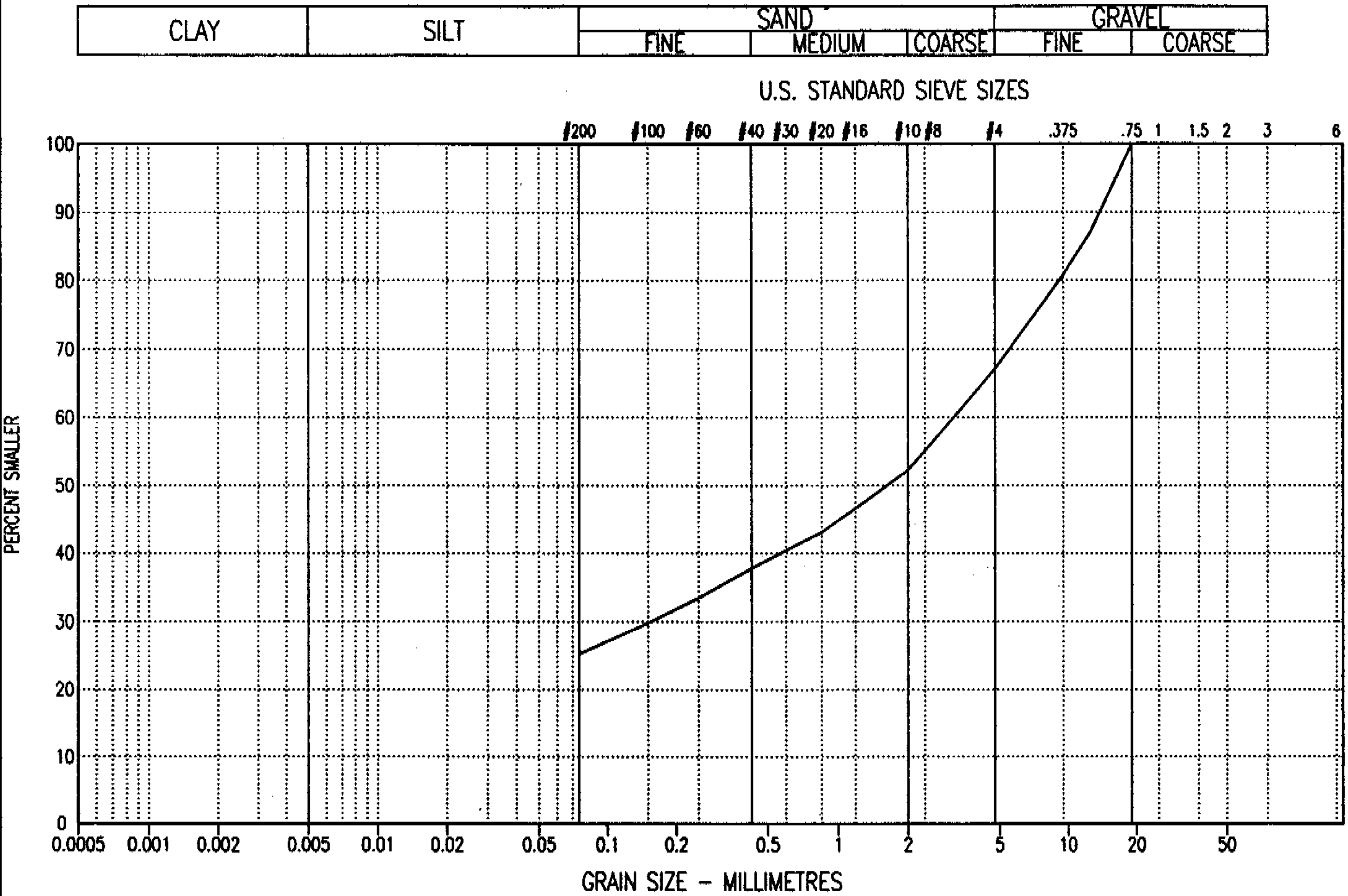
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
———	30	0.0 - 0.8	25.2	41.9	32.9	115.5	0.2	

