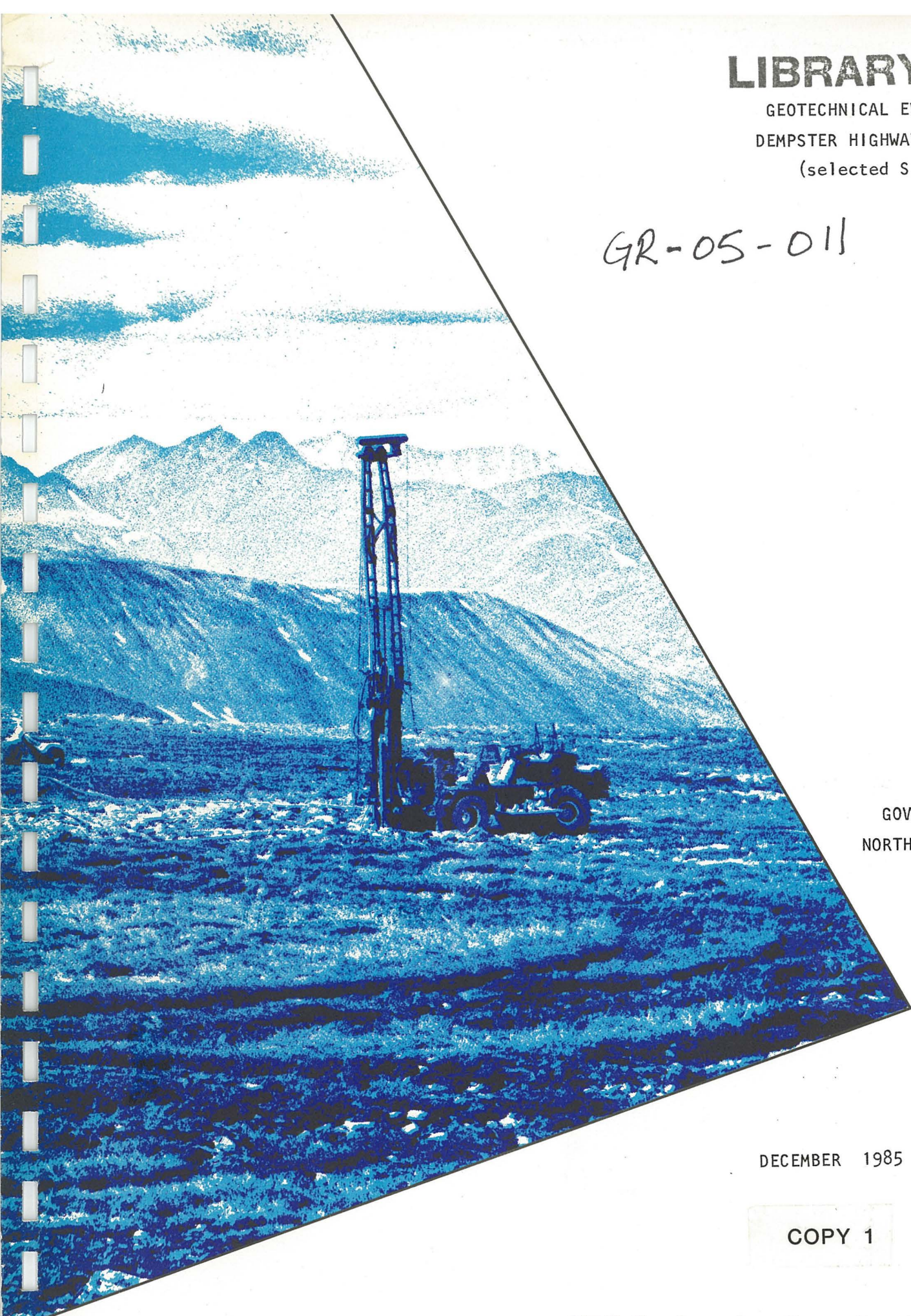


LIBRARY

GEOTECHNICAL EVALUATION
DEMPSTER HIGHWAY, N.W.T.
(selected Sites)

GR-05-011



Submitted to:
GOVERNMENT OF THE
NORTHWEST TERRITORIES

DECEMBER 1985

COPY 1

LIBRARY

GEOTECHNICAL EVALUATION
DEMPSTER HIGHWAY, N.W.T.
(Selected Sites)

Prepared by:
EBA ENGINEERING CONSULTANTS LTD.

Submitted to:
GOVERNMENT OF
THE NORTHWEST TERRITORIES
(DPW & HIGHWAYS)

DECEMBER 1985

JAN 22 1986

JUL - 7 1986

TABLE OF CONTENTS

		<u>PAGE</u>
1.0	INTRODUCTION	1
2.0	SITE EVALUATIONS	1
	2.1 Drilling and Soil Sampling	1
	2.2 Laboratory Testing	3
3.0	ENGINEERING EVALUATION	4
	3.1 General	4
4.0	GROUND RADAR SURVEY	4
5.0	CLOSURE	5

LIST OF APPENDICES

APPENDIX A	Accident Site (km 8.5)
APPENDIX B	Recurring Pot-Hole Site (km 18)
APPENDIX C	Slope Failure Site (km 27.9)
APPENDIX D	Slope Failure at Culvert Site (km 46.9)
APPENDIX E	Slope Failure at Culvert Site (km 50.9)
APPENDIX F	Sinkhole Site (km 227.2)
APPENDIX G	Culvert Site (km 229.8)
APPENDIX H	Culvert Site (km 247.0)

1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA) was retained by the Government of Northwest Territories (GNWT), DPW and Highways, to conduct geotechnical investigations at several sites along the NWT portion of the Dempster Highway, from the Yukon border to Inuvik. The work was to consist of drilling, soil sample collection, permafrost evaluation, and the collection of other field data, as required, to provide engineering evaluations at each of the specific sites. The project was authorized by Mr. J. Bowen on October 4, 1985, under service contract SC251217.

The majority of the sites were pre-selected by the GNWT Highways Department, and were chosen on the basis of existing or predicted maintenance problems. The site at km 8.5 required evaluation due to an accident which occurred in September. The problems at all sites were believed to be related to thawing of permafrost, and the investigations were planned and completed to examine this hypothesis. The results of the field and laboratory testing program are presented in the following sections, along with engineering interpretations, where applicable. Specific details of each site are presented in separate appendices of this report.

2.0 EVALUATION OF SITES

2.1 Drilling and Soil Sampling

Table 1 summarizes the sites investigated, and shows the number of boreholes drilled at each.

TABLE 1
SUMMARY OF SITES INVESTIGATED
DEMPSTER HIGHWAY, N.W.T.

SITE	APPENDIX OF THIS REPORT	BOREHOLES DRILLED	EXPLANATION
km 8.5	A	18 (1 thermistor cable installed)	vehicle accident location
km 18.0	B	2	recurring maintenance problem (pot-hole)
km 27.9	C	1	flowslide adjacent to highway
km 46.9	D	8	slope stability at culvert
km 50.9	E	8	slope stability at culvert
km 227.2	F	6 (1 thermistor cable installed)	sinkhole in ditch
km 229.8	G	2	culvert evaluation
km 247.0	H	1	culvert evaluation
8 sites total		46 holes total	

All holes were drilled with a CME 750 drill, contracted from Midnight Sun Drilling Co. Ltd. of Whitehorse, Yukon. This drill is mounted on an all-terrain vehicle and is equipped with both solid shaft and hollow stem augers. Permafrost samples were taken from the auger flights and with a permafrost core barrel. This core barrel is a CRREL ice auger barrel, modified to obtain 100 mm diameter permafrost soil cores. Insulated core boxes and freezer-packs were available during the field program to keep cores frozen, if necessary. In addition to retaining some of the frozen soil cores, the ground temperature was measured in all undisturbed samples, using a hand-held temperature probe. At two of the eight sites (km 8.5, km 227.2), ground temperature (thermistors) cables were installed, for long-term temperature monitoring.

In unfrozen soils, samples were taken from either the auger flights, or from a 51 mm diameter split spoon drive sampler. This sampler constitutes part of the standard penetration test (SPT), which is used to evaluate in-situ soil density.

All samples were classified in the field using the NRC permafrost classification system. The samples were then returned to EBA's Whitehorse laboratory for further classification testing, and USC designations.

2.2 Laboratory Testing

The natural moisture content was determined for all samples. Selected samples in representative soil types were tested for grain size characteristics (sieve and/or hydrometer testing), as well as degree of plasticity (Atterberg limits). The bulk density was measured in several of the permafrost cores, to obtain a confirmation of the ground ice content.

The results of the laboratory testing are presented on the borehole logs, where applicable, and on the particle-size distribution curves, located after the borehole logs in each appendix.

3.0 ENGINEERING EVALUATION

3.1 General

As previously noted, the present study was separated into eight different sites. Correspondingly, the results of the drilling and testing programs, and the engineering evaluation of each site are presented in separate appendices of this report. The sites and appendices are presented in the chronological order of drilling, and in increasing kilometre posts. Please refer to the appendices for site-specific information.

4.0 GROUND RADAR SURVEY

The subsurface-interface radar (SIR) unit was tried at several locations along the highway, with limited success. Previous EBA experience with a similar unit; however, has proven it to be useful for delineating zones of ice wedges and ice rich soil. It is believed that with experienced operators, the SIR unit could delineate ice-rich zones beneath the road surface, and save on the number and cost of boreholes in future drilling programs. It is recommended that consideration be given to a further evaluation of suitability of the SIR unit for this application. A cursory examination of the data obtained from the present study will be completed by EBA's SIR experts, to further evaluate its' potential use in this regard.

5.0 CLOSURE

The information and recommendations presented herein are based on the results and findings from 46 boreholes drilled at eight sites. The results are believed to be representative of the sites; however, if conditions other than those presented herein are encountered during any phase of site work, we should be notified so that our recommendations can be re-evaluated, in light of the new findings. Further information regarding the use of this report is found in the General Conditions, located before Appendix A.

Respectfully submitted,

EBA Engineering Consultants Ltd.

J.R. Trimble, P. Eng
Senior Project Engineer
Whitehorse Manager

JRT/was

**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.

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 be 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 otherwise 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

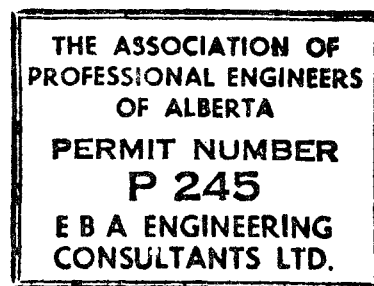
Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil type and soil condition. Construction activity and environmental circumstances can materially change a soil condition. The elevation at which a soil type occurs is variable. It is a requirement of 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.



UNIFIED SOIL CLASSIFICATION†

MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES	CLASSIFICATION CRITERIA			
COARSE-GRAINED SOILS <small>More than 50% retained on No. 200 sieve*</small>	GRAVELS <small>50% or more of coarse fraction retained on No. 4 sieve</small>	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	$C_u = D_{60}/D_{10}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting both criteria for GW Atterberg limits plot below 'A' line or plasticity index less than 4 Atterberg limits plot above 'A' line and plasticity index greater than 7		
		GRAVELS WITH FINES	GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines			
		SANDS	GM	Silty gravels, gravel-sand-silt mixtures			
		SANDS WITH FINES	GC	Clayey gravels, gravel-sand clay mixtures			
	SANDS <small>More than 50% of coarse fraction passes No. 4 sieve</small>	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 Not meeting both criteria for SW Atterberg limits plot below 'A' line or plasticity index less than 4 Atterberg limits plot above 'A' line and plasticity index greater than 7		
			SP	Poorly-graded sands and gravelly sands, little or no fines			
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures			
			SC	Clayey sands, sand-clay mixtures			
		FINE-GRAINED SOILS <small>50% or more passes No. 200 sieve*</small>	SILTS AND CLAYS <small>Liquid limit 50% or less</small>	ML		Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	<div style="text-align: center;"> PLASTICITY CHART For classification of fine-grained soils and fine fraction of coarse-grained soils Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols Equation of 'A' line: $PI = 0.73(LL - 20)$ </div>
				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 <small>Liquid limit greater than 50%</small>	MH		Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts				
	CH		Inorganic silts of high plasticity, fat clays				
	OH		Organic clays of medium to high plasticity				
	PT		Peat, muck and other highly organic soils				
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	SUBGROUP DESCRIPTION	
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 \pm 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

APPENDIX A

km 8.5, Dempster Highway, N.W.T.

- A-1 General
- A-2 Investigation Program
- A-3 Results and Conclusions
- A-4 Recommendations
 - Site Plan
 - Borehole Logs (BH 1 to BH 18, including moisture contents,
Atterberg limits, bulk densities, ground temperatures)
 - Photographs (Plates 1 to 8)
 - Ground Temperature Profile (Cable 82-10-19)
 - Grain Size Curves

APPENDIX A

km 8.5, Dempster Highway, N.W.T.

A-1 General

This site was selected for evaluation due to a fatal accident which occurred here in September, 1985. It is understood that the GNWT Highways had previously excavated a test pit at this site, and had encountered a water-filled void beneath a layer of ice. Further geotechnical data was required at this location to determine the cause of the road collapse, the potential for future collapses, and the recommended method for road repair.

A-2 Investigation Program

A total of eighteen boreholes (BH 1 to BH 18) were drilled at the site between October 10 and 14, 1985, at the locations shown on the enclosed Site Plan. The holes ranged in depth from 2.9 m to 8.9 m, with an average depth of 5.9 m. To monitor the permafrost temperature with depth, and to obtain data for further analysis, a ground temperature (thermistor) cable was installed in Borehole No. 15, off the side of the highway embankment. Also, after all the holes were drilled, a backhoe was used to excavate a trench down the centreline of the road, so that an accurate picture and understanding of soil and ice conditions could be obtained. Excavation of this trench was extremely difficult due to the seasonal frost penetration of approximately 1.2 m. A 'frost' bucket was required to complete the excavation.

A-3 Results and Conclusions

The highway in the vicinity of km 8.5 consists of road fill, averaging 1.6 m in thickness, placed directly on the natural terrain at the site. The permafrost table was consistently located at or near the original ground surface, insulated by a thin layer of organics. Subsurface conditions beneath the highway are summarized in Table 2 (summary prepared from averaged borehole data).

TABLE 2
SUMMARY OF SUBSURFACE CONDITIONS
km 8.5, DEMPSTER HIGHWAY, N.W.T.

SOIL TYPE (USC)	DESCRIPTION	GROUND ICE CONTENT (NRC)	AVERAGE DEPTH BELOW SURFACE	MAXIMUM RANGE IN THICKNESS
GRAVEL ROAD FILL (SW)	sandy, angular, dark grey	generally unfrozen to 1.5 m	0 to 1.6 m	0.6 to 2.9 m
-----	*-----*	*-----*	*-----*	*-----*
ORGANICS (PT/OL)	grasses, peat and organic silt, usually wet at base of active layer, and is the source of free water noted in several boreholes	permafrost at 1.5 m depth unfrozen to Vx, Vr 60%	1.6 to 2.0 m	0.2 to 1.5 m
SAND (TILL) (SW)	gravelly, some silt, olive brown	Vx 10% to Vx, Vr 50%, lenses up to 300 mm thick	2.0 to 4.3 m	1.2 to 3.4 m
SILT (ML)	some clay, trace of sand, olive brown	Vs, Vr 10% to 50%, lenses up to 50 mm thick	4.3 to 5.6 m	absent in some holes to greater than 3.1 m in others.
SHALE BEDROCK	platy fragments, dark grey	Vx, Vr 10% as fracture fill- ings (bedrock surface only)	5.6 m to depth of penetration	not deter- mined

0201-4426

Ground ice content in the permafrost was typically very high, and ranged from V_x , V_r 10% by volume up to ICE 100% in zones 2.5 m to 3.1 m thick.

Further examination of these ice zones in the backhoe test pit revealed that they were 'ice wedges', a typical feature of permafrost terrain. Plates numbered 6, 7 and 8 show details of the ice wedge in the trench. Ice wedges are formed by brittle fracturing through contraction of the permafrost, and the accompanying inflow and freezing of surface water in the fractures. This freezing and associated expansion causes further cracking, etc. The conditions at km 8.5 are suited for this natural process--relatively cold ground temperatures (-3°C at depth) and abundant free water in the active layer. Water was noted to be seeping in several of the boreholes drilled through the road fill (Boreholes No. 1, 2, 5, 10, 13, 18) and the organic surface of the natural ground was noted to be saturated in all the holes drilled off the road fill (Boreholes No. 15, 16, 17). Water was also seeping into the backhoe-excavated test pit (See Plate 8).

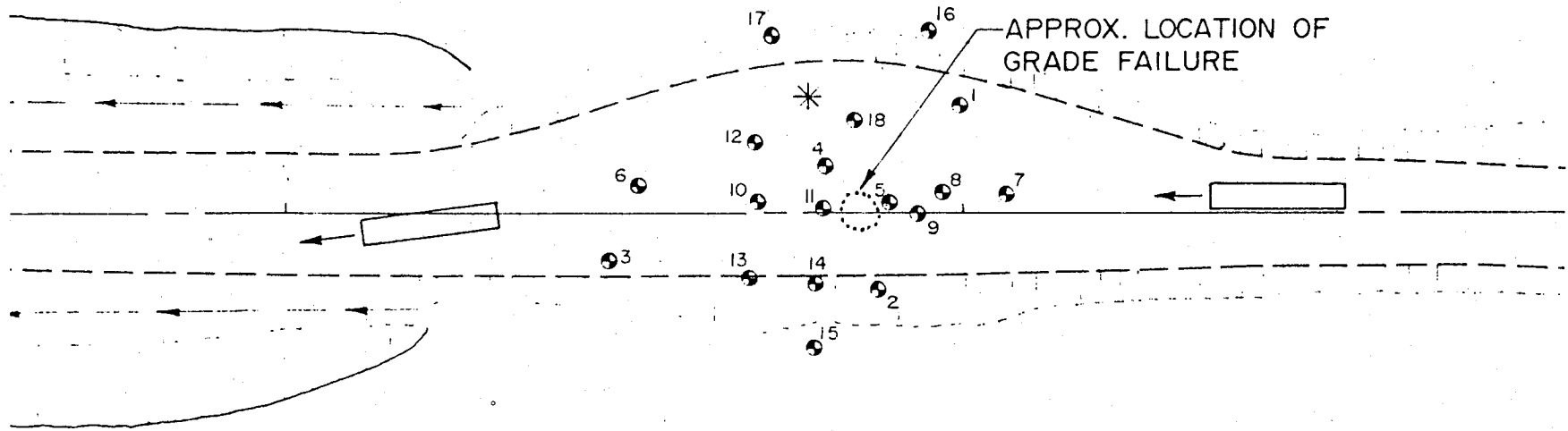
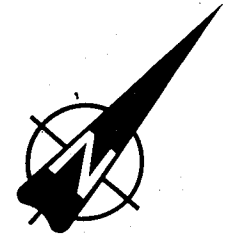
The reason for the road collapse at km 8.5 is believed to be thawing of a portion of one of the ice wedges at this site caused by sun-warmed surface water seeping into a permafrost crack, and thawing the ice. As the ice thawed, a 'cavern' was created into which more water seeped, etc. The surface fill acted as a bridge until the repeated loading from heavy trucks exceeded the structural capacity, and it started to collapse from below. Unfortunately, this is a natural phenomenon which is nearly impossible to predict.

0201-4426

Maintenance staff should be made aware of this potential occurrence, and should take extra care in examining the road surface for small pot-holes (the initial stage), particularly in the late summer and early fall when seasonal thawing is at its' deepest level. Truckers should also be requested to report on unusual pot-hole conditions, whenever possible.



A-4 Recommendations

The ice at km 8.5 must be removed and replaced with frost stable gravel backfill. The excavation should commence in the vicinity of Borehole No. 5 or 18, and follow the ice in all directions encompassing a zone denoted by a 45° degree slope extending outwards from the top of the road shoulder. A total excavation depth of 3.5 m should be sufficient. Based on the borehole and test pit information, the ice wedge(s) are not very large; however, the erratic nature of their distribution suggests that several days of summer excavation and backfill might be required to complete the work.



SITE PLAN AND BOREHOLE LOCATIONS
ACCIDENT SITE
km 8.5, DEMPSTER HIGHWAY, N.W.T.