Project: 101-11413 Date Tested: 94/04/19 BY: MH

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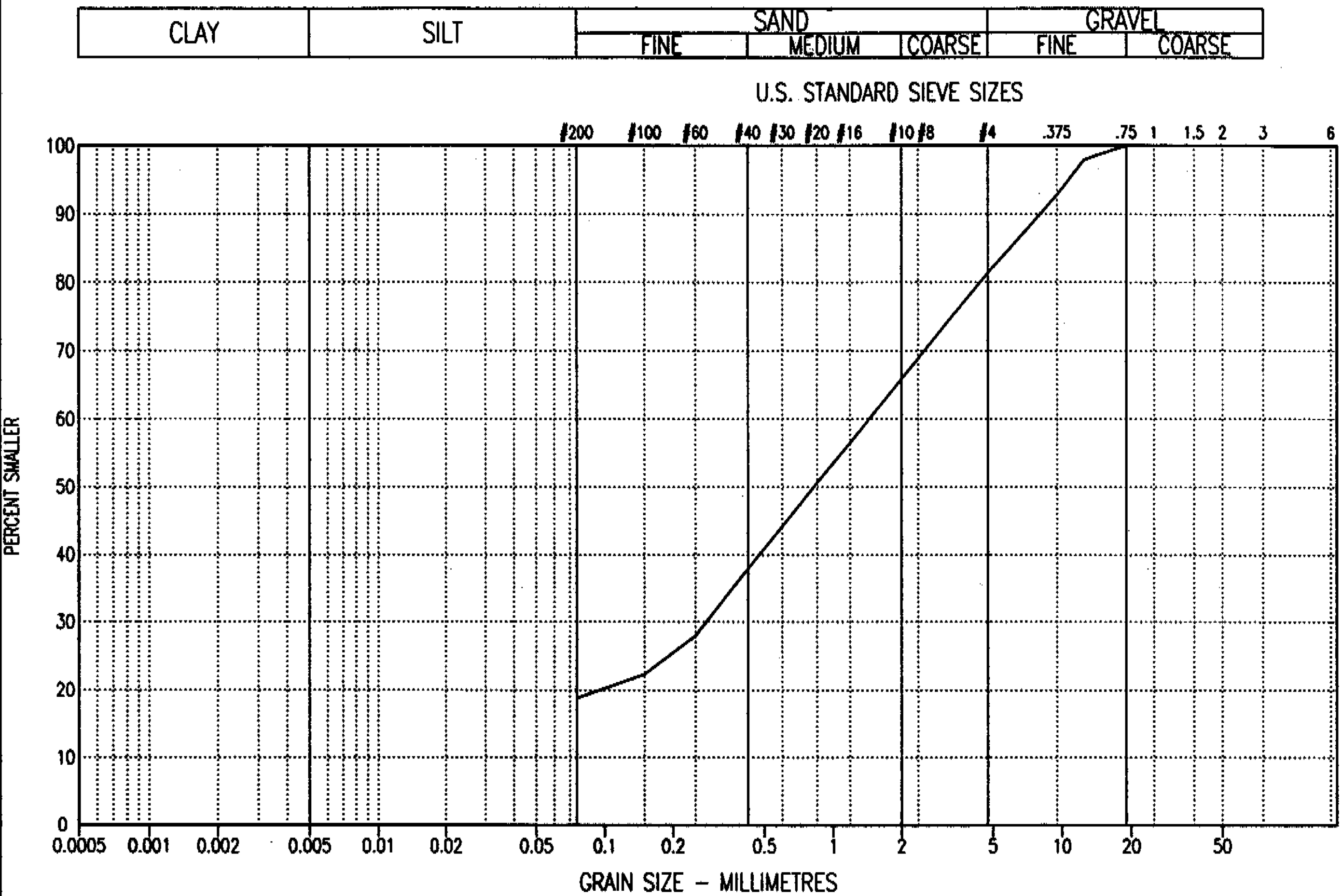
PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	30	3.0 – 3.8	18.7	62.7	18.6	39.0	1.3	SM

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

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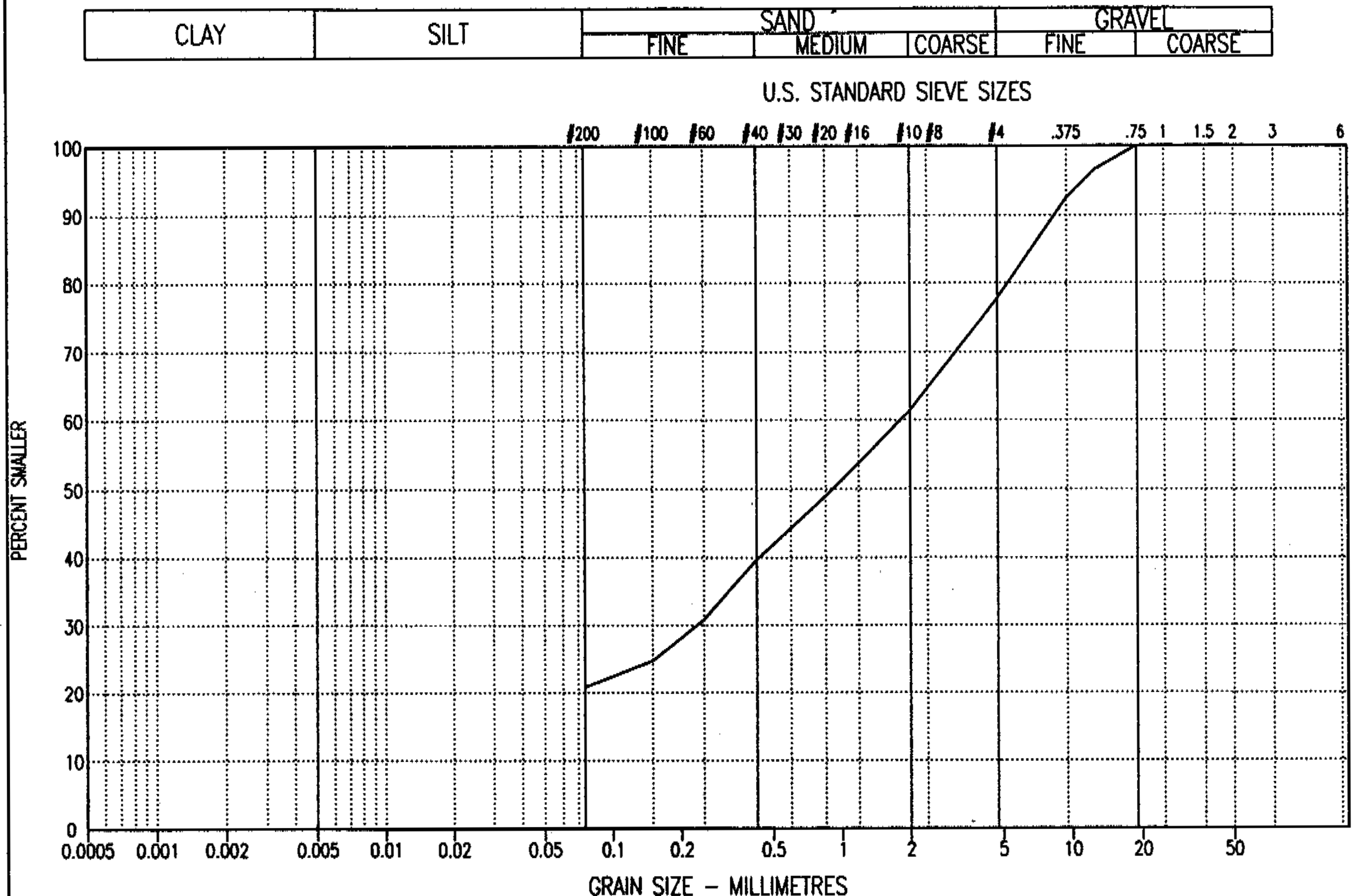
PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	30	6.1 – 6.9	20.7	57.1	22.2	51.7	0.8	SM