SCALE 1:500

EBA Engineering Consultants Ltd. 	
JOB NO. 0201-4426	DATE: 1985-12-16
DRAWN BY:	DRAWING NO.:
REVIEWED BY: 	4426-A1

NOTE: Drawing provided by Nordzone Consultants Ltd.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲						
				1.4	1.6	1.8	2.0	2.2		
				MOISTURE CONTENT						
					10	20	30	40	50	
1	GRAVEL (ROAD FILL) (SW)-sandy, angular, damp, dark grey		SEASONAL FROST							
		G	UNFROZEN							
	- water level in hole 1.0 m after 24 hours									
	ORGANICS (PT)-peat and grasses									73%
2	SAND (TILL) (SW)-gravelly, some silt, olive brown	C	FROZEN							80%
			Vx, Vc 30% to 40%							
		C	T=-0.82°C							
3		C	Vx 40%							
			T=-1.05°C							
		C	Vx, Vr 50%							60%
		C	T=-1.06°C							
4	SILT (ML)-some clay, olive brown	C	ICE+25% soil							
			T=-2.43°C							
		C	Vr 25% - 30% lenses to 20 mm thick							
		C	T=-2.67°C							
5	SHALE (BEDROCK) - platy shale fragments in ice matrix - random ice fillings and crystals, fractures filled with ice	C	Vx, Vr 50%							76%
			T=-2.02°C							
		C	T=-0.57°C							
		C	Vx, Vr 10%							
		C	T=-1.31°C							
6	- no ice below 6.4 m									
7	END OF HOLE									



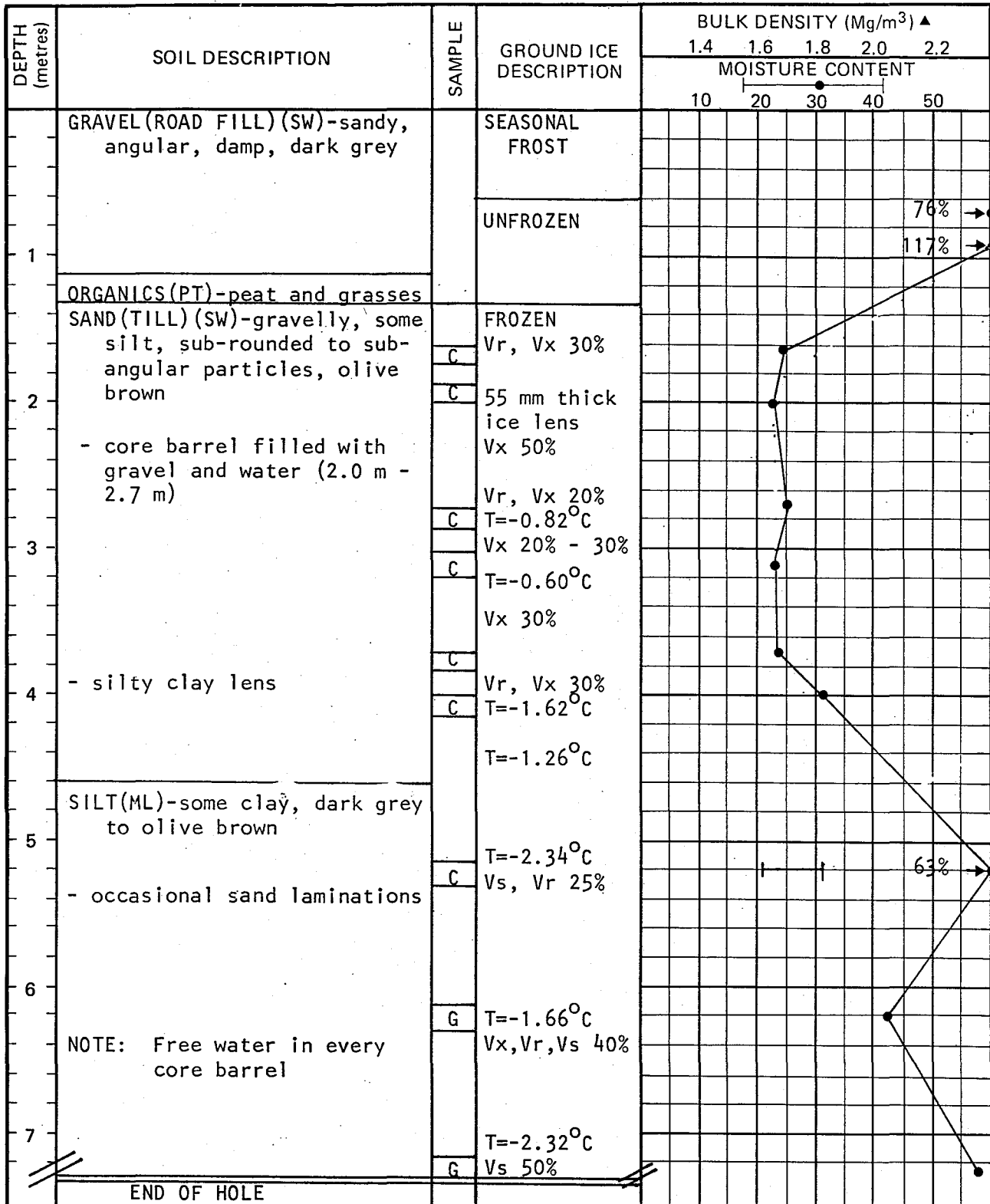
SFC. ELEVATION (m)	DATE DRILLED 1985-10-10
COMPLETION DEPTH (m) 6.7	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No.	1
PAGE 1 OF 1	

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY



SFC. ELEVATION (m)	DATE DRILLED 1985-10-10
COMPLETION DEPTH (m) 7.5	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No. 2
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL (ROAD FILL) (SW)-sandy, angular, damp, dark grey		SEASONAL FROST						
			UNFROZEN						
2		G							
		G	FROZEN						
3	SAND (TILL) (SW)-gravelly, some silt, olive brown	G	Vx 50% - ice has snowy texture					90%	
4	SILT (ML)-some clay, olive brown to dark grey	C	T=-1.30°C Vs 25%						
5		C	Vs 20% T=-1.41°C						
6		C	Vs 40%, ice lenses up to 50 mm thick T=-1.65°C						
7	NOTE: No water in this hole	G	Vx, Vr 25% to 30% T=-1.69°C						
	END OF HOLE								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-10
COMPLETION DEPTH (m) 7.0	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No. 3
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL (ROAD FILL) (SW)-sandy, angular, damp, dark grey		SEASONAL FROST					
			UNFROZEN					
2	SAND (TILL) (SW)-gravelly, some silt, olive brown, sub-angular to sub-rounded particles	C	FROZEN T=-0.69°C Vx trace, crystals to 3 mm diameter					
		C	T=-0.89°C Vx 50%					111% →
		C	T=-0.58°C Vx 10%					101% →
4	SHALE (BEDROCK)-fractured, dark grey, ice as fracture fillings	C	T=-0.90°C					
		C	Vc, Vx 15% ice fracture fillings T=-1.33°C					
5	END OF HOLE							



SFC. ELEVATION (m)	DATE DRILLED 1985-10-10
COMPLETION DEPTH (m) 5.0	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)


BOREHOLE No. 4
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL (ROAD FILL) (SW)-sandy, angular, damp, dark grey		SEASONAL FROST						
			UNFROZEN						
2	ORGANICS (PT)-peat, wet								
	ICE - occasional organic inclusions		FROZEN Ice 100% T=-0.51°C						259%
3	- snowy in texture and appearance - occasional silty inclusions	C							
		C	T=-0.51°C						112%
		C	T=-0.51°C						369%
4	SAND (TILL) (SW)-gravelly, some silt, dark grey, sub-angular to sub-rounded particles	C	ICE 40% to 60%						288%
		C	T=-0.51°C T=-0.52°C Vs 30% Vx 30%	1.1					253%
5	SILT (ML)-some clay, olive brown to dark grey	C	T=-0.52°C						233%
		C	Vx, Vs 50% T=-1.69°C lenses up to 0.25 mm thick						117%
6		C	T=-1.87°C						
		C	Vs 10% to 15% T=-2.9°C						
7	SHALE (BEDROCK) AT 7.5 m	C	Vs, Vr 20% T=-2.02°C						68%
END OF HOLE									

	SFC. ELEVATION (m)	DATE DRILLED 1985-10-11	BOREHOLE No. 5
	COMPLETION DEPTH (m) 7.7	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 8.5 (NWT)	PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL (ROAD FILL) (SW)-sandy angular, damp, dark grey		SEASONAL FROST					
			UNFROZEN					
2								
3	- no organics noted		FROZEN Vx trace, crystals to 6 mm diameter					
3	SAND (TILL) (SW)-gravelly, some silt, sub-angular to sub-rounded particles, olive brown to dark grey							
4		C	T=-0.80°C					
5	SILT (ML)-some clay, dark grey	C	T=-1.53°C Vs 10% to 20% lenses up to 20 mm thick at 20 mm spacing					98%
6	- uniform in appearance	C	T=-2.02°C					92%
7	SHALE (BEDROCK) AT 7.2 m							
	END OF HOLE							



SFC. ELEVATION (m)	DATE DRILLED 1985-10-11
COMPLETION DEPTH (m) 7.2	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No. 6
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL (ROAD FILL) (SW)-sandy, angular, damp, dark grey		SEASONAL FROST						
			UNFROZEN						
2	ORGANICS (PT/OL)-topsoil/peat, organic silt below 1.7 m, orange-brown - auger grinding on gravel (till?)	C	FROZEN						
			Vx, Vr 50% to 60% T=-0.83°C						118% →
3		C	T=-1.02°C Nbn						116% →
3	END OF HOLE (CRREL barrel and auger refusal on gravel/cobbles)								
4									
5									
6									
7									



SFC. ELEVATION (m)	DATE DRILLED 1985-10-11
COMPLETION DEPTH (m) 2.9	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No.
7
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL (ROAD FILL) (SW)-sandy, angular, damp, dark grey		SEASONAL FROST						
			UNFROZEN						
2	ORGANICS (PT/OL)-peat at 1.5 m, then organic silt with peaty fibres		FROZEN						
		G	Vx 50%						105%
3	SILT (TILL) (SW)-sandy, some gravel, sub-angular to sub-rounded particles, olive brown								
		G							
4									
5	SILT (ML)-some clay, dark grey								
		G	Vx 30%						75%
6	END OF HOLE								
7									



SFC. ELEVATION (m)	DATE DRILLED 1985-10-11
COMPLETION DEPTH (m) 5.4	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No.
8
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL (ROAD FILL) (SW)-sandy, angular fragments, damp, dark grey		SEASONAL FROST						
			UNFROZEN						
	ORGANICS (PT)-peat								
2	SAND (TILL) (SW)-gravelly, some silt, sub-angular to sub-rounded particles, olive brown	C	FROZEN Vx 40%, crystals to 50 mm diameter T=-0.78°C Vx 30% to 40%						
3		C	T=-1.04°C Vx 20%						
	- decreasing ground ice content								
4	SHALE (BEDROCK)	C	T=-1.68°C Vx 10%, in fractures						
5	END OF HOLE								
6									
7									



SFC. ELEVATION (m)	DATE DRILLED 1985-10-12
COMPLETION DEPTH (m) 4.5	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No. 9
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL (ROAD FILL) (SW)-sandy, angular fragments in a clayey matrix, olive brown, occasional trace of organics - trench backfill (original investigative trench)		SEASONAL FROST					
2			UNFROZEN					
3								
4								
5	END OF HOLE							
6	NOTE: No samples taken							
7								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-12
COMPLETION DEPTH (m) 4.3	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No.
10
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL (ROAD FILL) (SW)-sandy, angular fragments in clayey matrix, damp, olive brown		SEASONAL FROST						
			UNFROZEN						
	ORGANICS (PT/OL)-peat, orange-brown, silt		FROZEN						
2	SAND (TILL) (SW)-gravelly, some silt, sub-angular to sub-rounded particles, olive brown		Vx 50%						
3	- gravel sizes to 75 mm diameter		Vx 10%						
4		C	T=-1.30°C			●			
5	- shaly gravel fragments		ice crystals to 10 mm diameter						
6	SILT (ML)-some clay, olive brown		Vs 20%						
7	END OF HOLE								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-12
COMPLETION DEPTH (m) 6.4	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No. 11
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL (ROAD FILL) (SW)-sandy, angular fragment in clayey matrix, damp, olive brown		SEASONAL FROST					
	ORGANICS (PT)-peat, organic silt, some grass tufts							
	SAND (TILL) (SW)-gravelly, some silt, sub-angular to sub-rounded particles, olive brown							
2	- gravel to 75 mm diameter on augers		FROZEN Vx, Vs 40% some lenses to 300 mm thick					
3	- augers grinding on cobbles							
4	- dark grey colour	G						
5	SILT (ML)-some clay, dark grey to olive brown colour	C	T=-1.00°C Vs 10% to 15%					
6			Vs 50%					
7	SHALE (BEDROCK)	G	Vx 10% crystals to 5 mm diameter					
	END OF HOLE (Auger refusal)							



SFC. ELEVATION (m)	DATE DRILLED 1985-10-12
COMPLETION DEPTH (m) 7.1	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No.
12
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL (ROAD FILL) (SW)-sandy, till-like in appearance - sub-angular pieces up to 75 mm diameter - traces of organics - trench backfill from original investigative trench		SEASONAL FROST					
2			UNFROZEN					
3								
4	GRAVEL (ROAD FILL) (SW)-sandy, till-like in appearance - numerous shaley fragments on augers - wet below 3.0 m - sampling very difficult, as soil washed off augers	G						
5								
6								
7	SILT (ML)-some clay, olive brown	G	POSSIBLY FROZEN					
7	END OF HOLE							



SFC. ELEVATION (m)	DATE DRILLED 1985-10-12
COMPLETION DEPTH (m) 7.0	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)


BOREHOLE No. 13
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

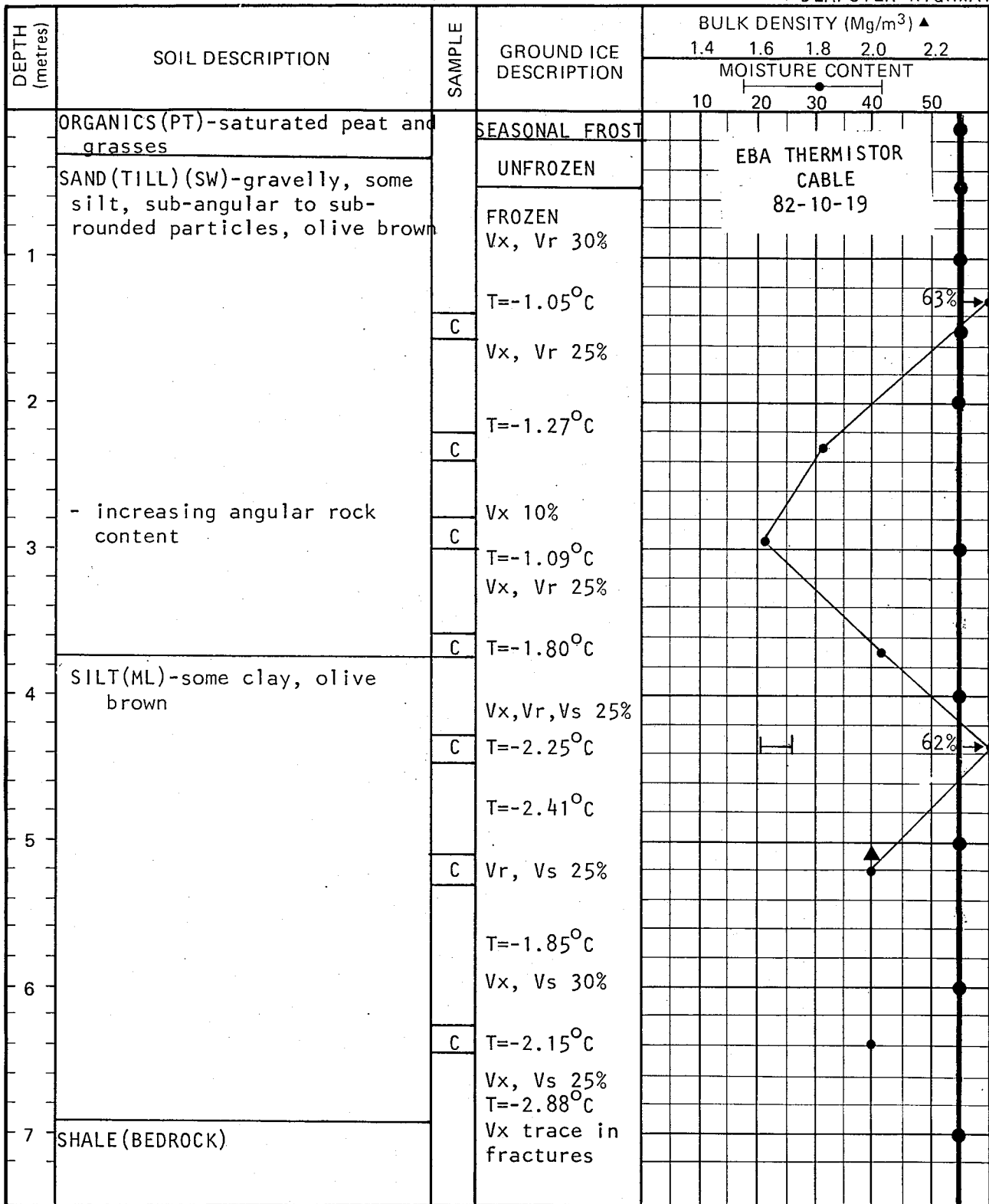
DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL (ROAD FILL) (SW)-sandy, angular to sub-angular, fragments, dark grey		SEASONAL FROST						
	UNFROZEN								
2	ORGANICS (PT)-peat and silt								
	SAND (TILL) (SW)-gravelly, some silt, angular to sub-angular fragments, damp, dark grey		G						
3			FROZEN						
			G	V _x , V _r 5% to 10% T=-0.61°C					
4									
			C	T=-0.87°C					
5	- core barrel grinding on rocks								
	SILT (ML)-some clay, olive brown		C	V _x , V _s 5% to 10% T=-0.73°C					
6									
			C	V _x , V _s 10% T=-2.14°C					
7									
	END OF HOLE		C	V _x , V _s 15%					

	SFC. ELEVATION (m)	DATE DRILLED 1985-10-12	BOREHOLE No. 14 PAGE 1 OF 1
	COMPLETION DEPTH (m) 6.2	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 8.5 (NWT)	

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY



	SFC. ELEVATION (m)	DATE DRILLED 1985-10-12	BOREHOLE No. 15
	COMPLETION DEPTH (m) 8.9	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 8.5 (NWT)	PAGE 1 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
8	SHALE (BEDROCK)		FROZEN Vx trace in fractures					
9	END OF HOLE (Auger refusal)							
10	NOTE: EBA Thermistor cable 82-10-19 installed in this borehole.							
11								
12								
13								
14								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-12
COMPLETION DEPTH (m) 8.9	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION Km 8.5 (NWT)

BOREHOLE No.
15
PAGE2 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	ORGANICS (PT)-peat, grasses		FROZEN					
	ICE - snowy white, trace of organic inclusions		ICE 100%					
2								
3	GRAVEL (TILL) (SW)-sandy							
4	END OF HOLE							
	NOTE: Probe hole only, no samples							
5								
6								
7								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-13
COMPLETION DEPTH (m) 3.1	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No.
16
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
	ORGANICS (PT)-grass and peat		FROZEN						
1	SAND (TILL) (SW)-gravelly, some silt, sub-angular to sub-rounded particles, olive brown								
2									
3		G				•			
4	END OF HOLE								
5									
6									
7									



SFC. ELEVATION (m)	DATE DRILLED 1985-10-13
COMPLETION DEPTH (m) 3.0	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No.
17
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL (ROAD FILL) (SW)-sandy, angular fragments in a clayey matrix, dark grey		SEASONAL FROST					
			UNFROZEN					
2	ORGANICS (PT)-peat CE - organic inclusions (10%) from 1.6 to 2.0 m		FROZEN ICE 100%					
3	- water in hole below 2.5 m depth							
4								
5	SILT (ML)-some clay, olive brown		Vs 50%					
	SHALE (BEDROCK)							
6	END OF HOLE NOTE: Probe hole only, no samples							
7								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-13
COMPLETION DEPTH (m) 5.6	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 8.5 (NWT)

BOREHOLE No. 18
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.



PLATE 1

General view of km 8.5 site (upper
centre of photo - see drill rig
mast), taken from Y.T. direction.



PLATE 2

Typical ice lenses (V_r , V_s 20%) in
Borehole at km 8.5 site (silt stratum).

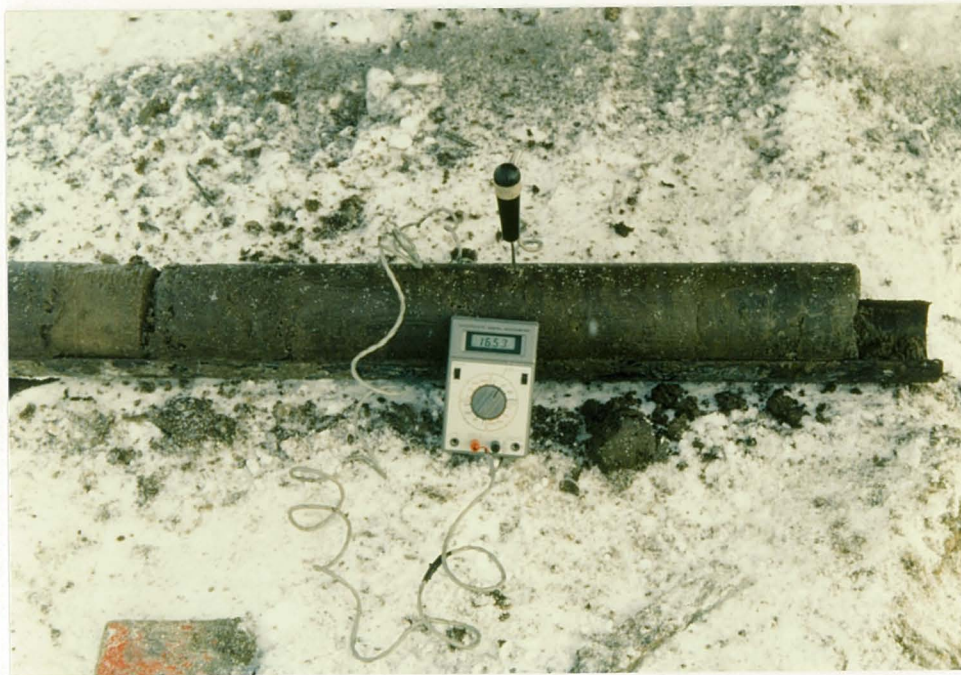


PLATE 3

Typical sample of permafrost core taken
using CRREL barrel at km 8.5 site (tem-
perature probe and resistance in kilo-ohms
shown).

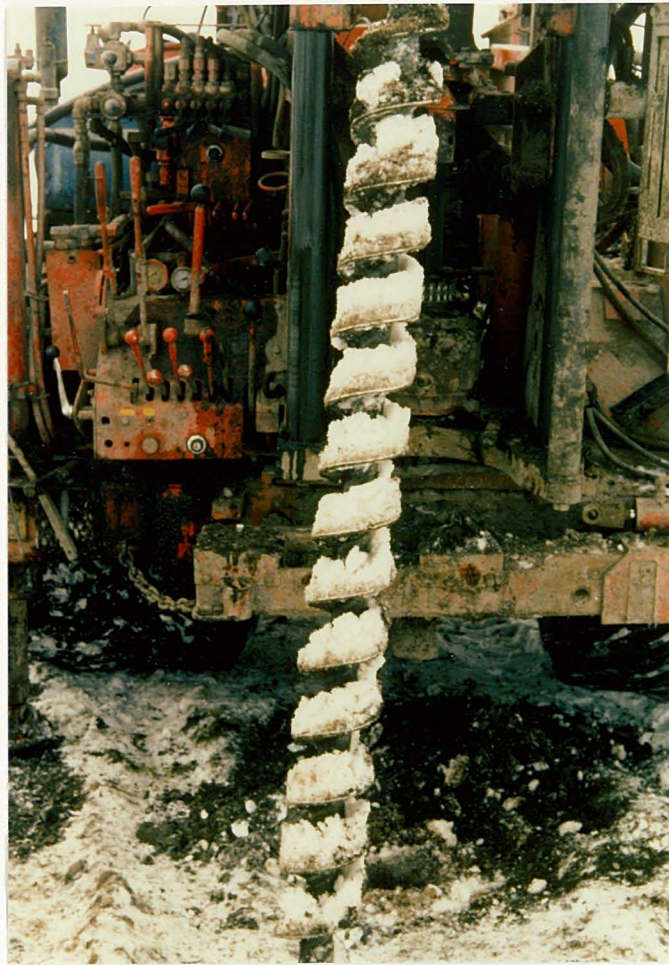


PLATE 4

Massive ice on auger
in Borehole No. 18.