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

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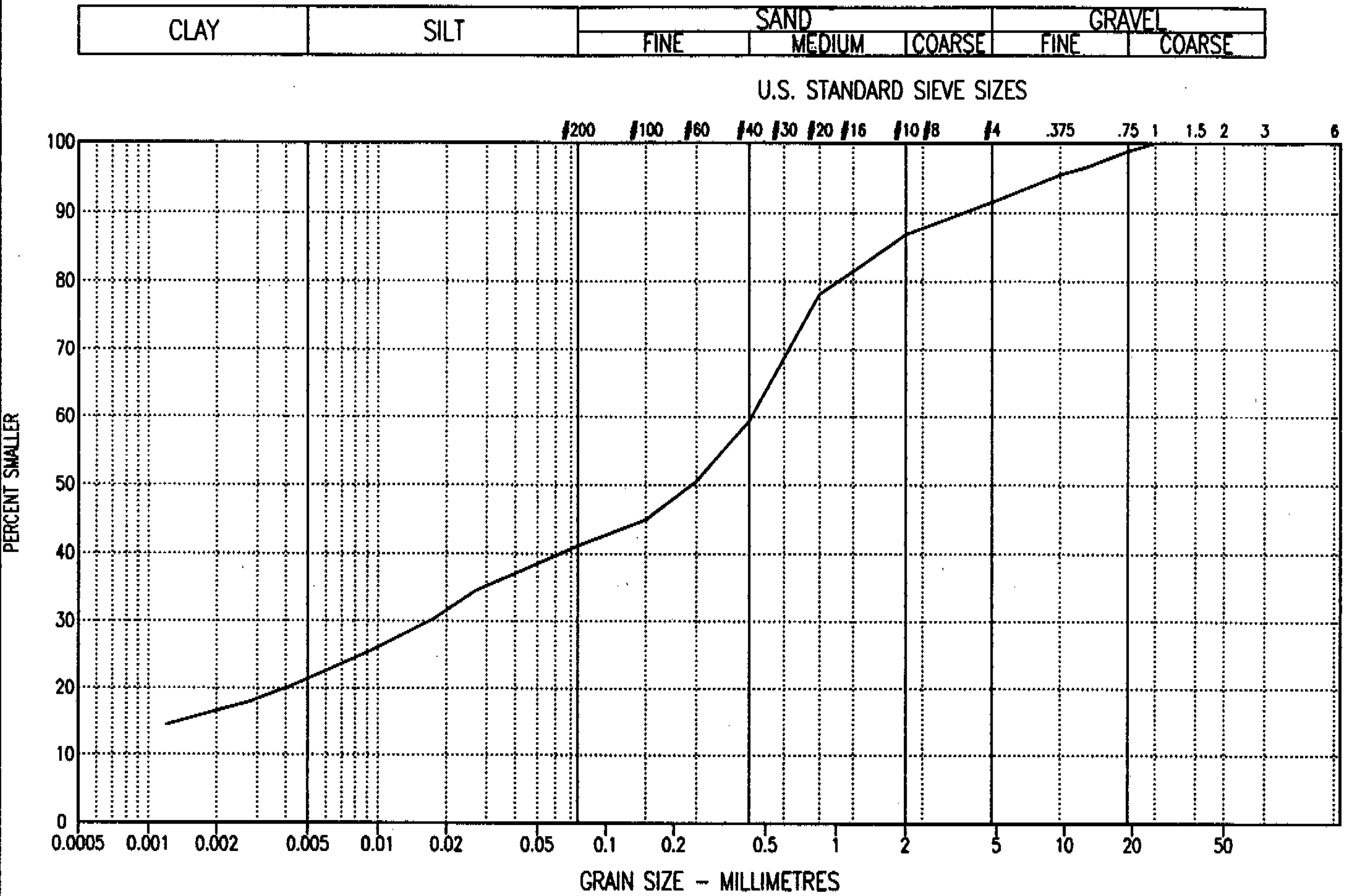
PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	31	0.60 – 0.80	21.3	19.8	50.3	8.6	–	–	

Project: 101–11413 Date Tested: 94/05/13 BY: IS

Tested in accordance with ASTM D422 unless otherwise noted.

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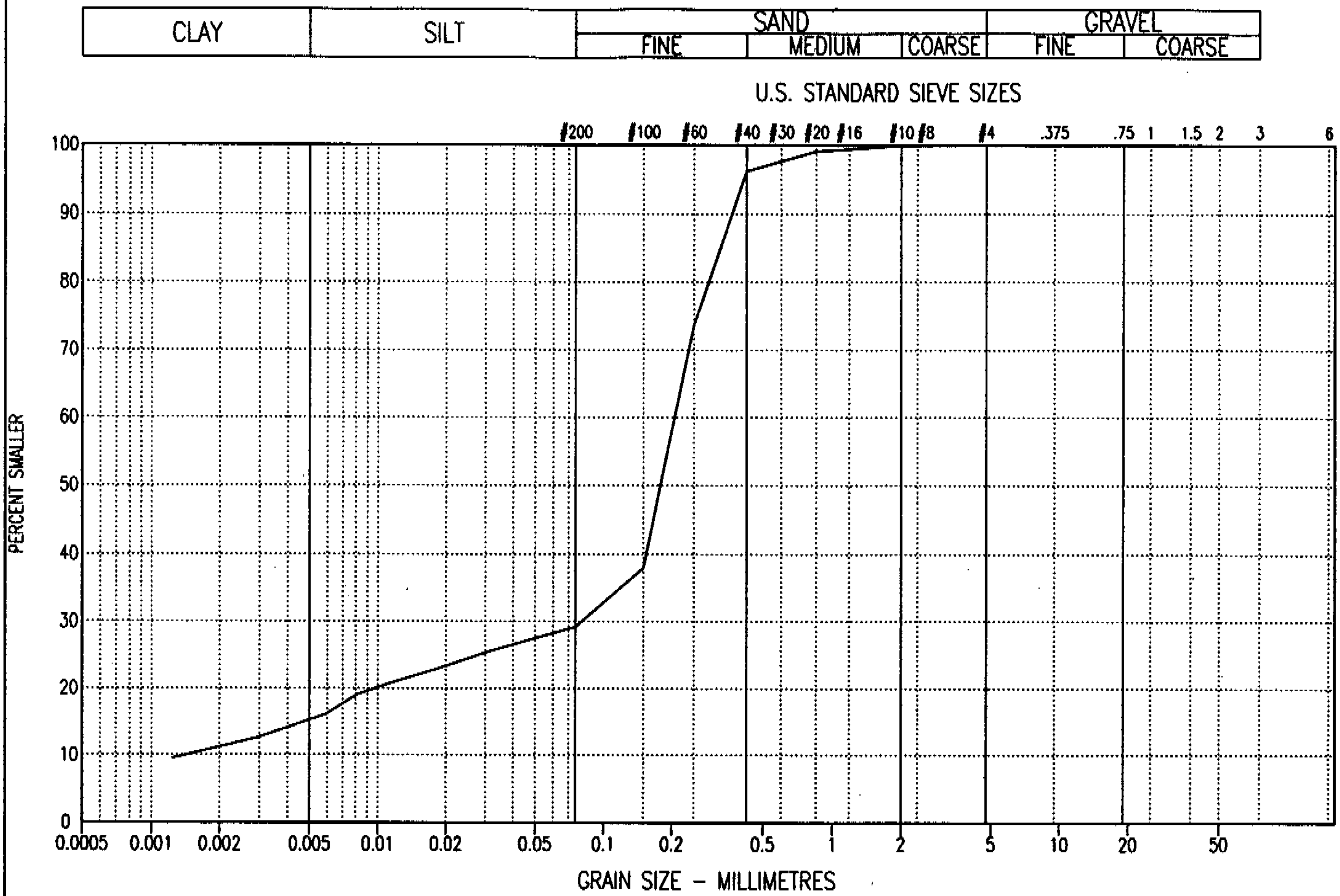
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	31	1.40 - 1.50	14.9	14.2	70.9	0.0	140.8	21.1	

Project: 101-11413 Date Tested: 94/04/25 BY: MH

Tested in accordance with ASTM D422 unless otherwise noted.