PLATE 5

Massive ice on auger
in Borehole No. 18.





PLATE 6

View of ice wedge in centreline trench, km 8.5 site. Top of wedge is approximately 2.0 m wide, and starts immediately below organic layer at 1.6 m depth. Base of trench is 3.0 m deep, and ice had thinned to approximately 1.2 m in width.



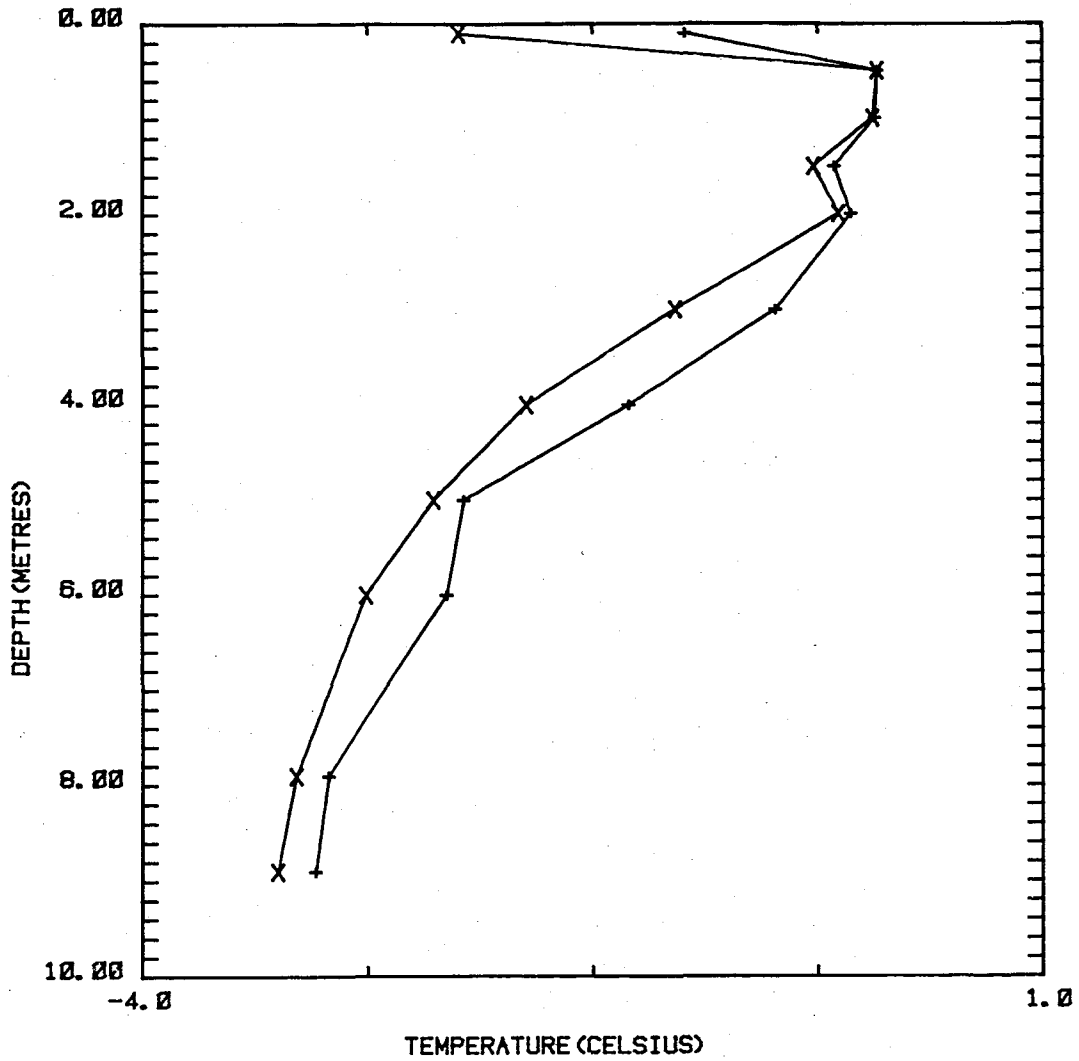
PLATE 7

Outline of Borehole
No. 5 in ice wedge, at
side of trench.

PLATE 8


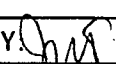
Water seeping down sides of
trench, from base of the
active layer (bottom of
organics).





THERMISTOR NUMBER 82-10-19
 DATE INSTALLED 85-10-14

+ 85-10-14
 x 85-10-21

EBA Engineering Consultants Ltd. 	
JOB NO. 0201-4426	DATE: 1985-12-16
DRAWN BY:	DRAWING NO.:
REVIEWED BY: 	4426-A2

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (Km 8.5)
Northwest Territories

Project Number: 0201-4426

Date Tested: 1985-11-07

Borehole Number: 1

Depth: 0.5 m

Soil Description: Gravel & Sand- some silt, trace of clay

Cu: _____

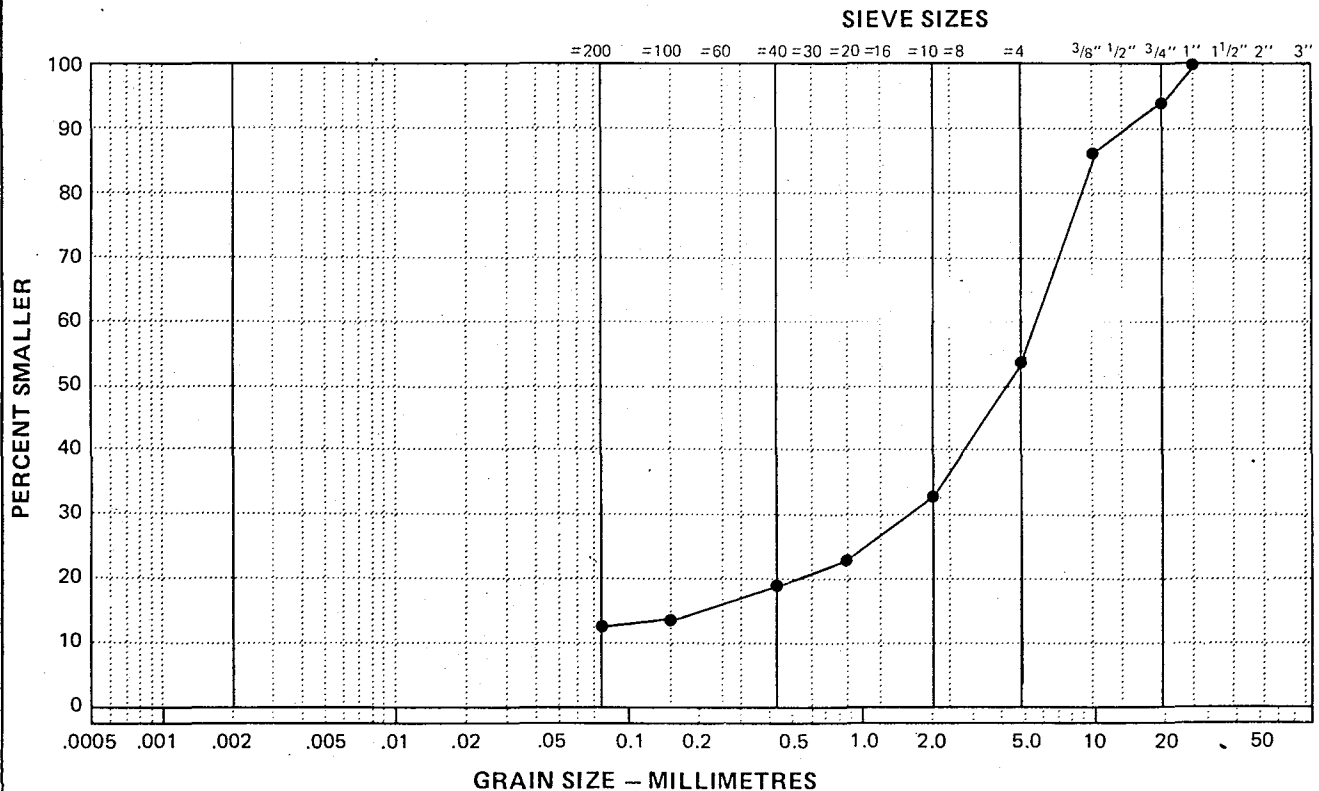
Cc: _____

Natural Moisture Content: 9.8 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	100
3/4"	94
1/2"	86
3/8"	78
No. 4	54
No. 10	33
No. 20	23
No. 40	19
No. 60	16
No. 100	14
No. 200	13

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 8.5)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-13

Borehole Number: BH 2

Depth: 5.2 m

Soil Description: SILT - some clay, trace of sand

Cu: _____

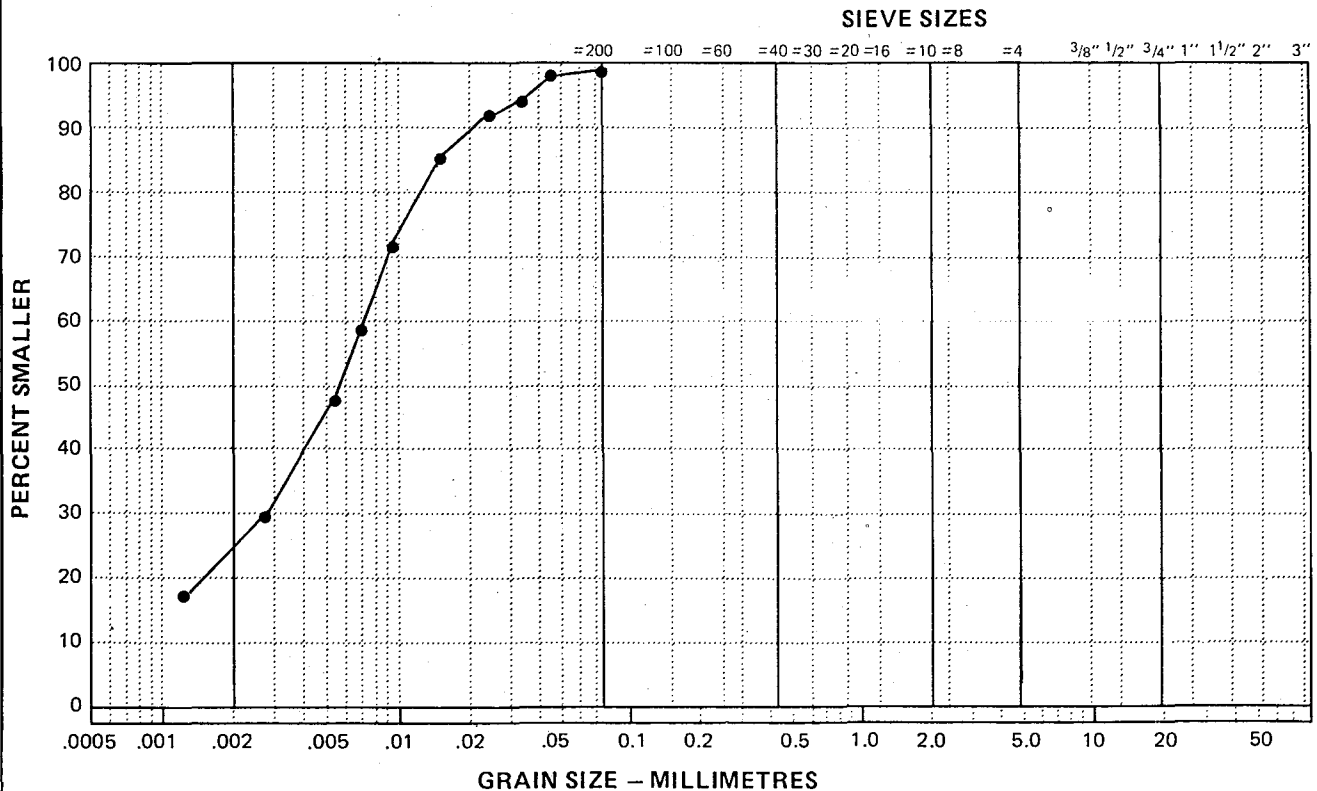
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	
No. 20	
No. 40	
No. 60	
No. 100	
No. 200	99.6

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (Km 8.5)
Northwest Territories

Project Number: 0201-4426

Date Tested: 1985-11-07

Borehole Number: 3

Depth: 2.0 m

Soil Description: Sand - Gravelly, some silt & clay

Cu: _____

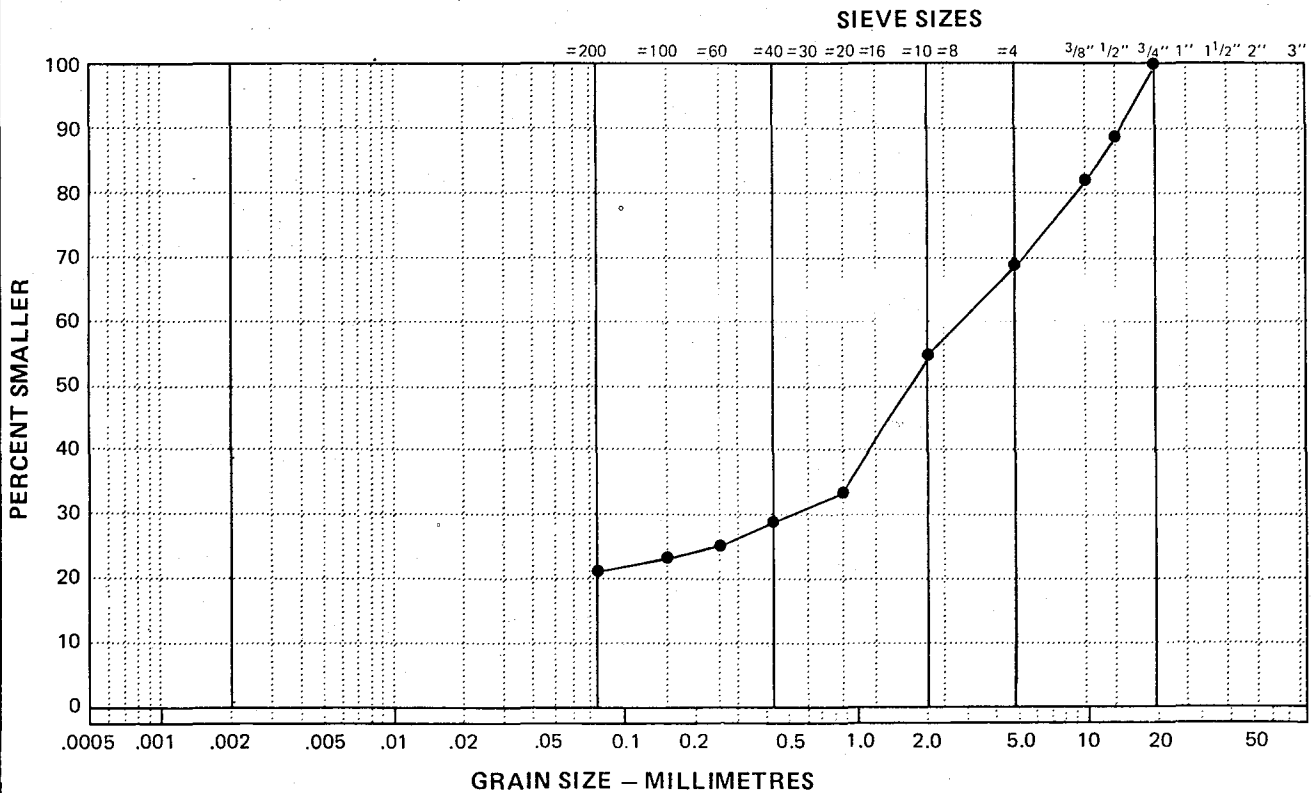
Cc: _____

Natural Moisture Content: 14.3 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	100
1/2"	89
3/8"	82
No. 4	69
No. 10	55
No. 20	33
No. 40	29
No. 60	25
No. 100	23
No. 200	21

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (Km 8.5)
Northwest Territories

Project Number: 0201-4426

Date Tested: 1985-11-07

Borehole Number: 4

Depth: 3.0 m

Soil Description: SAND & GRAVEL - traces of silt & clay

Cu: _____

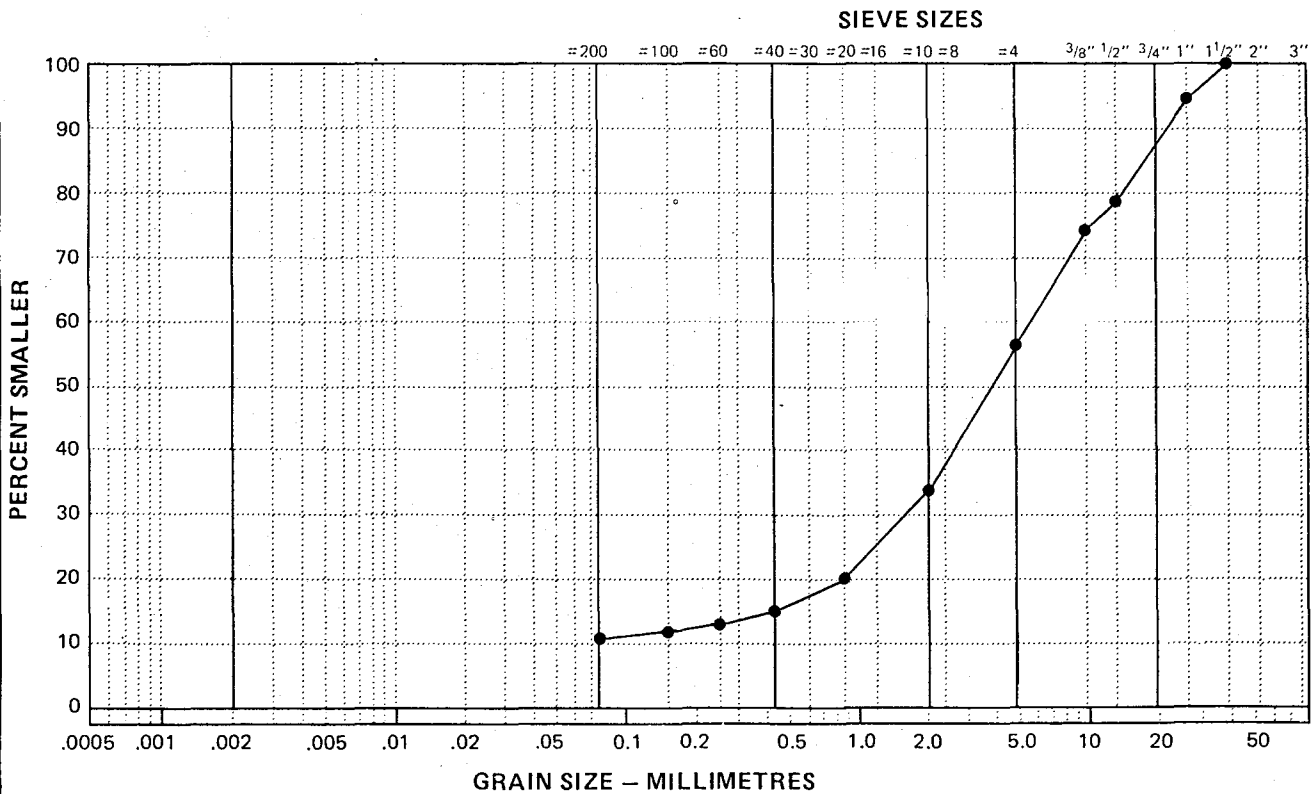
Cc: _____

Natural Moisture Content: 14.3 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	100
1"	95
3/4"	
1/2"	79
3/8"	74
No. 4	56
No. 10	34
No. 20	20
No. 40	15
No. 60	13
No. 100	12
No. 200	11

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 8.5)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-13

Borehole Number: BH 5

Depth: 4.3 - 4.4 m

Soil Description: SILT - some clay, trace of sand

Cu: _____

Cc: _____

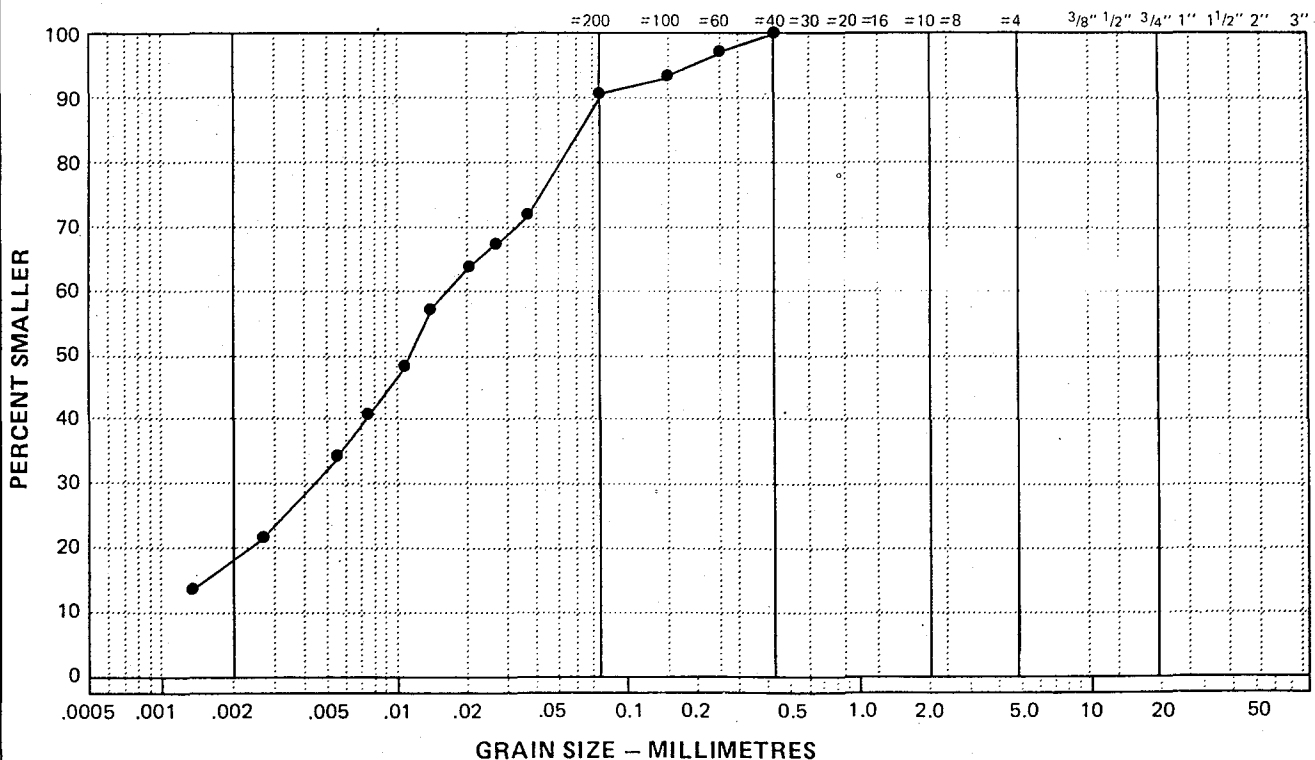
Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100.00
No. 20	
No. 40	
No. 60	97
No. 100	94
No. 200	91