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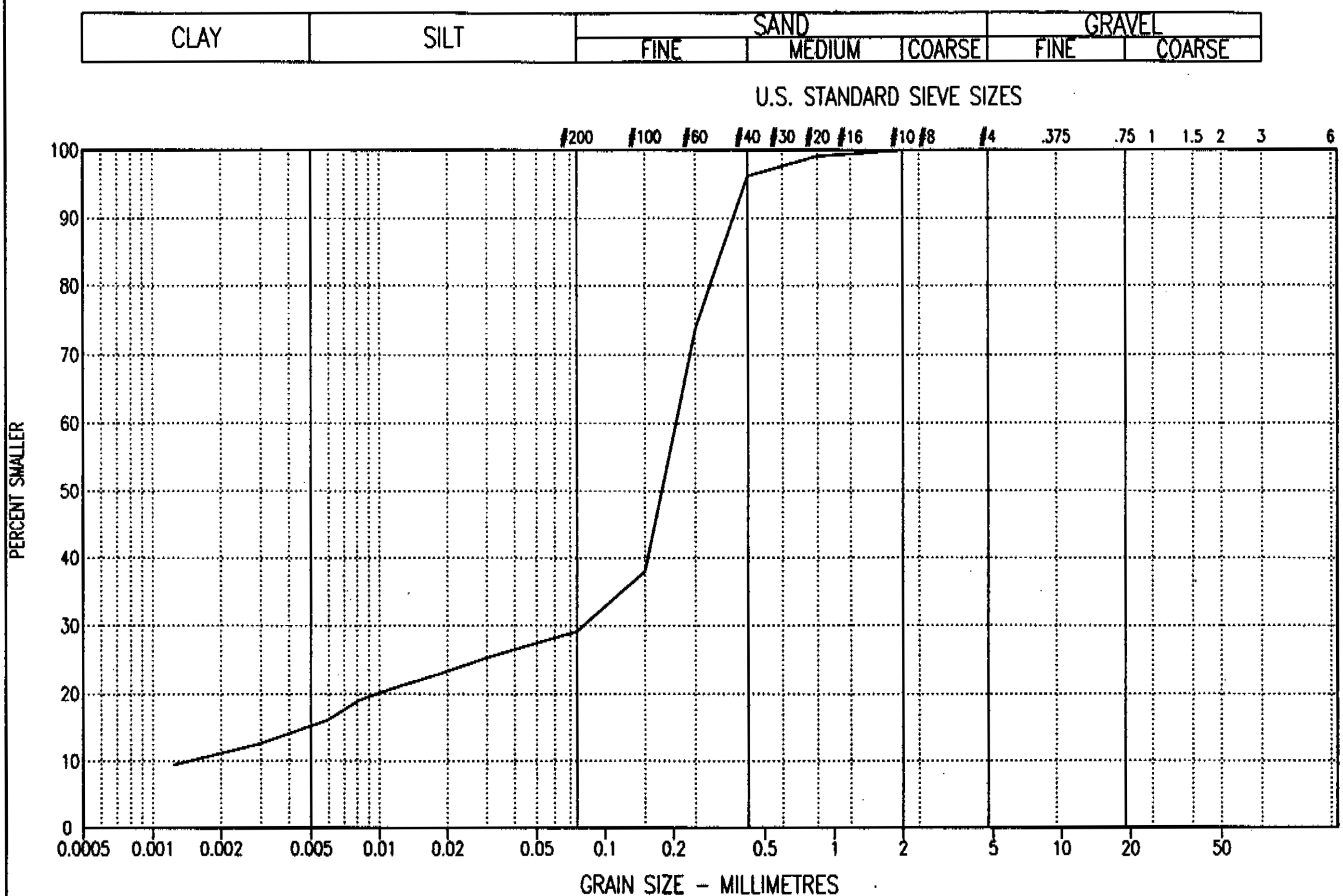
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	31	1.40 - 1.50	14.9	14.2	70.9	0.0	140.8	21.1	

Project: 101-11413 Date Tested: 94/04/25 BY: MH

Tested in accordance with ASTM D422 unless otherwise noted.

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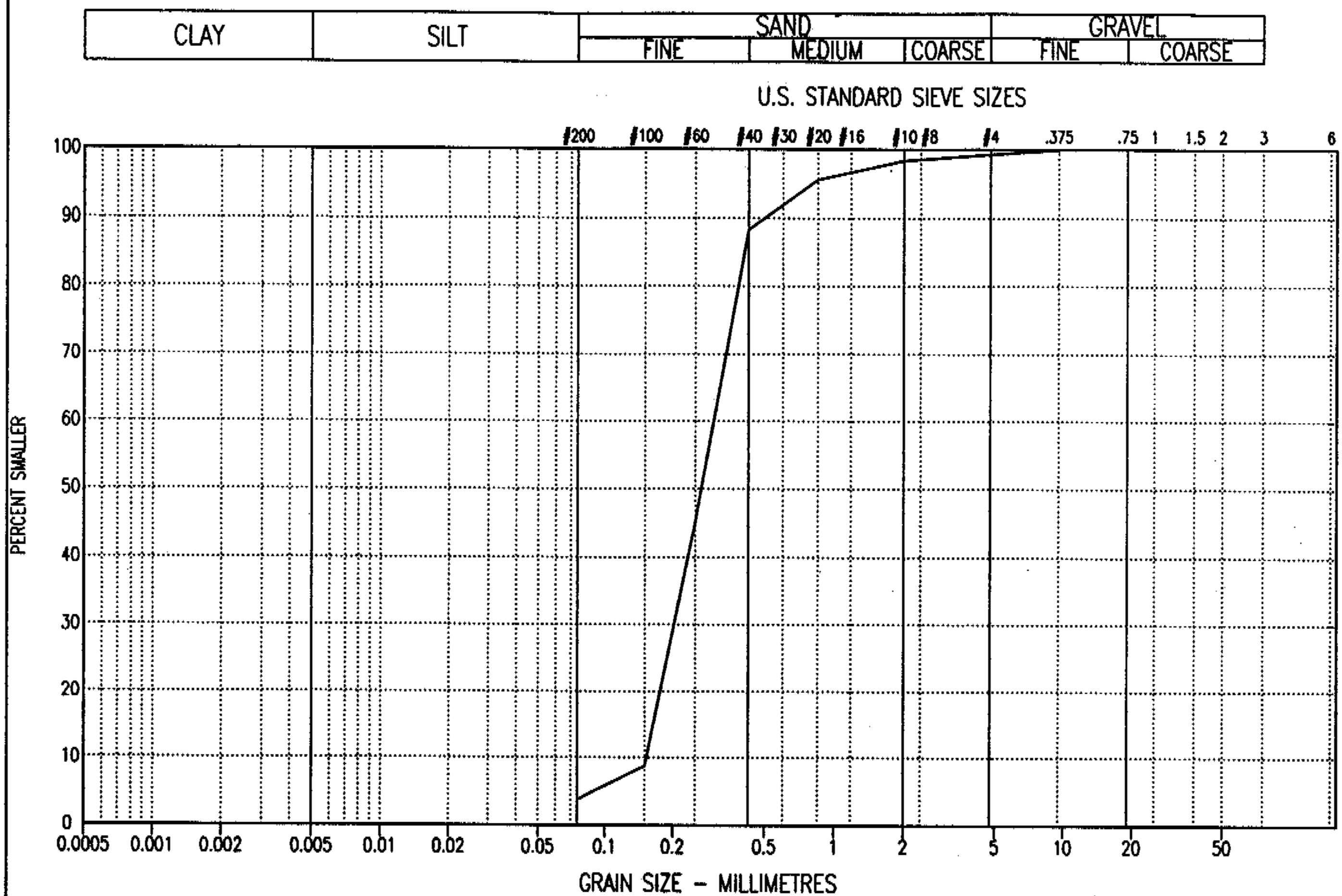
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION: CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	31	2.5 - 2.7	3.7	95.5	0.8	2.0	0.9	SP

Project: 101-11413

Date Tested: 94/04/19

BY: MH

Tested in accordance with ASTM D422 unless otherwise noted.

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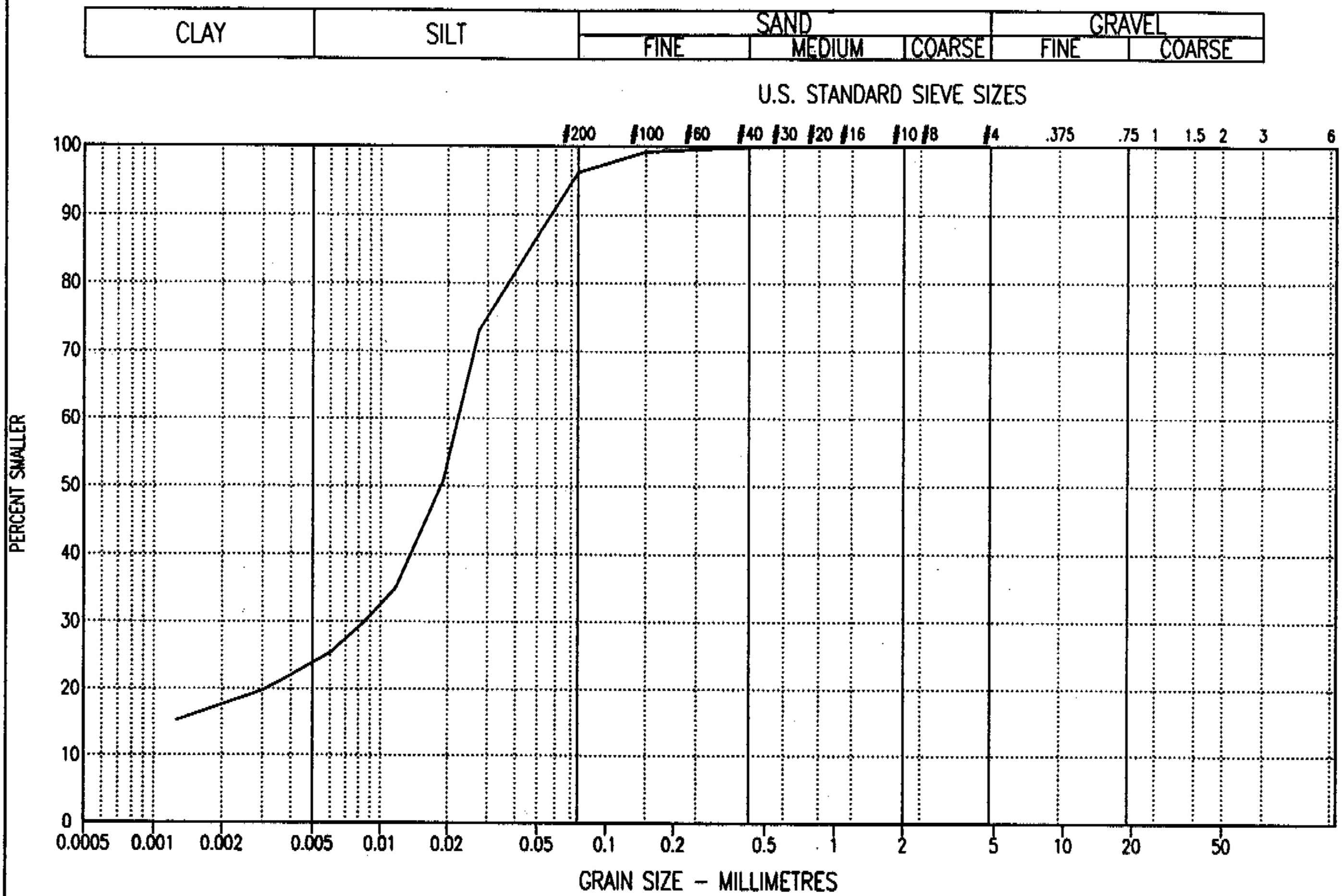
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	32	0.60 - 0.80	23.5	72.6	3.9	0.0	-	-	