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

SIEVE SIZES



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (Km 8.5)
Northwest Territories

Project Number: 0201-4426

Date Tested: 1985-11-07

Borehole Number: 8

Depth: 3.5 m

Soil Description: SILT - Sandy, some gravel and clay

Cu: _____

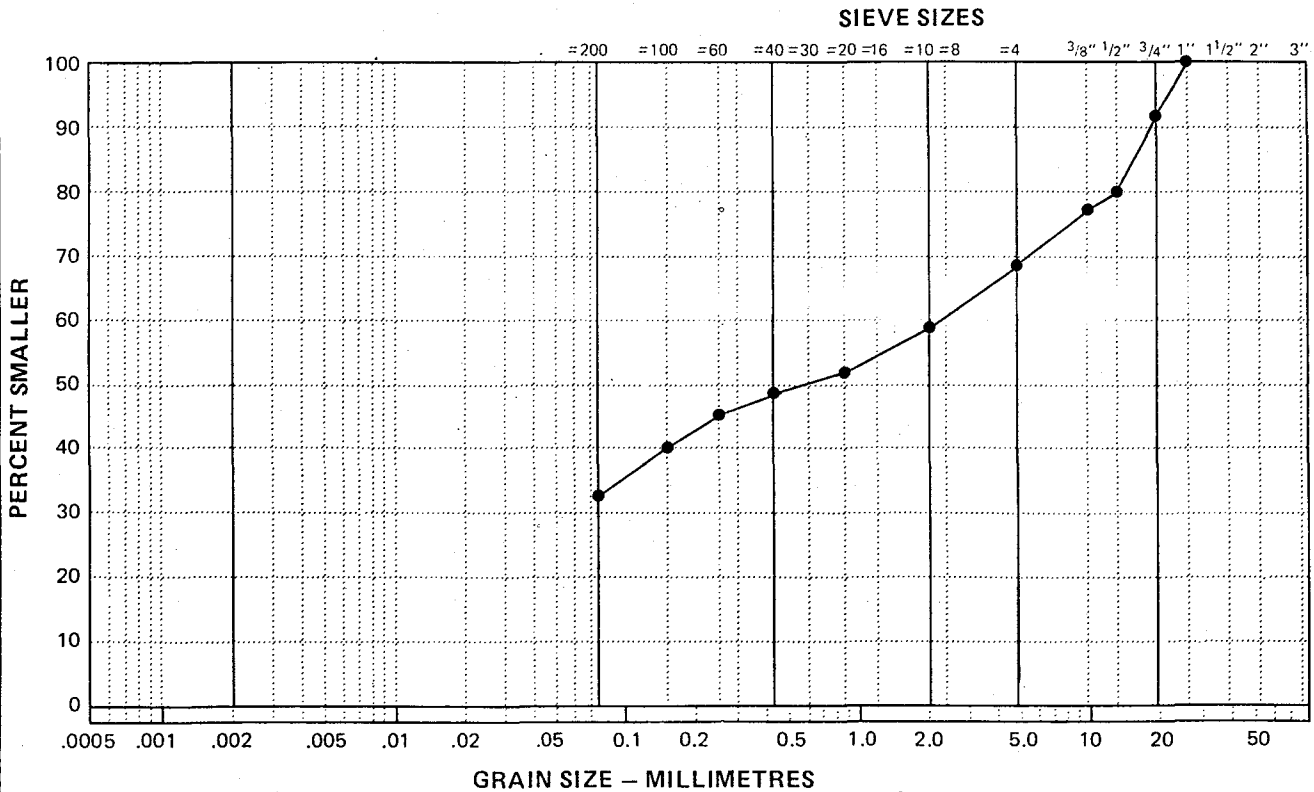
Cc: _____

Natural Moisture Content: 35.7 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	100
3/4"	92
1/2"	90
3/8"	88
No. 4	79
No. 10	69
No. 20	62
No. 40	59
No. 60	55
No. 100	50
No. 200	43

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (Km 8.5)
Northwest Territories

Project Number: 0201-4426

Date Tested: 1985-11-07

Borehole Number: 12

Depth: 4.0 m

Soil Description: SAND - Some gravel and silt, trace of clay

Cu: _____

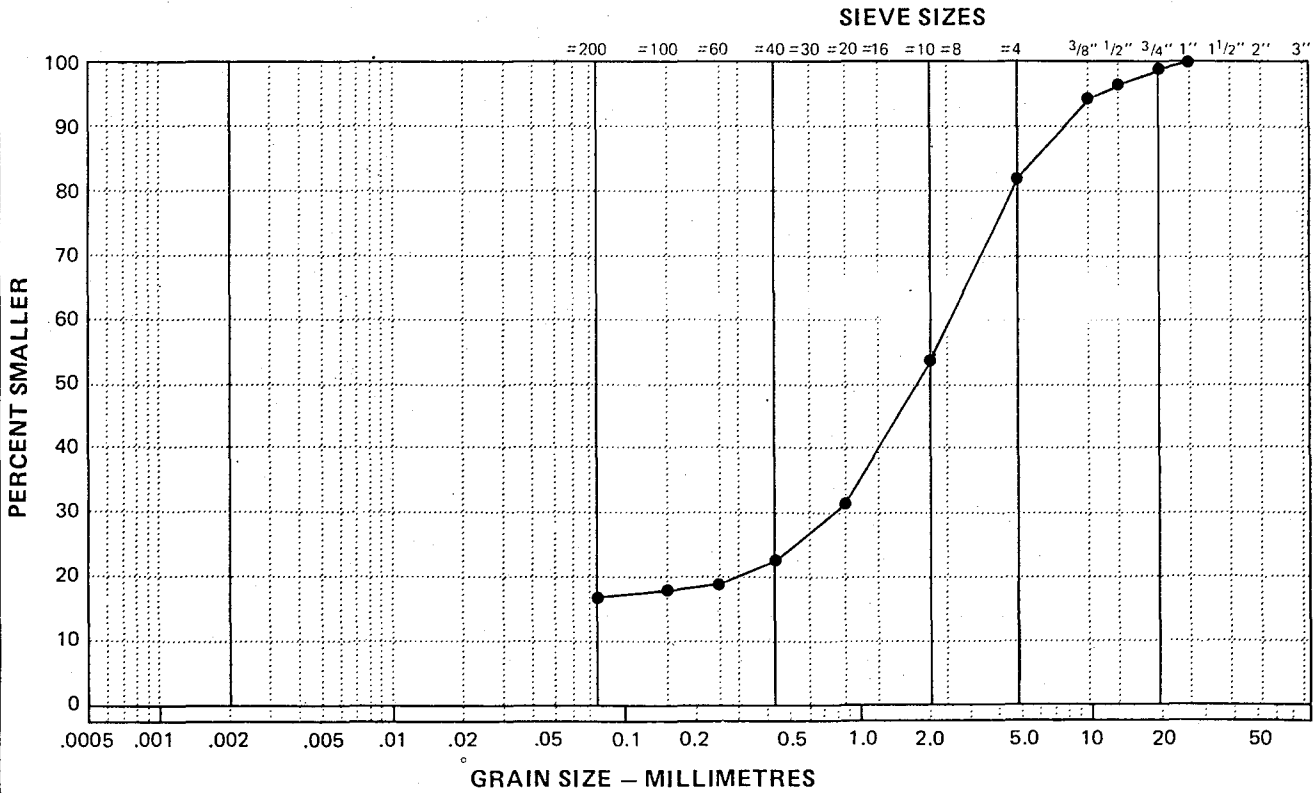
Cc: _____

Natural Moisture Content: 17.8 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	100
3/4"	99
1/2"	96
3/8"	94
No. 4	82
No. 10	54
No. 20	31
No. 40	23
No. 60	19
No. 100	18
No. 200	16

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (Km 8.5)
Northwest Territories

Project Number: 0201-4426

Date Tested: 1985-11-07

Borehole Number: 13

Depth: 3.0 m

Soil Description: GRAVEL - Sandy, some silt and clay

Cu: _____

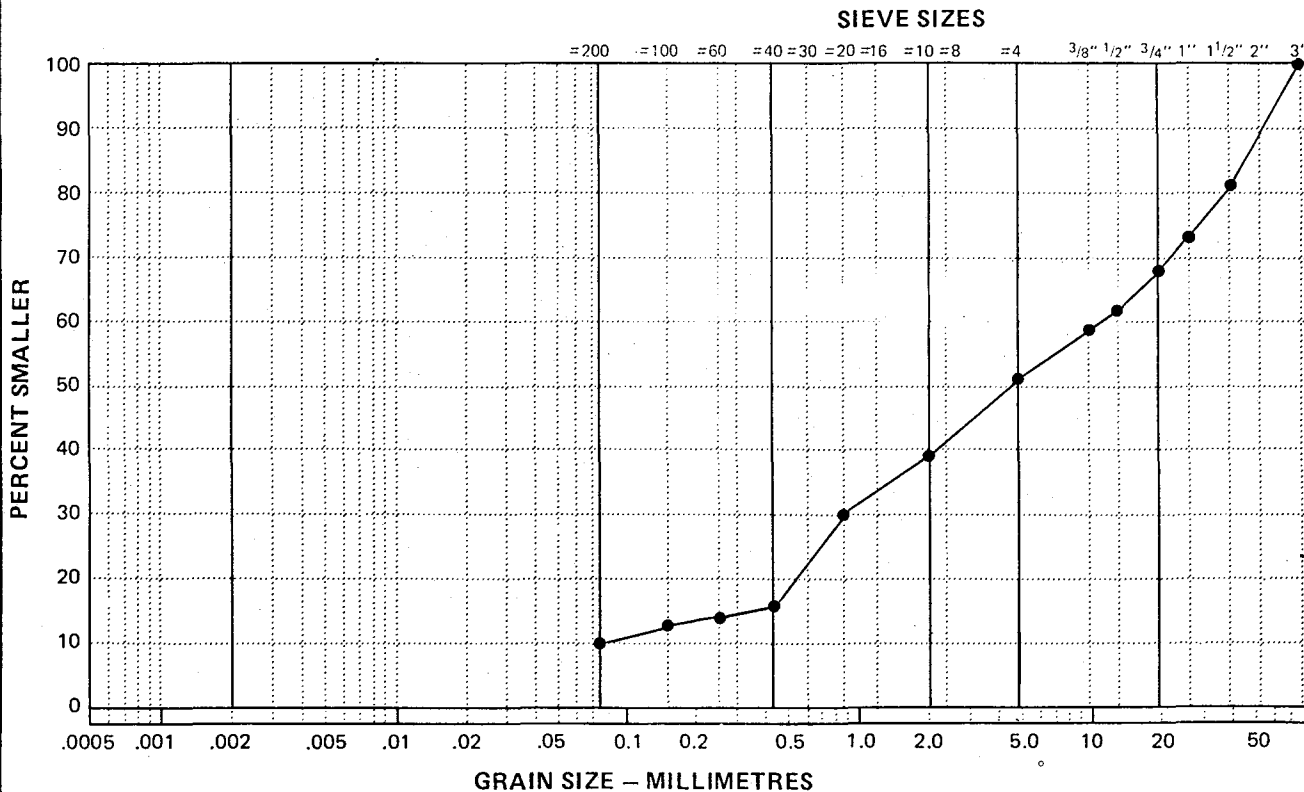
Cc: _____

Natural Moisture Content: 10.5 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	100
1 1/2"	81
1"	73
3/4"	68
1/2"	62
3/8"	59
No. 4	51
No. 10	39
No. 20	30
No. 40	26
No. 60	24
No. 100	23
No. 200	20

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (Km 8.5)
Northwest Territories

Project Number: 0201-4426

Date Tested: 1985-11-07

Borehole Number: 14

Depth: 3.5 m

Soil Description: SAND - Gravelly, some silt & clay

Cu: _____

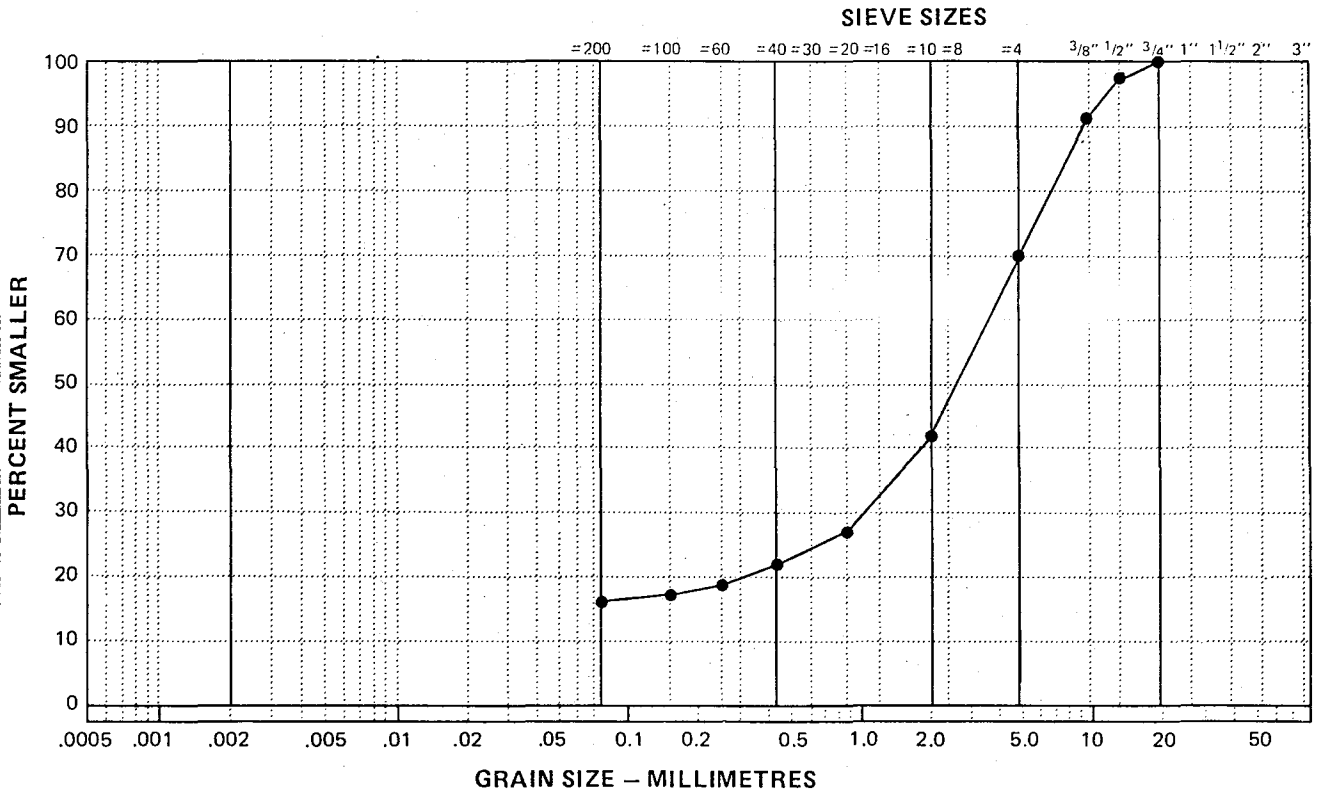
Cc: _____

Natural Moisture Content: 19.1 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	100
1/2"	97
3/8"	91
No. 4	70
No. 10	42
No. 20	27
No. 40	22
No. 60	19
No. 100	18
No. 200	16

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 8.5 N.W.T.)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-13

Borehole Number: BH 15

Depth: 4.3 - 4.4 m

Soil Description: SILT - some clay, trace of sand

Cu: _____

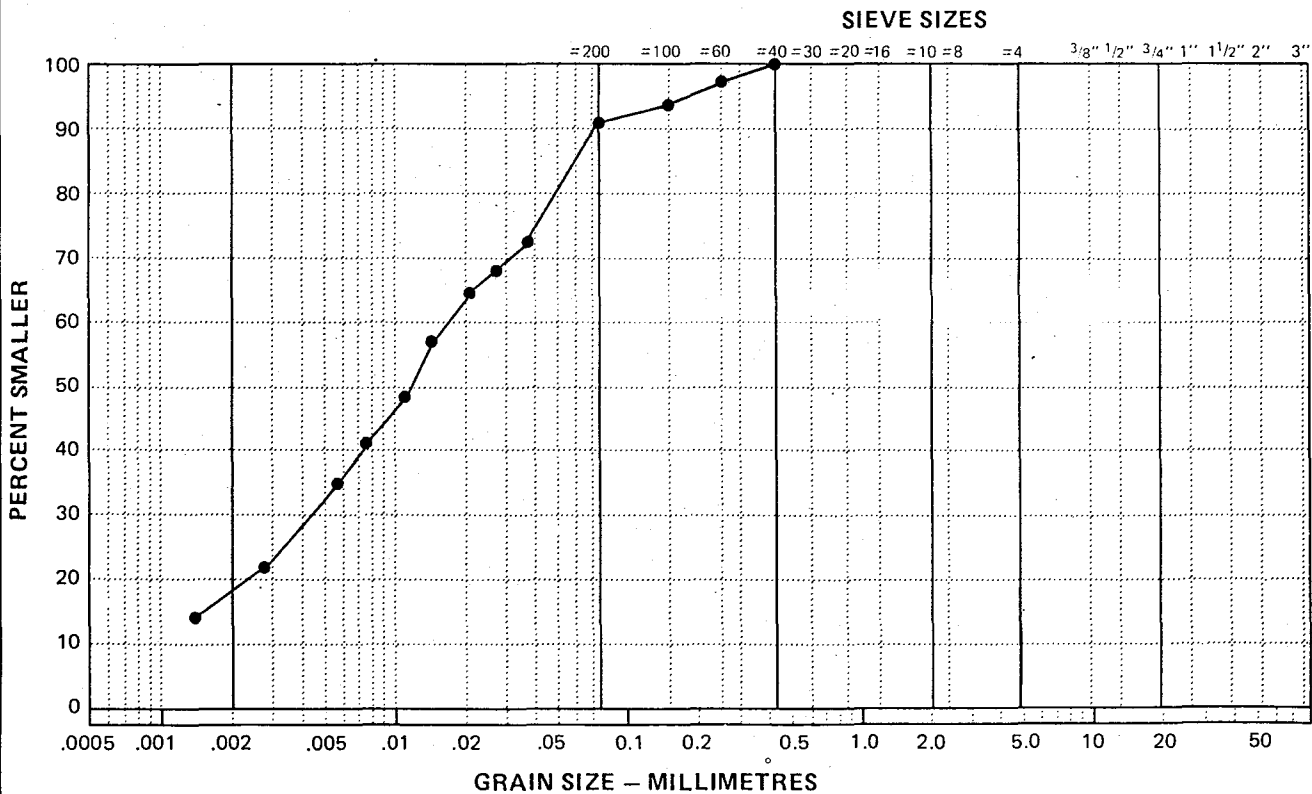
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	
No. 40	
No. 60	97
No. 100	94
No. 200	91

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

APPENDIX B

km 18.0, Dempster Highway, N.W.T.

- B-1 General
- B-2 Investigation Program
- B-3 Results and Conclusions
- B-4 Recommendations

Borehole Logs (BH 19, BH 20)

APPENDIX B

km 18.0, Dempster Highway, N.W.T.

B-1 General

A recurring pot-hole has been observed at this location (outer left hand lane only, near guard rail) for several years.

B-2 Investigation Program

Two boreholes (BH 19 and BH 20) were drilled at this site during the morning of October 14, 1985. These holes were both drilled to a depth of 5.2 m, -- no samples were taken. The borehole locations were selected by Highways maintenance staff, and were positioned according to their best recollection of where the pot-hole was located.

B-3 Results and Conclusions

The borehole logs are attached. This site is located adjacent to a steep sided ravine and borrow pit, and the roadway materials are thus almost identical to the natural soils. Data from the borehole logs indicates that there is nothing at these locations to explain the recurring pot-hole. Some visible ice was observed in the permafrost at depth, but not enough to cause an annual problem at the road surface.

B-4 Recommendations

Maintenance staff should mark the exact locations of the pot-hole, and record its characteristics (time of year noticed, size, depth, etc.). The specific site could then be investigated and/or repaired with a backhoe next summer.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL (ROAD FILL) (SW) sandy - angular shale fragments, dark grey		SEASONAL FROST					
			UNFROZEN					
2								
3								
4	SAND (TILL) (SW) gravelly, trace of silt, angular shale fragments, dark grey		FROZEN Vx trace, crystals to 1 mm dia.					
5			- crystals to 25 mm dia. from 4.0 to 5.0 m					
5	SHALE (BEDROCK) ?							
6	END OF HOLE NOTE: Probe hole only, no samples taken.							
7								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-14
COMPLETION DEPTH (m) 5.2	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 18 (NWT)

BOREHOLE No. 19
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL (ROAD FILL) (SW) sandy, angular, shale fragments, dark grey		SEASONAL FROST						
			UNFROZEN						
2									
3	SAND (TILL) (SW) gravelly, some silt, dark grey to black - wet below 3.5 m		FROZEN Nbn						
4			Vx trace below 4.0 m, crystals to 20 mm dia.						
5									
6	END OF HOLE NOTE: Probe hole only, no samples taken								
7									



SFC. ELEVATION (m)	DATE DRILLED 1985-10-14
COMPLETION DEPTH (m) 5.2	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 18 (NWT)

BOREHOLE No. 20
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

APPENDIX C

APPENDIX C

km 27.9, Dempster Highway, N.W.T.