Project: 101-11413 Date Tested: 94/04/25 BY: MH

Tested in accordance with ASTM D422 unless otherwise noted.

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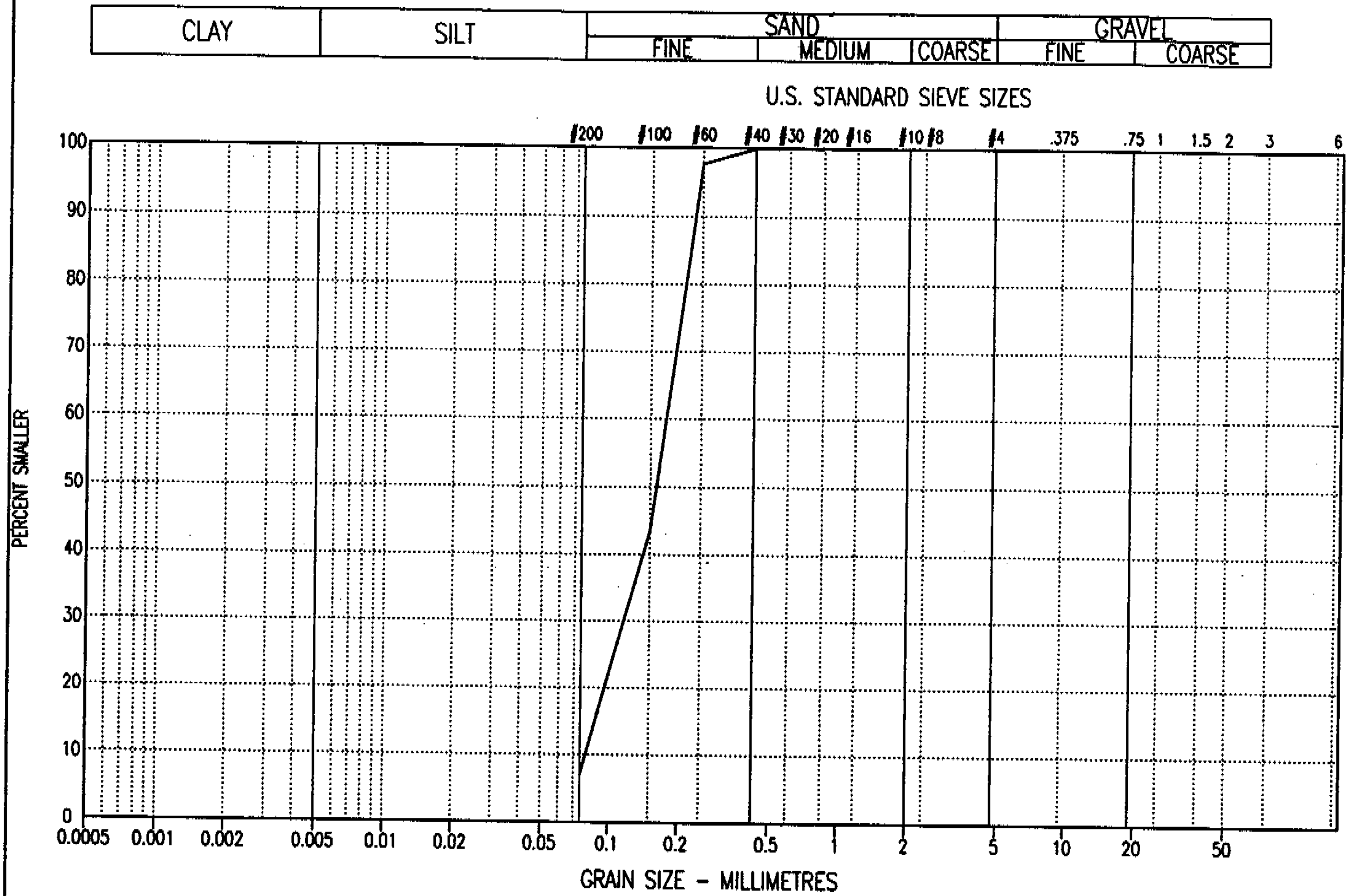
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY & SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
——	32	1.5 - 1.7	7.0	93.0	0.0	2.2	1.0	SP/SM

Project: 101-11413

Date Tested: 94/04/19 BY: MH

Tested in accordance with ASTM D422 unless otherwise noted.

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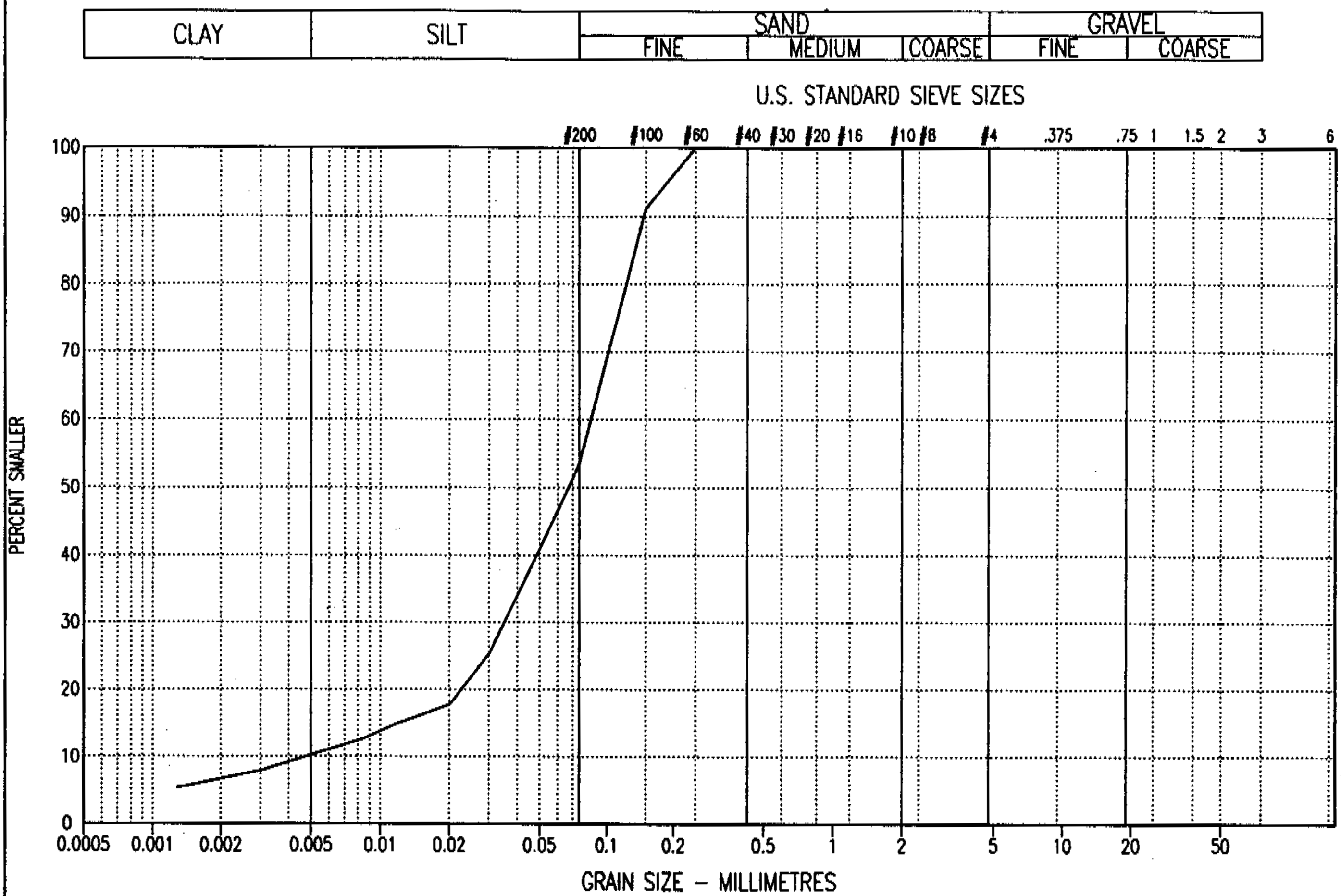
PARTICLE SIZE - ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
———	32	2.74 - 2.90	10.0	43.5	46.5	0.0	17.6	3.2	

Project: 101-11413 Date Tested: 94/05/09 BY: IS

Tested in accordance with ASTM D422 unless otherwise noted.