- C-1 General
- C-2 Investigation Program
- C-3 Results and Conclusions
- C-4 Recommendations

Borehole Logs (BH 21, including moisture contents, Atterberg
Limits and ground temperatures)

Photographs (Plates 9 & 10)

Grain Size Curve

APPENDIX C

km 27.9, Dempster Highway, N.W.T.

C-1 General

A short section of highway in the vicinity of km 27.9 is being threatened by a thawing and advancing permafrost face approximately 100 m or so to the right of the highway embankment. A small active layer flowslide has shortened this distance to approximately 30 m at one location -- and one borehole was drilled between the top of this slide and the base of the highway embankment.

C-2 Investigation Program

BH 21 was drilled at the location shown on Plate 9, on October 14, 1985. The purpose of the hole was to determine whether or not the flowslide might eventually affect the highway embankment. The condition of the bedrock surface was also examined to determine its stability when thawed.

C-3 Results and Conclusions

The borehole log is enclosed, and shows approximately 3.5 m of overburden (silt till) overlying shale bedrock. The till was noted to be relatively free of visible ground ice, except near the bedrock where ice up to 10% by volume was observed. The top of the bedrock surface also contained some visible ice, primarily as fracture fillings. Plate 10 shows high ice-content permafrost in the exposed face downslope of BH 21. Rapid meltback of this face is occurring due to the high ice content--the soils in BH 21 had much less ice. Therefore, the rate of advance of the face should decrease as it nears the road.

The data indicates that there is a potential for the flowslide to extend up to the roadway embankment, anywhere along this section of the highway. It is understood that some previous drilling at the site indicates that the road is underlain by shallow bedrock, and that the overburden

'pinched out' under the road. If this is the case, then the effect on the roadway embankment will be minimized.

C-4 Recommendations

The slope in the vicinity of km 27.9 should be closely monitored, particularly in the spring. If practical, some improvements should be made to the drainage ditch on the upslope side of the highway, to minimize water seepage into the active layer on the downslope side.

Water in the active layer is the primary cause of the flowslide -- it saturates the soil, allowing it to slide on the permafrost surface.

In the event that the flowslides or the thaw front eventually reach the road embankment, a pervious downslope granular toe berm will have to be placed to protect the road. If necessary, this granular berm could be stabilized by the use of vertically installed heat pipes or 'cryo-anchors'.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMSPETER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
0	ORGANICS (PT)-topsoil, grasses		SEASONAL FROST					
0	SILT (TILL) (SM)-sandy, some gravel, sub-rounded particles, olive brown		UNFROZEN					
1			FROZEN					
1.5			Vx trace					
2		G						
3			T=-1.88°C					
3.5		C	Vx, Vs 10%					
4	SHALE (BEDROCK)-trace of ice in fractures at 3.5 m depth	C						
5	END OF HOLE							
6								
7								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-14
COMPLETION DEPTH (m) 4.5	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 27.9 (NWT)

BOREHOLE No. 21
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.



PLATE 9

Site of Borehole No. 21,
km 27.9. Flowside scar
in background.

PLATE 10

Exposed face near Borehole
No. 21, km 27.9. Ice-rich
soil underlain by small ice
wedges.



EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 27.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-20

Borehole Number: BH 21

Depth: 1.6 - 1.7 m

Soil Description: SILT & SAND - clayey

Cu: _____

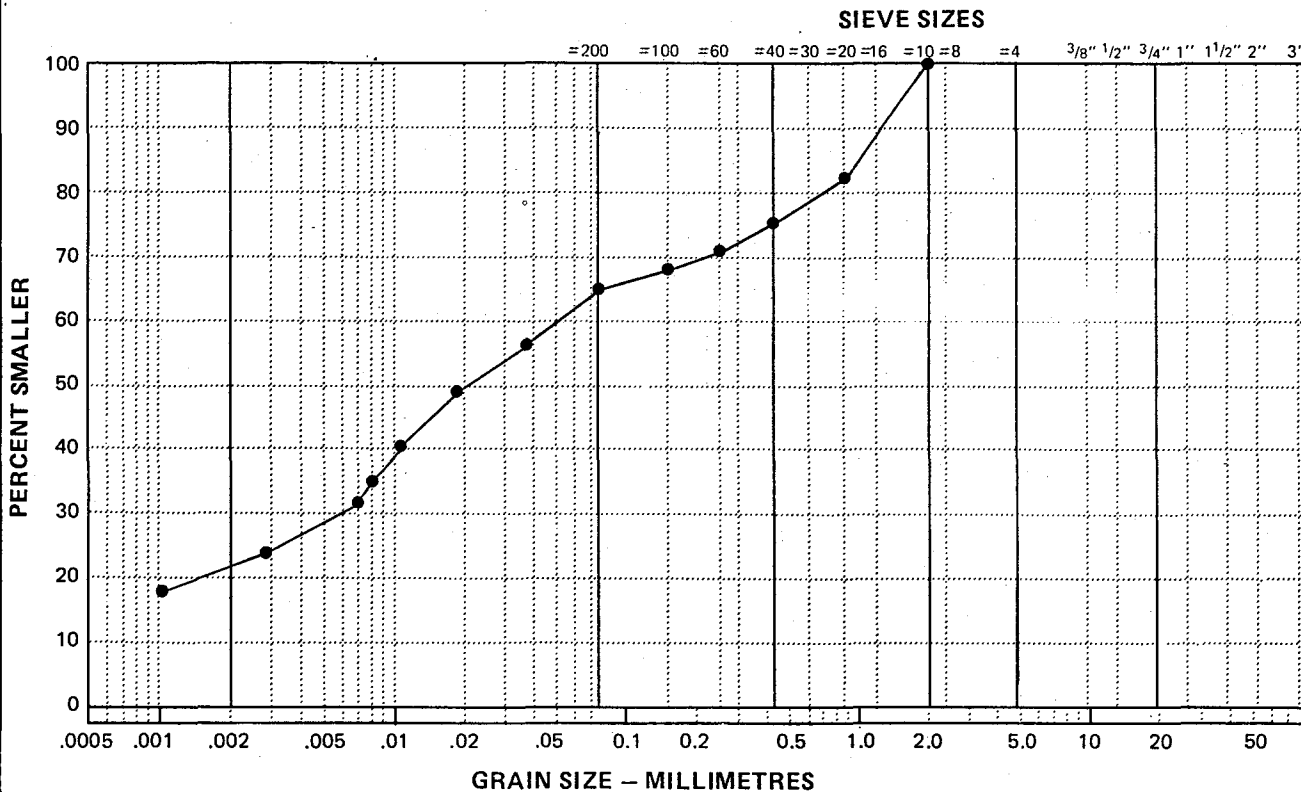
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	82
No. 40	75
No. 60	71
No. 100	68
No. 200	65

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

APPENDIX D
km 46.9, Dempster Highway, N.W.T.

- D-1 General
- D-2 Investigation Program
- D-3 Results and Conclusions
- D-4 Recommendations

Site Plan

Borehole Logs (BH 22 to BH 29, including moisture contents,
Atterberg Limits, bulk densities and ground temperatures)

Photograph (Plate 11)

Grain Size Curves

APPENDIX D

km 46.9, Dempster Highway, N.W.T.

D-1 General

The south-facing slope of the roadway embankment at this culvert site is experiencing stability problems. Longitudinal tension cracks were noted on the road shoulder, and there was evidence of previous slumping at the toe of the slope, along with some culvert damage. Plate 11 shows a section of the slope, along with evidence of culvert repairs.

D-2 Investigation Program

A total of eight holes were drilled at this site between October 15 and 16, 1985, at the locations shown on the attached Site Plan. All holes extended through the road fill and into the natural subgrade. The intent was to delineate the permafrost surface within the road fill, and determine both soil stratigraphy and ground ice contents to evaluate the mechanism causing the slope instability. Boreholes No. 27, 28 and 29 were drilled off the side of the embankment, to evaluate the natural (undisturbed) soil and permafrost conditions at the site.

D-3 Results and Conclusions

The borehole logs are enclosed, following the Site Plan. The data indicates that the permafrost surface has extended up into the roadway embankment, to within approximately 2.2 m of the road surface. The frozen road fill was noted to be relatively free of visible ice (Vx trace) at all locations. The thickness of organics beneath the embankment was observed to be quite irregular; ranging from 0.8 m in BH 22 up to 2.5 m in BH 25. In addition, this organic layer was very ice-rich (up to Vx 60%, moisture contents up to 171%) A dark grey silty till was encountered at

depth in all holes and is considered to be relatively stable base. However, some ice lenses (Vs 30%) were observed near the organics/till contact, at some locations.

The slope stability problem at km 46.9 is believed to be caused by the downslope creep of an unfrozen 'veneer' of soil sliding on the frozen roadway core. The problem is aggravated by a lack of resistance at the toe of the slope, caused by unfrozen peat sliding on the permafrost table. The fact that this is a south facing slope also adds to the problem as seasonal thawing will be greater at this slope orientation.

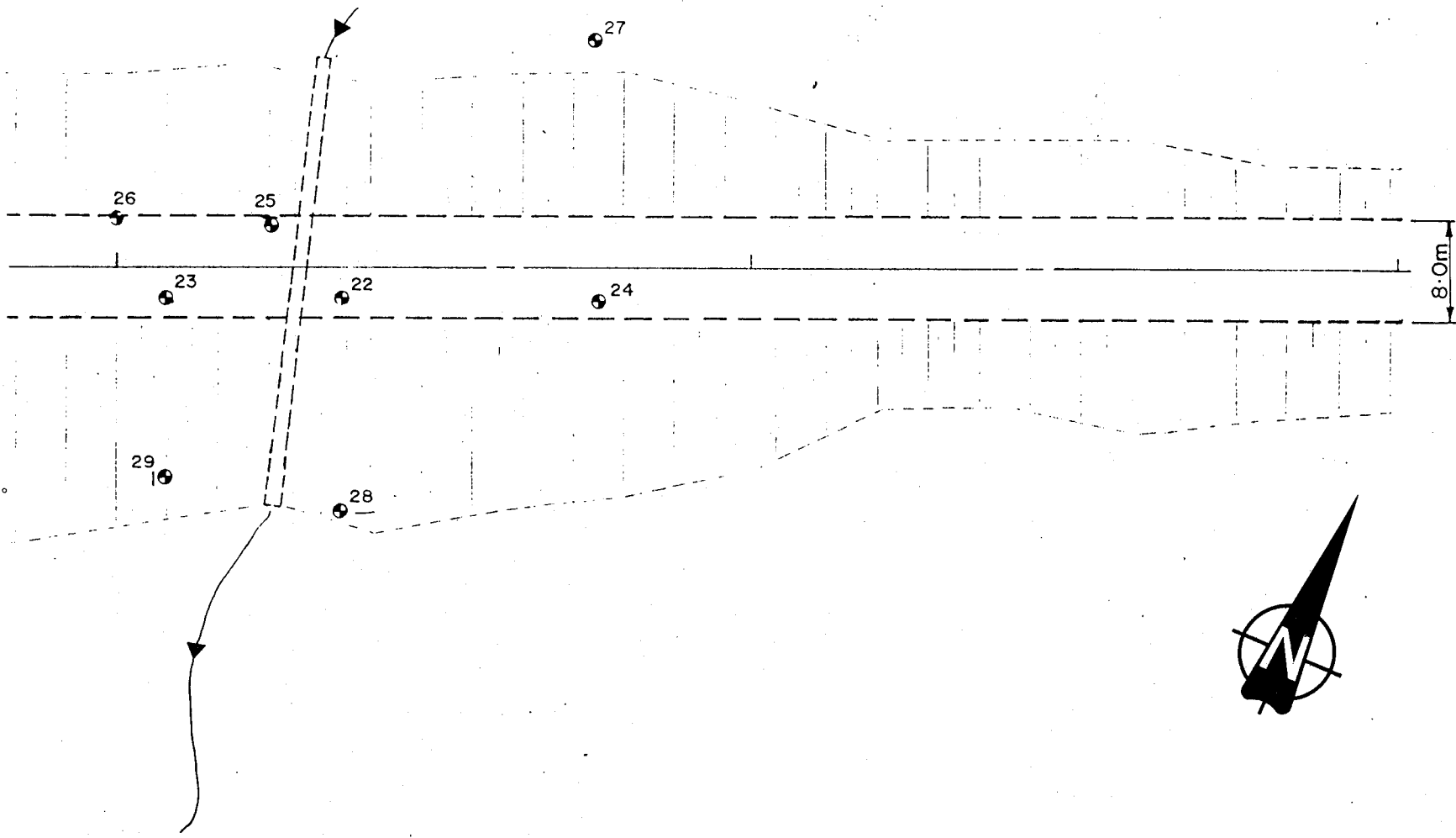
D-4 Recommendations

The stability of the slope at km 46.9 could be increased by:

- (i) repairing the end of the culvert to restore proper drainage.
- (ii) re-grading and compaction of the existing slope.
- (iii) removal of peat/organics and slumped material at the toe of the slope, as well as any high ice-content zones detected in the top of the till stratum. This cleaning should extend for a width of not less than 3.0 m from the toe.
- (iv) placement of a gravel berm at the toe of the slope, at least 2.0 m in thickness, extending across the width of the observed tension cracks (berm width estimated to be approximately 120 m).



0201-4426

This work would best be completed in the early fall, so that a complete freezing season could be available to stabilize the new fill. In the spring, some form of insulation could be placed on top of the toe berm, to maintain the frozen ground. In addition, it may be desirable to install a mechanism for freezing stabilization such as heat pipes or 'cryo-anchors', to ensure permanently frozen ground. Additional details can be provided, upon request.



SITE PLAN AND BOREHOLE LOCATIONS
 SLOPE FAILURE AT CULVERT SITE
 km 46.9, DEMPSTER HIGHWAY, N.W.T.

SCALE 1:500

EBA Engineering Consultants Ltd. 	
JOB NO. 0201-4426	DATE: 1985-12-16
DRAWN BY:	DRAWING NO.:
REVIEWED BY: 	4426-01

NOTE: Drawing provided by Nordzone Consultants Ltd.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
0	GRAVEL SURFACE SILT (ROAD FILL) (ML) - some sand, trace of angular gravel sizes		SEASONAL FROST						
1			UNFROZEN						
2									
3	- occasional angular gravel sizes noted	C	FROZEN T=-1.13°C Vx trace						
4		G	Vx trace						
5									
6	- trace of woody fragments	C	T=-1.22°C						
7	ORGANICS - peat and ice								



SFC. ELEVATION (m)	DATE DRILLED 85-10-15
COMPLETION DEPTH (m) 9.3	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 46.9 (NWT)

BOREHOLE No.
22
PAGE 1 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geographic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				MOISTURE CONTENT				
				1.4	1.6	1.8	2.0	2.2
				10	20	30	40	50
	ORGANICS - peat and ice		FROZEN T=-1.29°C					
8	SILT(TILL)-sandy, gravelly, rounded gravel up to 75 mm diameter in core barrel, olive brown to dark grey	C	Vr, Vs 30%					
9		C	T=-1.37°C					
10	END OF HOLE							
11								
12								
13								
14								



SFC. ELEVATION (m)	DATE DRILLED	1985-10-15
COMPLETION DEPTH (m) 9.3	LOGGED BY	JRT
DRILLING RIG CME 750	LOCATION	km 46.9(NWT)

BOREHOLE No.	22
PAGE 2 OF 2	

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
0	GRAVEL SURFACE SILT (ROAD FILL) (ML)-some sand, trace of angular gravel sizes		SEASONAL FROST						
1			UNFROZEN						
2	- occasional angular gravel sizes noted		FROZEN						
3		C	T=-1.57°C Vx trace						
4									
5	- trace of rootlets								
6	ORGANICS - peat, organic silt, and ice	C	T=-1.59°C Vx 50%						155%
7		C	Vx 60% T=-1.83°C	▲ ← 1.1					171%



SFC. ELEVATION (m)	DATE DRILLED 1985-10-15
COMPLETION DEPTH (m) 8.2	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 46.9 (NWT)

BOREHOLE No.
23
PAGE 1 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time and local conditions and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
	ORGANICS - peat, organic silt and ice		FROZEN Vx 50%					
8	SILT(TILL) (ML)-sandy, some gravel, dark grey	C	Vx, Vs 10%					
	END OF HOLE							
9								
10								
11								
12								
13								
14								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-15
COMPLETION DEPTH (m) 8.2	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 46.9 (NWT)

BOREHOLE No. 23
PAGE 2 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426

DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
0	GRAVEL SURFACE SILT (ROAD FILL) (ML)-sandy, trace of angular gravel, sizes		SEASONAL FROST						
1			UNFROZEN						
2									
2.5	- occasional angular gravel sizes	C	T=+1.05°C						
3			FROZEN						
3.5			Vx trace						
4									
5	- trace of rootlets								
6	ORGANICS - peat and organic silt	C	T=-1.62°C Vx 50%						131%
6.5	- possibly into till at bottom of hole?	C	Vx, Vs 15%						97%
7	END OF HOLE								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-15
COMPLETION DEPTH (m) 6.8	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 46.9 (NWT)

BOREHOLE No. 24
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL SURFACE SILT (ROAD FILL) (ML)-some sand, olive brown, occasional angular gravel sizes		SEASONAL FROST					
			UNFROZEN					
2	GRAVEL (ROAD FILL) (GW)-silty, angular gravel sizes, olive brown							
3			FROZEN NF					
			Vx trace					
4	- layer of sandy silt fill, 4.0 m to 5.0 m	G						
5	ORGANICS (PT)-interbedded organic silt and peat							
6			Vs 50% Nbn Vx trace					
7		C	Vs, Vx 50%					



SFC. ELEVATION (m)	DATE DRILLED 1985-10-15
COMPLETION DEPTH (m) 8.2	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 46.9 (NWT)


BOREHOLE No.
25
PAGE 1 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
	ORGANICS (PT)-interbedded organic silt and peat							
8	SILT (TILL) (ML)-sandy, some rounded gravel up to 75 mm diameter, dark grey	C	Vs 10% lenses up to 5 mm thick					
	END OF HOLE							
9								
10								
11								
12								
13								
14								

	SFC. ELEVATION (m)	DATE DRILLED	1985-10-15	BOREHOLE No. 25
	COMPLETION DEPTH (m) 8.2	LOGGED BY	JRT	
	DRILLING RIG CME 750	LOCATION	km 46.9 (NWT)	
				PAGE 2 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL SURFACE SILT (ROAD FILL) (ML) - some sand, dark grey colour - trace of angular gravel sizes		SEASONAL FROST UNFROZEN						
2	GRAVEL (ROAD FILL) (GW) - sandy, dark grey colour		FROZEN						
3	- rootlets and twigs		Vx trace						
4	ORGANICS - organic silt and ice, some peat pockets		Vs, Vx 50%						
5	SILT (TILL) (ML) - sandy, some gravel, dark grey		Vx 25%						
6	END OF HOLE (Augers grinding)								
7									



SFC. ELEVATION (m)	DATE DRILLED 1985-10-15
COMPLETION DEPTH (m) 7.0	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 46.9 (NWT)

BOREHOLE No. 26
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	ORGANICS - 150 mm peat at surface, underlain by organic silt		SEASONAL FROST					
			UNFROZEN					
			FROZEN					
2	SILT(TILL) (ML)-sandy, some rounded gravel (sandstone) sizes up to 75 mm diameter		Vx trace					
3	END OF HOLE (Augers grinding)							
	NOTE: Probe hole only, no samples taken							
4								
5								
6								
7								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-16
COMPLETION DEPTH (m) 2.4	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 46.9(NWT)

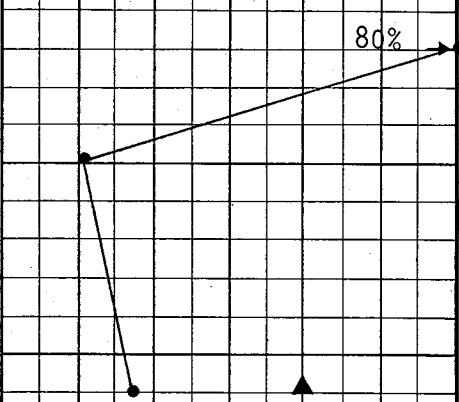
BOREHOLE No. 27
PAGE 1 OF 1


This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	SILT (FILL) (ML)-some sand, from culvert repairs		SEASONAL FROST						
	ORGANICS (PT)-peat and organic silt		UNFROZEN						
2	SILT (TILL) (ML)-sandy, some gravel, some organics to 1.8 m depth, olive brown		FROZEN Vs 30% lenses up to 20 mm thick						
				C	T=-1.02°C				
3			Vs 15%						
				C	T=-0.82°C				
4			T=-1.59°C Vs 10% lenses up to 3 mm thick						
				C					
5	END OF HOLE								
6									
7									




	SFC. ELEVATION (m)	DATE DRILLED 1985-10-16	BOREHOLE No. 28
	COMPLETION DEPTH (m) 4.0	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 46.9 (NWT)	PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	SILT(FILL) (ML)-some sand - occasional angular gravel sizes		SEASONAL FROST					
			UNFROZEN					
2								
3	ORGANICS(OL)-peat and organic silt		FROZEN Vx trace					
3	SILT(TILL) (ML)-gravelly, some sand, dark grey colour	C	T=-1.12°C					
4								
4		C	T=-1.02°C Vx trace					
5	END OF HOLE							
6								
7								

	SFC. ELEVATION (m)	DATE DRILLED 1985-10-16	BOREHOLE No. 29
	COMPLETION DEPTH (m) 4.1	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 46.9(NWT)	PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.



PLATE 11

CME 750 drill travelling between
Borehole No. 28 and Borehole No. 29,
km 46.9.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 46.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-19

Borehole Number: BH 22

Depth: 4.1 m

Soil Description: SILT - clayey, trace of sand

Cu: _____

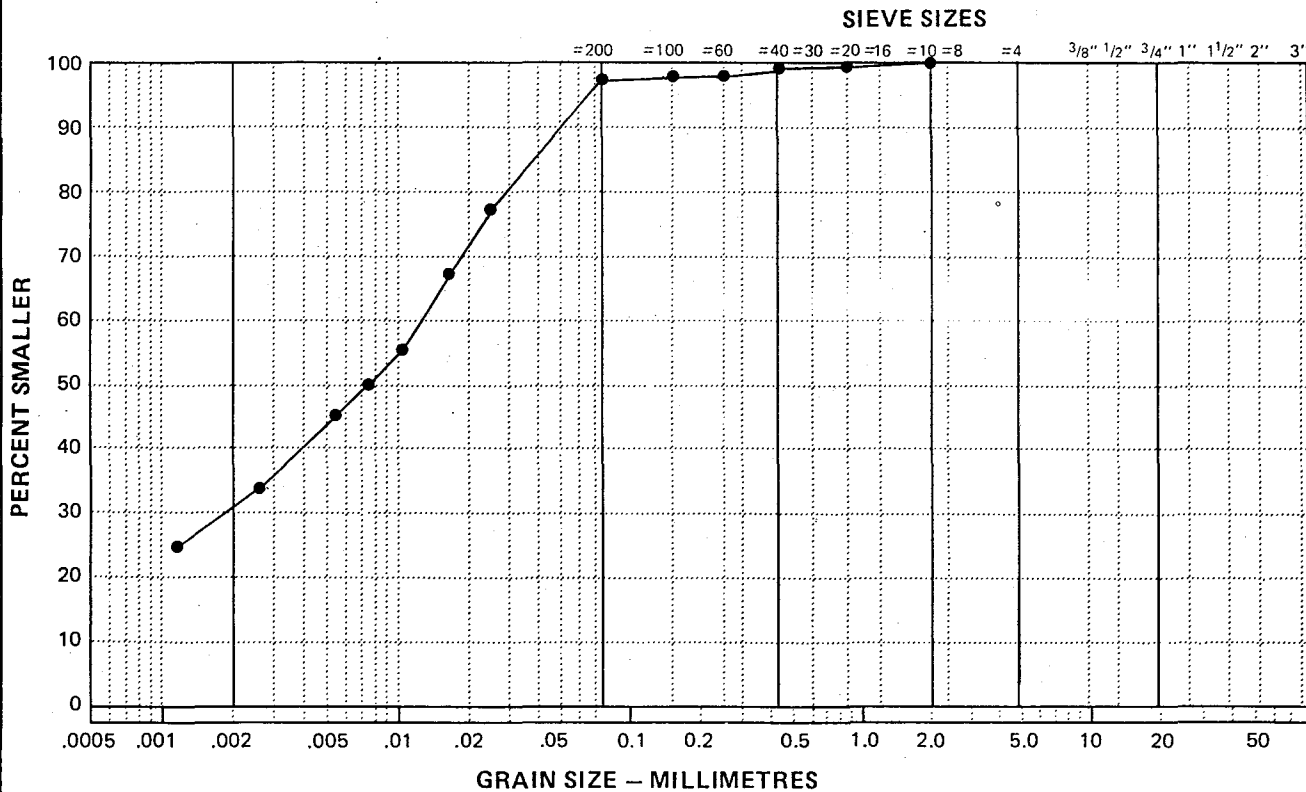
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	99
No. 40	99
No. 60	98
No. 100	98
No. 200	97

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 46.9)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-18

Borehole Number: 22

Depth: 8.8 - 9.0 m

Soil Description: SILT & SAND - gravelly, trace of clay

Cu: _____

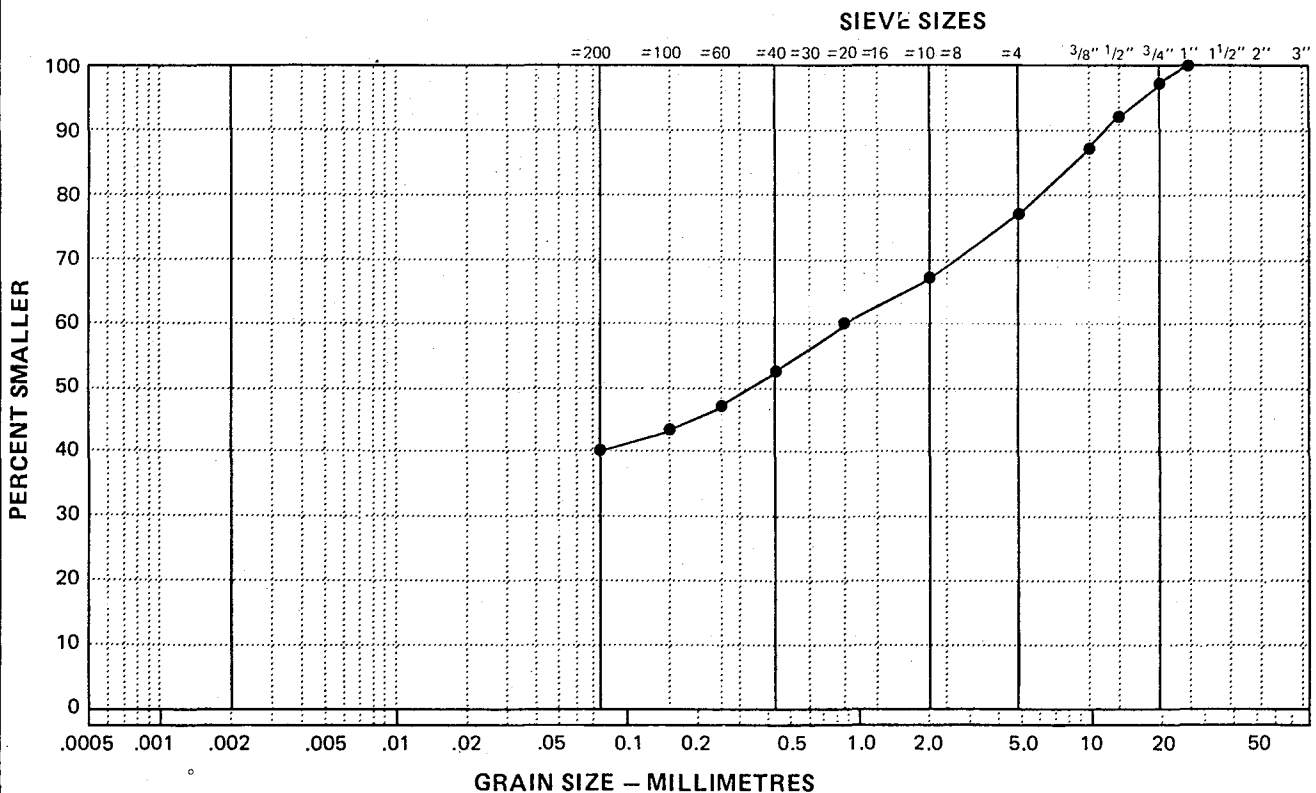
Cc: _____

Natural Moisture Content: 14.7 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	100
3/4"	97
1/2"	92
3/8"	87
No. 4	77
No. 10	67
No. 20	60
No. 40	53
No. 60	47
No. 100	43
No. 200	40

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 46.9 NWT)
Northwest Territories

Project Number: 02014426

Date Tested: 85-11-19

Borehole Number: BH 23

Depth: 5.8 - 6.0 m

Soil Description: SILT - trace of sand, trace of clay

Cu: _____

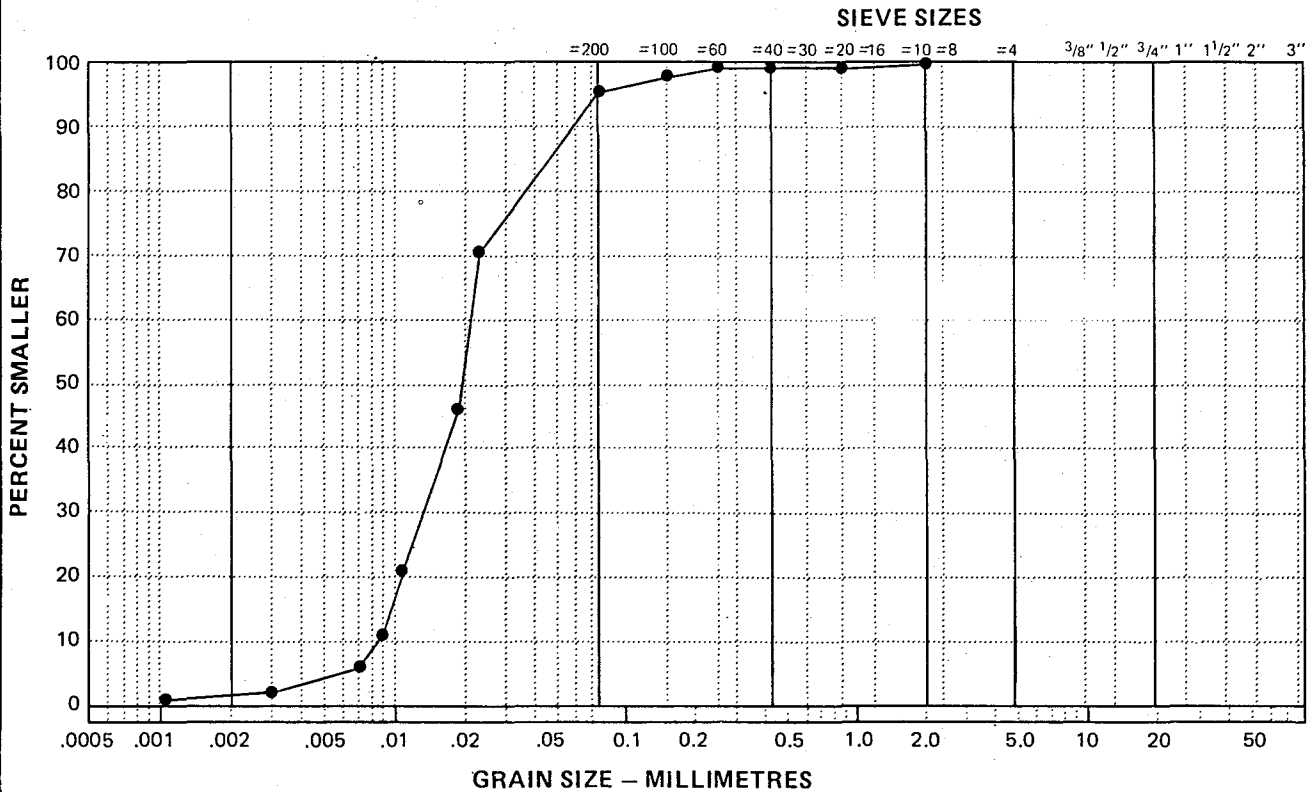
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	99
No. 40	99
No. 60	99
No. 100	98
No. 200	96

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 46.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-20

Borehole Number: BH 25

Depth: 3.5 m

Soil Description: SILT - clayey, trace of sand

Cu: _____

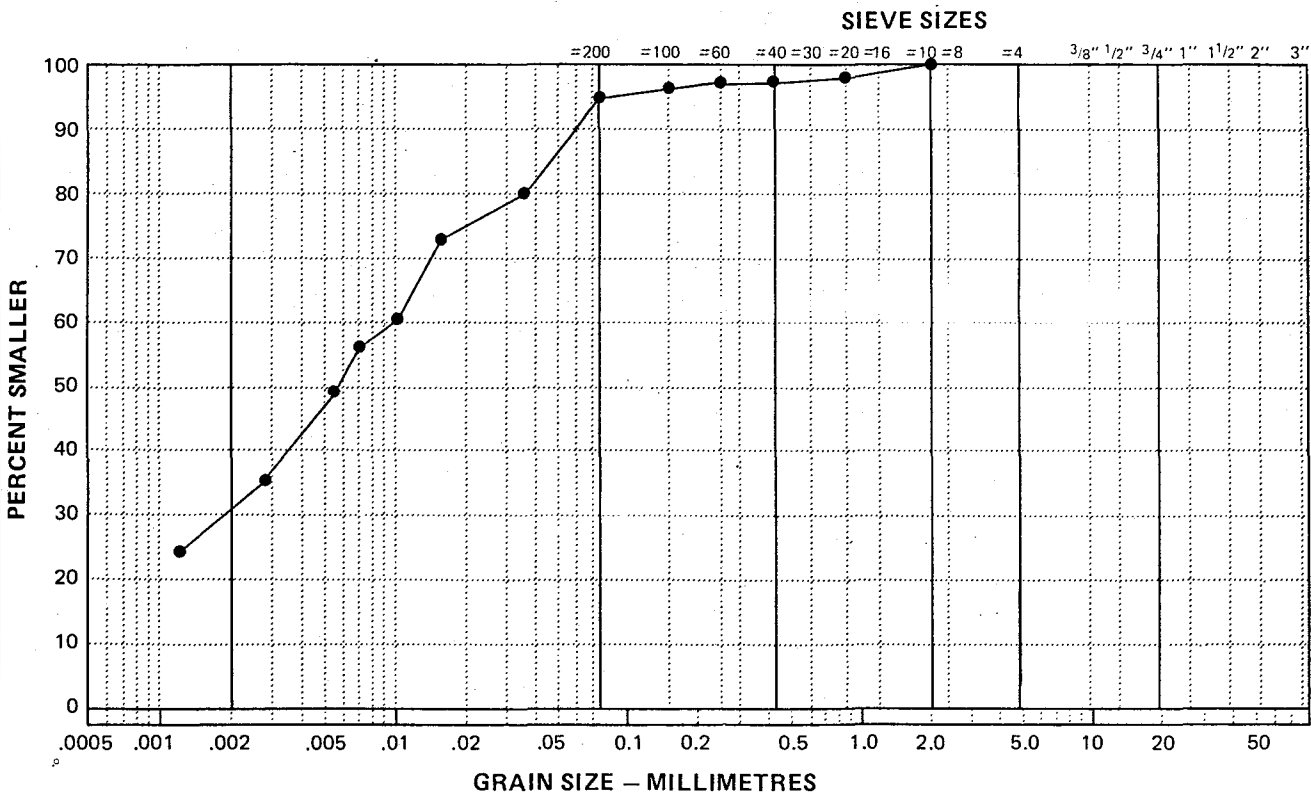
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	98
No. 40	97
No. 60	97
No. 100	96
No. 200	95

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 46.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-19

Borehole Number: BH 25

Depth: 7.8 - 8.0 m

Soil Description: SILT - some sand, trace of clay

Cu: _____

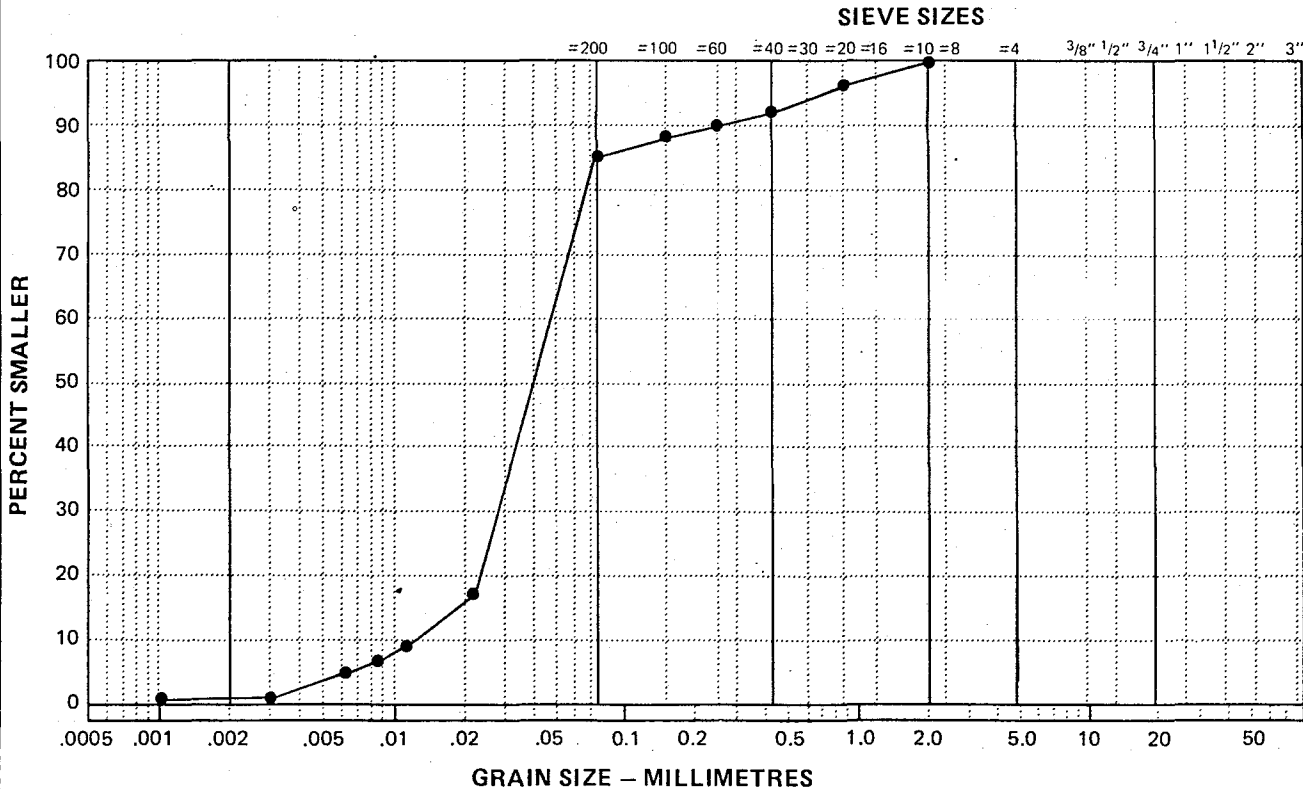
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	96
No. 40	93
No. 60	90
No. 100	88
No. 200	85

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 46.9)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-18

Borehole Number: 29

Depth: 4.0 - 4.1 m

Soil Description: SILT - gravelly, some sand & clay

Cu: _____

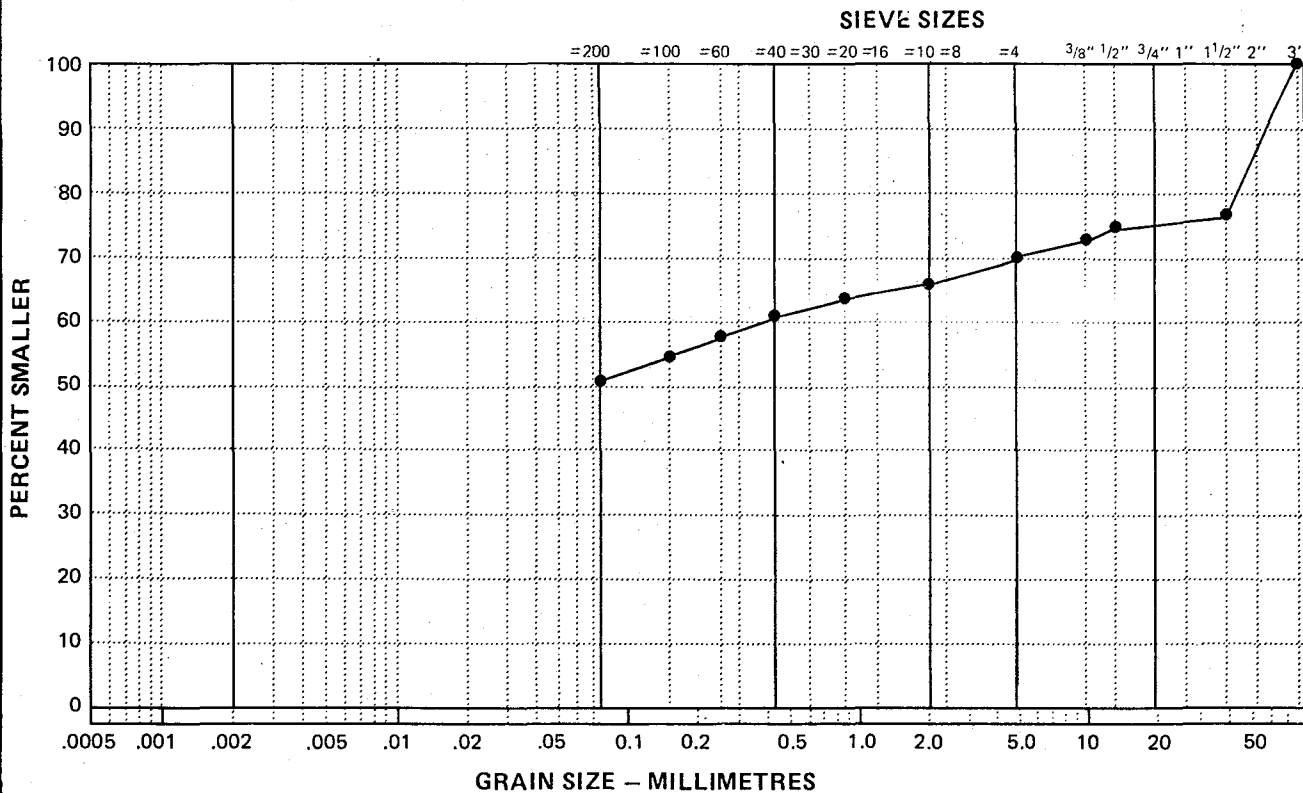
Cc: _____

Natural Moisture Content: 26.0 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	100
1 1/2"	77
1"	-
3/4"	-
1/2"	75
3/8"	73
No. 4	70
No. 10	66
No. 20	64
No. 40	61
No. 60	58
No. 100	55
No. 200	51

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

APPENDIX E

km 50.9, Dempster Highway, N.W.T.

- E-1 General
- E-2 Investigation Program
- E-3 Results and Conclusions
- E-4 Recommendations

Site Plan

Borehole Logs (BH 30 to BH 37, including moisture contents,
Atterberg Limits, bulk densities and ground temperatures)

Photographs (Plates 12, 13 and 14)

Grain Size Curves

APPENDIX E

km 50.9, Dempster Highway, N.W.T.

E-1 General

The south-facing slope of the roadway embankment at this culvert location is experiencing slope stability problems similar to those at km 46.9. The tension cracks noted here were longer and wider than those at km 46.9, and a much larger 'spoil' pile was noted at the toe of the slope. In addition, the upstream end of the culvert was not visible, and a significant volume of water (ice) was noted to be ponding on the upstream side. Plate 12 shows a general view of the south-facing roadway embankment at this location.

E-2 Investigation Program

Eight boreholes were drilled and sampled at this location on October 16 and 17, 1985. The locations are shown on the Site Plan, attached. All holes extended through the road fill and underlying organics, and were continued until low ice-content frozen glacial till was encountered. It was important that all holes extended below any ice-rich or thaw-unstable zones, so that a thorough analysis of the anticipated slope failure mechanism could be analyzed.

E-3 Results and Conclusions

The borehole logs are enclosed, following the Site Plan. Boreholes No. 30 and 31 were drilled through the gravel pad on the upslope side of the roadway, and encountered up to 1.0 m of water in the fill on top of the permafrost table. Boreholes No. 32 to 35 were drilled through the original road embankment, and detected permafrost at an average depth of 2.3 m below the road surface. This indicates that the permafrost table has extended upwards at least 2.0 m from original ground into the

0201-4426

road embankment. The two holes drilled through the 'spoil' material on the downslope (south-facing) side showed a 0.2 m thick ice lens on top of a silt (till) in BH 36, and approximately 1.5 m of ice-rich organics overlying silt (till) in BH 37. The till detected at the bottom of all boreholes is considered to be relatively thaw-stable.

The cause of the slope instability at km 50.9 is the same as that at km 46.9 -- a 'veneer' of unfrozen soil sliding on the frozen inner core of the embankment. A contributing factor is the lack of toe resistance due to the active layer sliding on ice-rich permafrost. In BH 36, an ice lens was detected directly below the spoil pile at this location. Plate 13 shows lensing in an ice-rich section of core near the top of the till stratum, and Plate 14 shows the typical high ice content in the organics/organic silt stratum, immediately below the roadway embankment.

E-4 Recommendations

The remedial measures at km 50.9 are similar to those recommended for km 46.9.

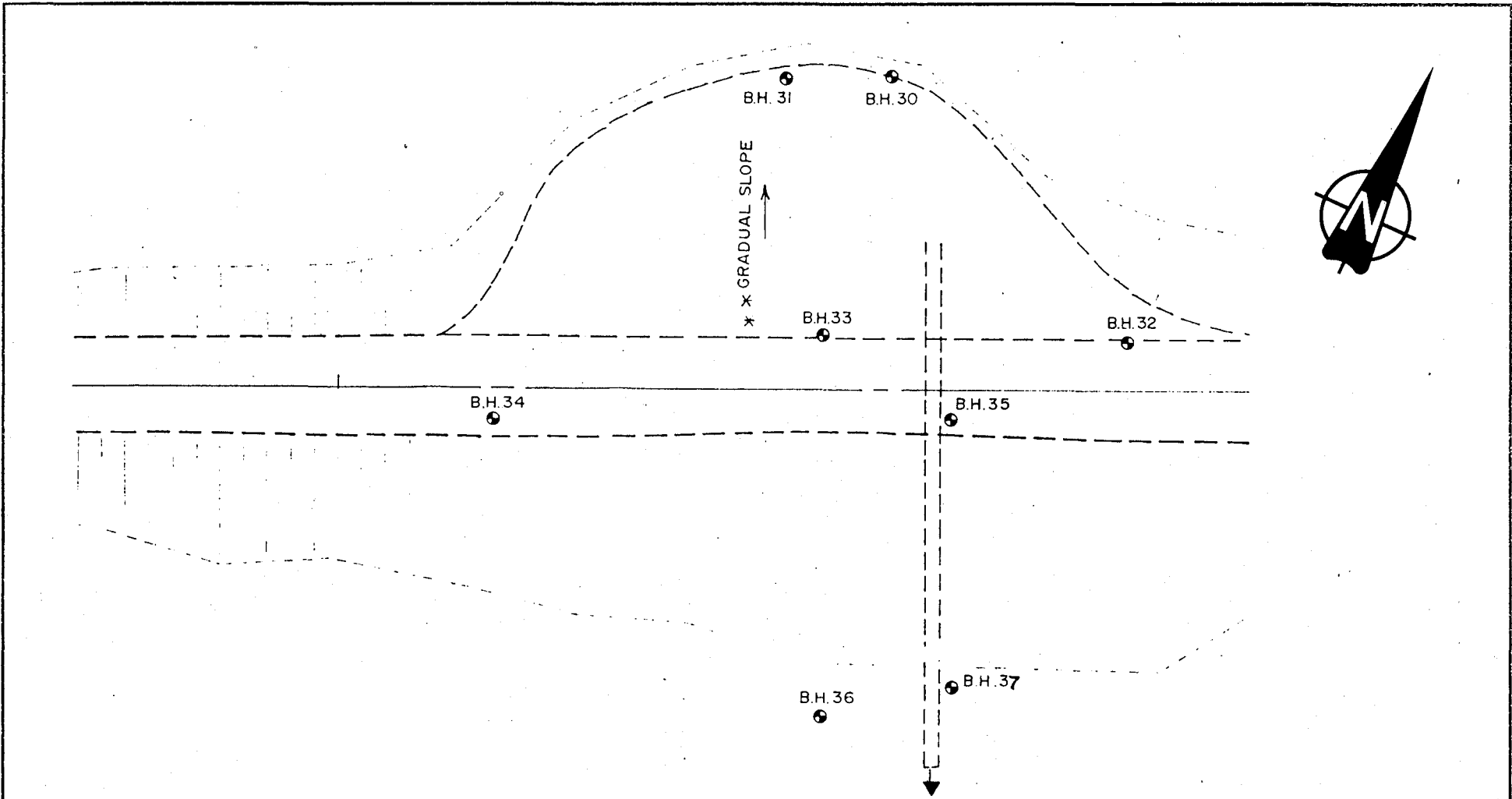
- (i) Drain the water from the upslope side. At this site, this would best be accomplished by constructing a short ditch from the end of the gravel pad to the north, just over the top of the ridge. Consideration should also be given to leaving this short ditch in place, to minimize the water load through the culvert.

0201-4426

If this is not feasible, then the recommendations as noted - Appendix D will also apply here:

- (ii) repair the end of the culvert to restore proper drainage
- (iii) re-grade and compact the existing slope
- (iv) remove all peat/organics and slumped material at the toe of the slope, as well as any high ice-content zones detected in the top of the till stratum. This clearing should extend for a width of not less than 3.0 m from the toe.
- (v) place a gravel berm at the toe of the slope, at least 2.0 m in thickness, extending across the width of the observed tension cracks (berm width estimated to be approximately 120 m).



This work would best be completed in the early fall, so that a complete freezing season could be available to stabilize the new fill. In the spring, some form of insulation could be placed on top of the toe berm, to maintain the frozen ground. In addition, it may be desirable to install a mechanism for stabilization such as heat pipes or 'cryo-anchors', to ensure permanently frozen ground. Additional details can be provided upon request.



SITE PLAN AND BOREHOLE LOCATIONS
 SLOPE FAILURE AT CULVERT SITE
 km 50.9, DEMPSTER HIGHWAY, N.W.T.

SCALE 1:500

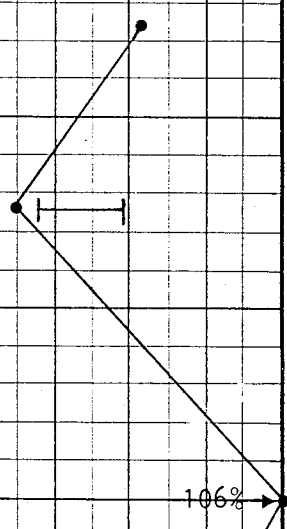
NOTE: Drawing provided by Nordzone Consultants Ltd.


EBA Engineering Consultants Ltd. 	
JOB NO. 0201-4426	DATE: 1985-12-16
DRAWN BY:	DRAWING NO.: 4426-E1
REVIEWED BY: 	

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL (FILL) (GP)-sandy, rounded particles, olive brown - saturated at 1.5 m		SEASONAL FROST UNFROZEN					
2	ORGANICS (OL)-silt, trace of peat, very ice-rich		FROZEN Vx 50%					
3	- sandy, silt zones, trace of gravel sizes	G						
4		G						
5	SILT (TILL) (ML)-sandy, some gravel, dark grey	G		T=-1.46°C Vs, Vx 25%				
6	END OF HOLE	C						
7								



	SFC. ELEVATION (m)	DATE DRILLED 1985-10-16	BOREHOLE No. 30
	COMPLETION DEPTH (m) 6.0	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 50.9 (NWT)	PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and ambiguous in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activities.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	GRAVEL (FILL) (GP)-sandy, rounded particles, olive brown - saturated at 1.5 m		SEASONAL FROST						
			UNFROZEN						
3	ORGANICS (OL)-silt, trace of peat, very ice-rich with depth - all core barrels filled with wet slough from surface fill - strong organic odour	C	FROZEN Vs 10% T=-0.95°C			▲			
			Vx 50%						
4		G							79%
5		G							159%
	SILT (TILL) (ML)-sandy, dark grey								
6	END OF HOLE								
7									



SFC. ELEVATION (m)	DATE DRILLED	1985-10-16
COMPLETION DEPTH (m) 5.5	LOGGED BY	JRT
DRILLING RIG CME 750	LOCATION	km 50.9 (NWT)

BOREHOLE No.	31
PAGE 1 OF	1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the time and place indicated and that may vary with time, season, and local hydrogeological conditions.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	SILT (ROAD FILL) (ML) - some sand, trace of fine gravel		SEASONAL FROST						
2			UNFROZEN						
3	- trace of organics		FROZEN T=-1.22°C						
4	SILT (TILL) (ML) - sandy, some gravel, fine grained (12 mm) rounded particles, olive brown	G	Vx 25%						
5	- gravel to 20 mm diameter	C	T=-1.33°C ICE+20% soil (4.3 - 4.6 m)						126%
6	- gravel to 50 mm diameter	C	T=-2.26°C ICE+40% soil						
7		G	Vx 60%						
8	END OF HOLE	C	T=-2.28°C						



SFC. ELEVATION (m)	DATE DRILLED 1985-10-16
COMPLETION DEPTH (m) 6.2	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 50.9 (NWT)

BOREHOLE No. 32
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that they vary with time, season, wind, tides, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	SILT (ROAD FILL) (ML)-some sand, trace of fine gravel sizes, olive brown colour		SEASONAL FROST					
			UNFROZEN					
2								
3			FROZEN Vx trace					
			C T=-1.76°C					
4	- trace of organics		Vx, Vr 10%					
			C T=-1.69°C					
5	ORGANICS (OL)-silt, trace of peat, light brown and grey coloured, trace of root-lets, trace of rounded gravel		T=-1.36°C					
			C T=-1.77°C Vx 50%					291%
6	- black organic silt, traces of woody fragments		T=-2.07°C					
			C T=-1.99°C Vx 45%					113%
7	SILT (TILL) (ML)-sandy, some rounded gravel, dark grey							



SFC. ELEVATION (m)	DATE DRILLED 1985-10-16
COMPLETION DEPTH (m) 8.2	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 50.9 (NWT)


BOREHOLE No. 33
PAGE 1 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
8	SILT (TILL) (ML) -sandy, some rounded gravel, dark grey		Vx 45% Vx, Vs 45% T=-1.39°C					
9	END OF HOLE							
10								
11								
12								
13								
14								

	SFC. ELEVATION (m)	DATE DRILLED 1985-10-16	BOREHOLE No. 33
	COMPLETION DEPTH (m) 8.2	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 50.9 (NWT)	PAGE 2 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	SILT (ROAD FILL) (ML) - some sand, dark grey		SEASONAL FROST						
			UNFROZEN						
			FROZEN						
3	- trace of gravel sizes		Vs, Vx 15% T=-1.89°C						
4	ORGANICS (OL) - silt, orange brown colour, traces of wood and rootlets	C	Vs, Vx 45% T=-1.28°C						
5	- trace of rounded gravel sizes	C	lenses up to 15 mm thick Vs, Vx 50% T=-2.11°C Vc trace						
6	SILT (TILL) (ML) - sandy, rounded gravel to 75 mm diameter	C	T=-2.01°C Vx, Vs trace						
7	END OF HOLE								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-17
COMPLETION DEPTH (m) 6.6	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 50.9 (NWT)

BOREHOLE No. 34
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426

DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	SILT (ROAD FILL) (ML)-clayey, some sand, olive brown		SEASONAL FROST					
			UNFROZEN					
2	- dark grey colour	G						
3		G	FROZEN T=-0.95°C					
			Vx trace					
4	ORGANICS (OL)-silt, light brown	C	Vx 10%					
5	- trace of rounded gravel sizes throughout	C	T=-1.76°C					
			Vs 50%					
6	SILT (TILL) (ML)-sandy, some rounded gravel, trace of organics, dark grey to black	C	T=-1.76°C					
			Vx 25%					
7	- augers grinding	C	Vx 40%					
			Vs 10% - 15%					
	END OF HOLE							

139%



SFC. ELEVATION (m)	DATE DRILLED 1985-10-17
COMPLETION DEPTH (m) 7.0	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 50.9 (NWT)

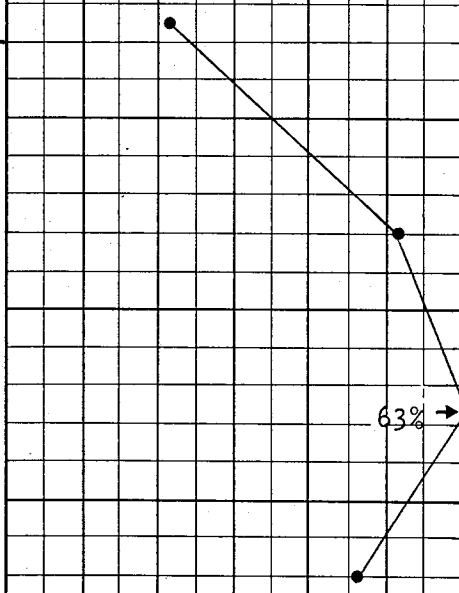
BOREHOLE No. 35
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	SILT(FILL) (ML)-clayey, some sand, olive brown, trace of gravel sizes		SEASONAL FROST					
			UNFROZEN					
2								
3	- trace of organics	G	FROZEN T=-1.00°C					
	ICE LENS							
4	SILT(TILL) (ML)-sandy, some rounded gravel up to 50 mm diameter - some light brown organic silt zones - black organic silt 4.2 - 4.6 m depth	C	Vs 80% T=-1.11°C					
5	- dense, dark grey to black till, rounded gravel throughout	C	Nbn					
6	END OF HOLE NOTE: Hole on spoil from previous slope failures		Vx, Vs 10%					
		G						
7								



SFC. ELEVATION (m)	DATE DRILLED 1985010-17
COMPLETION DEPTH (m) 5.5	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 50.9 (NWT)

BOREHOLE No. 36
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	SILT(FILL)(ML)-clayey, some sand, trace of gravel sizes		SEASONAL FROST						
			UNFROZEN						
2		G							
3	ORGANICS(OL)-silt and ice, trace of wood fibres and peat	G	FROZEN						
			Vx 50%						
4		G							
5	SILT(TILL)(ML)-sandy, some rounded gravel sizes, dark grey to black - augers grinding	G	Vx trace						
6	END OF HOLE								
	NOTE: Hole on spoil from previous slope failures								
7									



SFC. ELEVATION (m)	DATE DRILLED 1985-10-17
COMPLETION DEPTH (m) 5.4	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 50.9 (NWT)

BOREHOLE No. 37
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.



PLATE 12

General view of south-facing roadway
embankment, km 50.9.



PLATE 13

km 50.9, core from Borehole No. 32:
4.6 m to 5.5 m depth.



PLATE 14

km 50.9, core from Borehole No. 33:
4.9 m to 5.1 m depth.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 50.9)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-18

Borehole Number: 30

Depth: 3.5 m

Soil Description: SILT - sandy, some clay, trace of gravel

Cu: _____

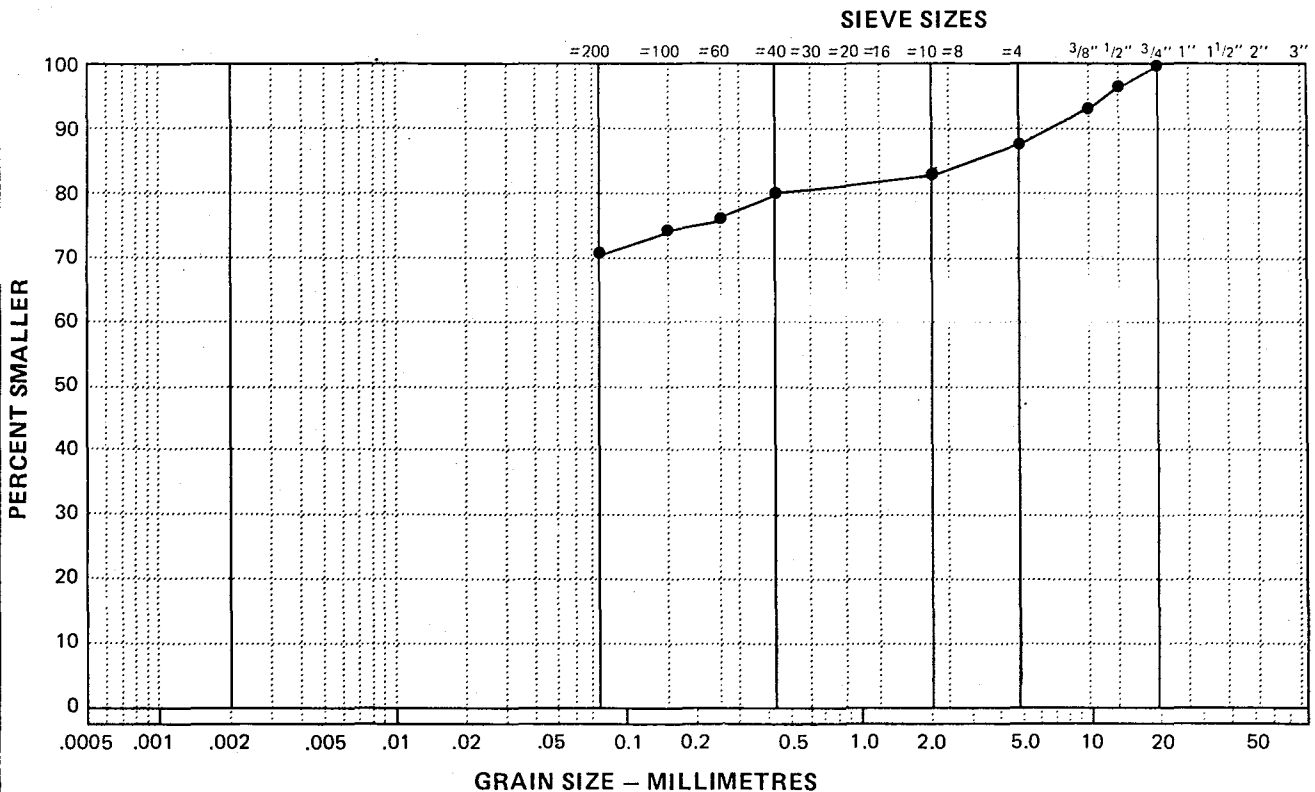
Cc: _____

Natural Moisture Content: 24.8 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	100
1/2"	96
3/8"	93
No. 4	91
No. 10	87
No. 20	84
No. 40	80
No. 60	76
No. 100	74
No. 200	71

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 50.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-19

Borehole Number: BH 30

Depth: 5.5 - 5.7 m

Soil Description: SILT & CLAY - trace of sand

Cu: _____

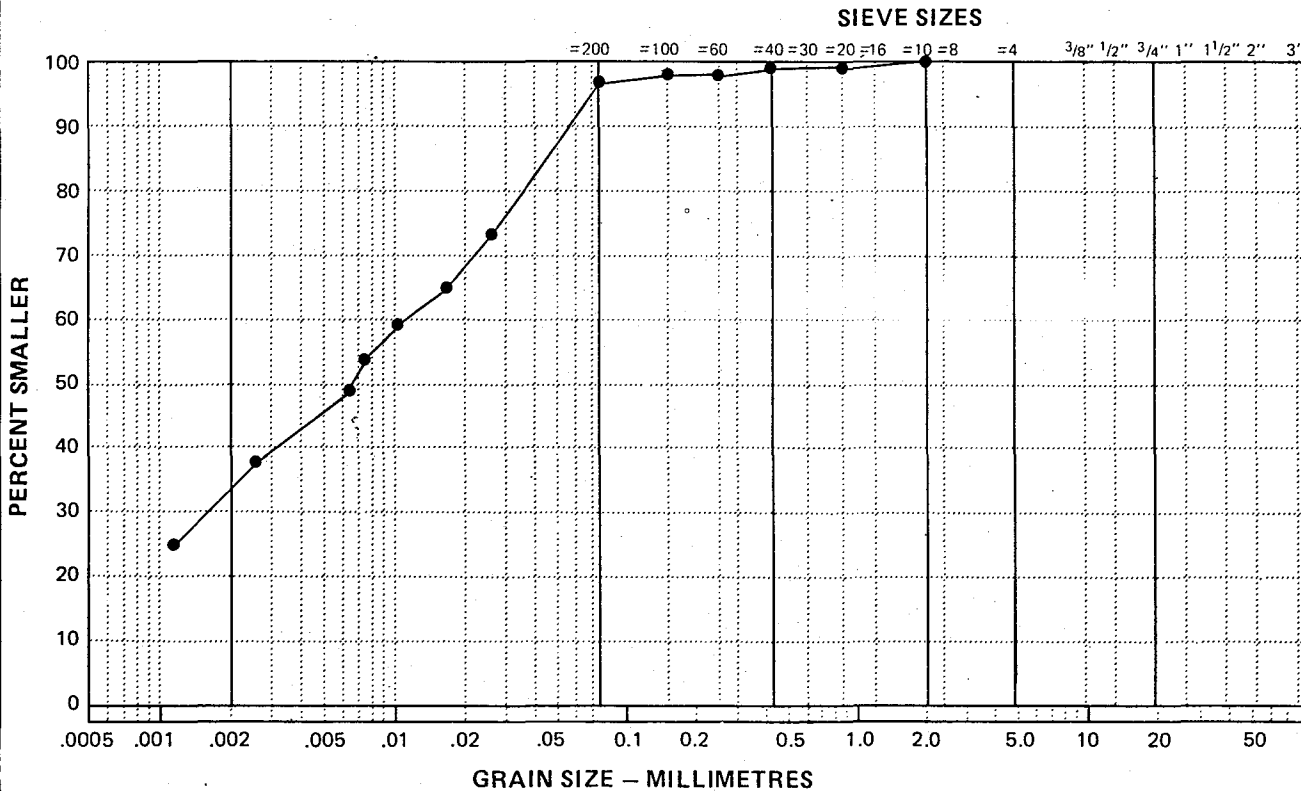
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	99
No. 40	99
No. 60	98
No. 100	98
No. 200	96

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 50.9)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-18

Borehole Number: 33

Depth: 3.1 - 3.2 m

Soil Description: SILT - clayey, some sand

Cu: _____

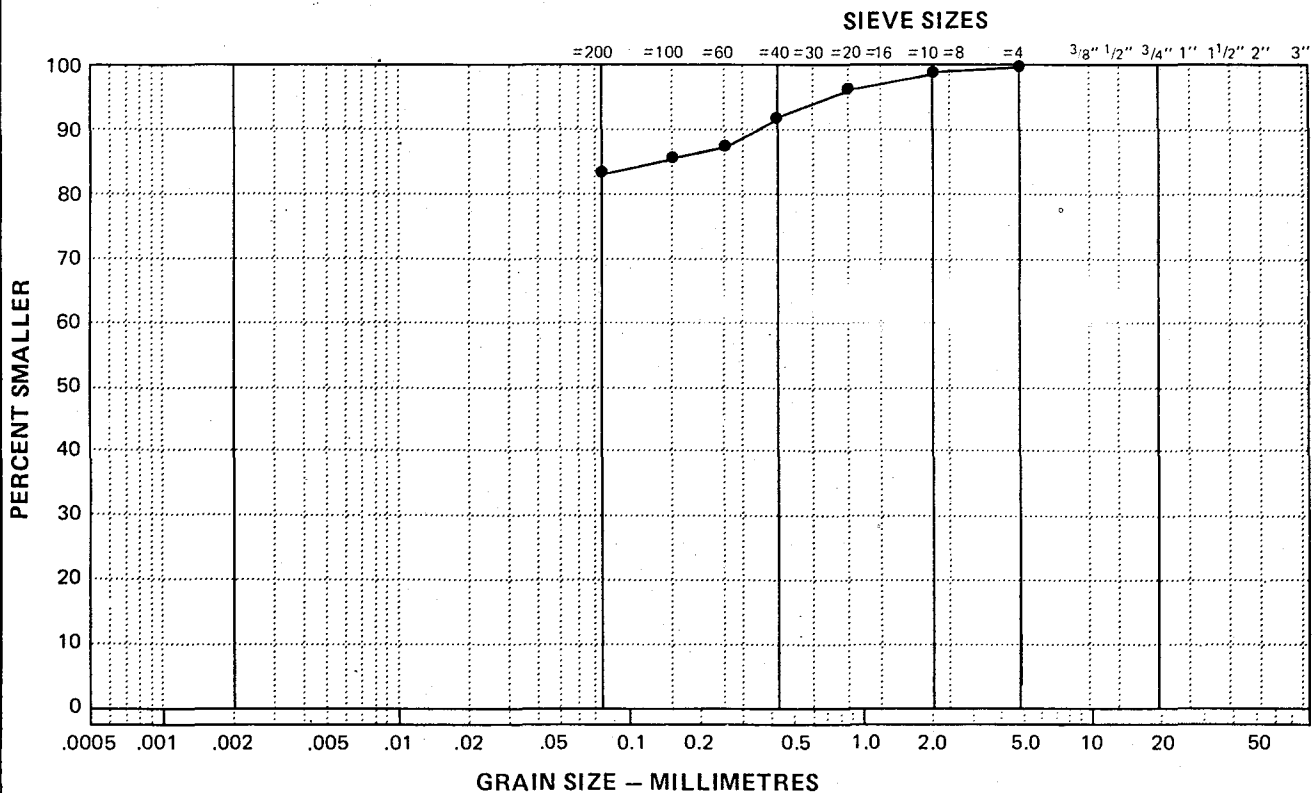
Cc: _____

Natural Moisture Content: 38.1 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	100
No. 10	99
No. 20	96
No. 40	92
No. 60	88
No. 100	86
No. 200	84

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 50.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-21

Borehole Number: BH 33

Depth: 7.8 - 8.0 m

Soil Description: SILT & CLAY - trace of sand

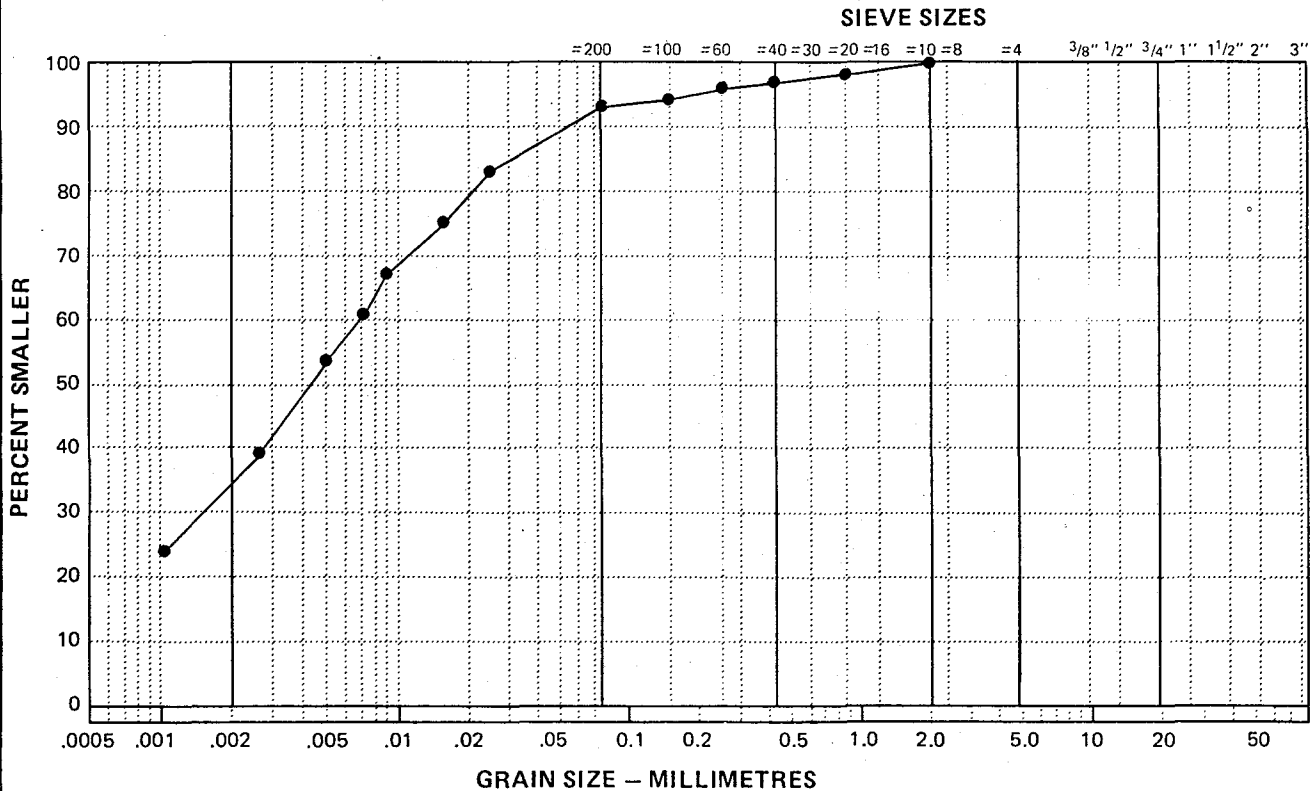
Cu: _____
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	98
No. 40	97
No. 60	96
No. 100	95
No. 200	94

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 50.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-20

Borehole Number: BH 34

Depth: 4.4 - 4.6 m

Soil Description: SILT - sandy, some clay

Cu: _____

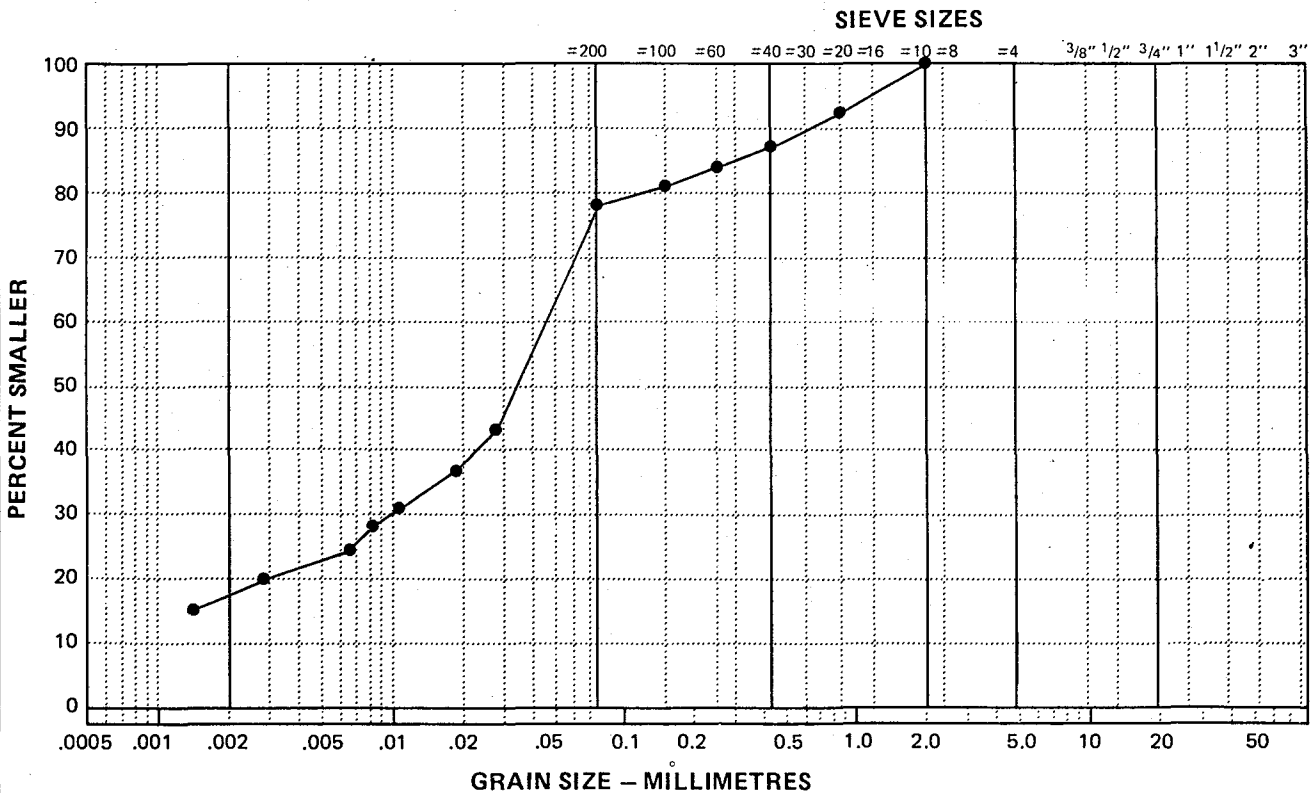
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	93
No. 40	87
No. 60	84
No. 100	81
No. 200	78

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 50.9)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-18

Borehole Number: 35

Depth: 3.3 m

Soil Description: SILT - clayey, trace of sand & gravel

Cu: _____

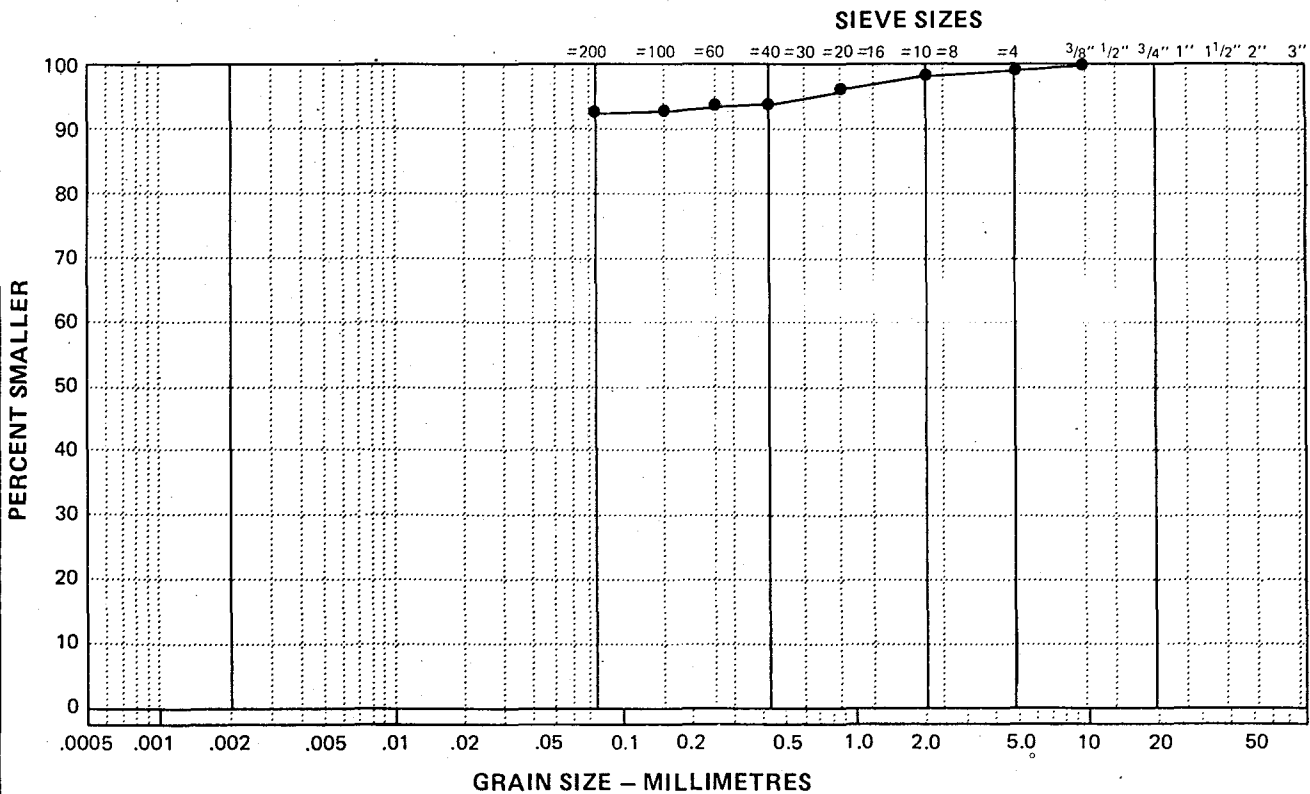
Cc: _____

Natural Moisture Content: 13.5 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	100
No. 4	99
No. 10	98
No. 20	96
No. 40	94
No. 60	94
No. 100	93
No. 200	93

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 50.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-20

Borehole Number: BH 35

Depth: 6.4 - 6.5 m

Soil Description: SILT - some clay, trace of sand

Cu: _____

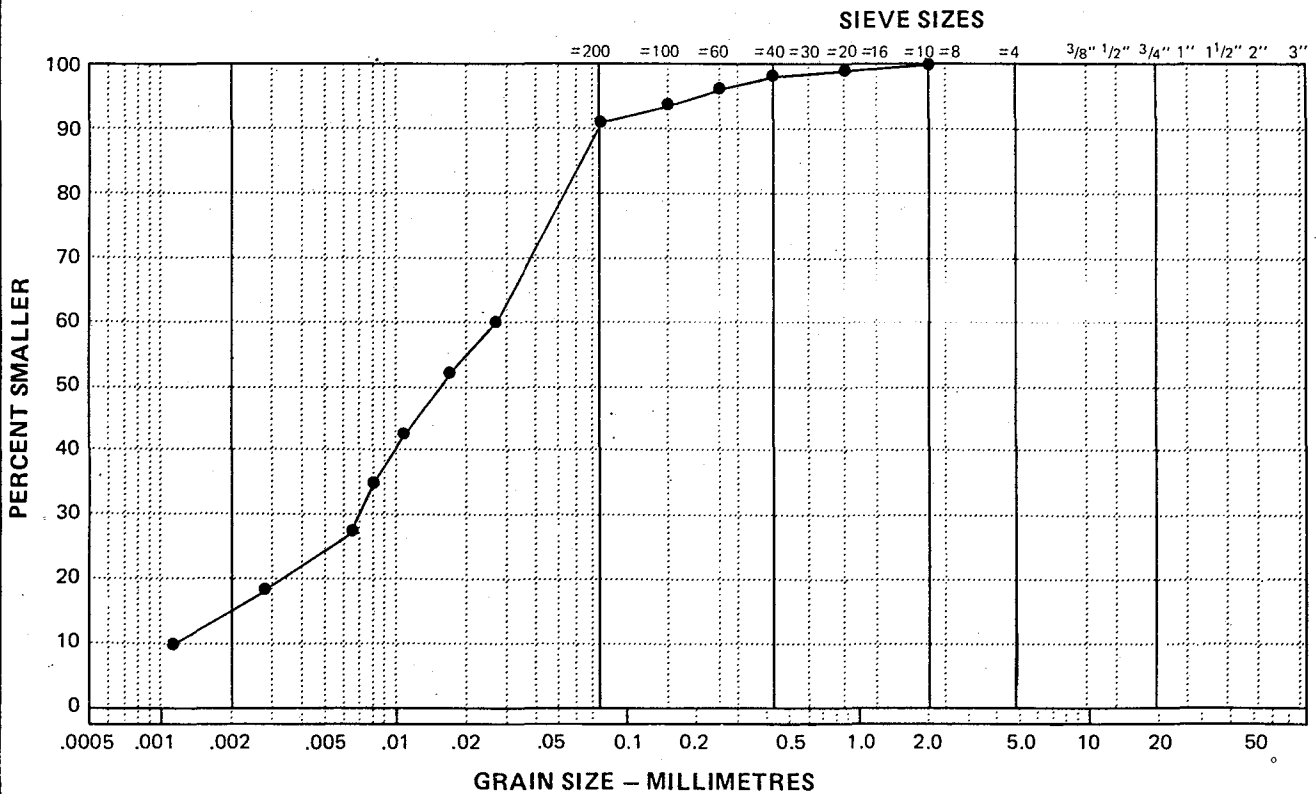
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	99
No. 40	98
No. 60	96
No. 100	94
No. 200	91

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 50.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-19

Borehole Number: BH 36

Depth: 2.5 m

Soil Description: SILT - clayey, trace of sand

Cu: _____

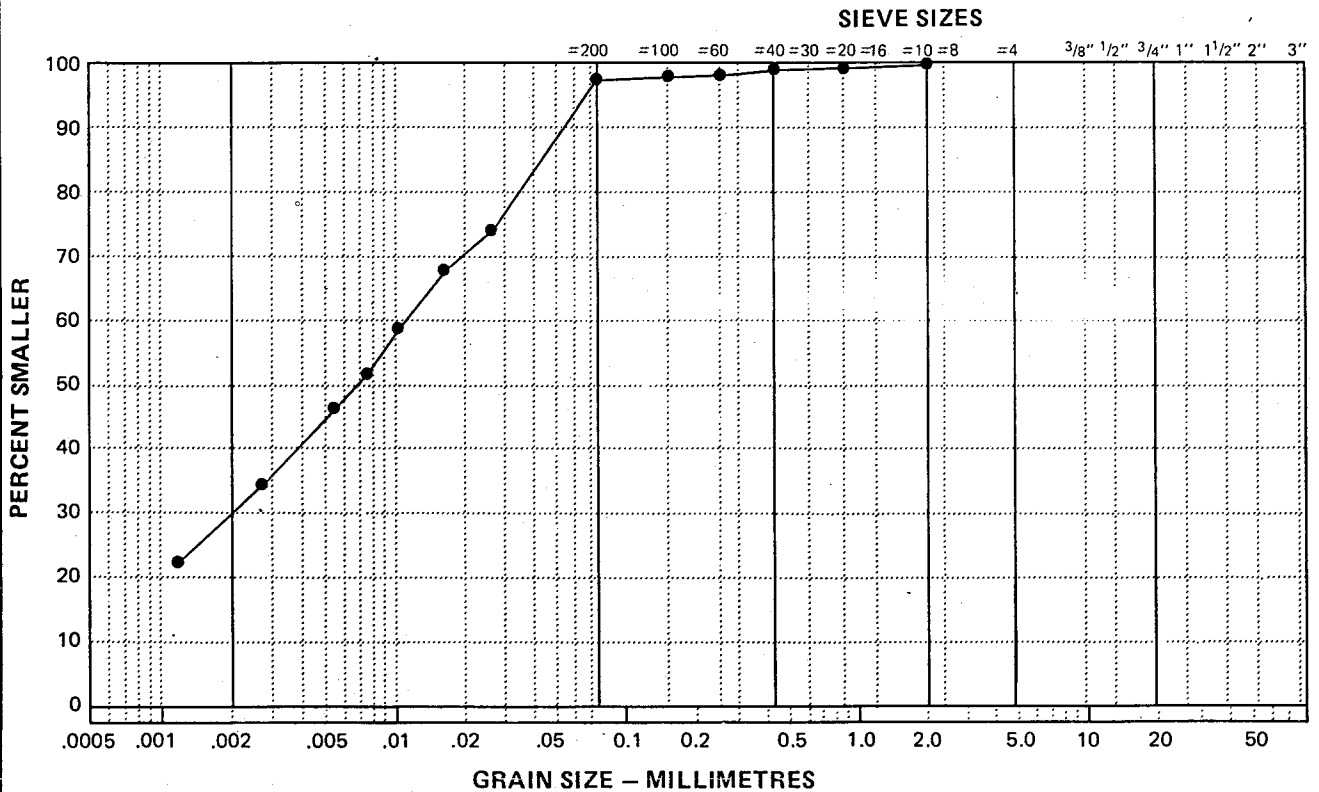
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	99
No. 40	99
No. 60	98
No. 100	98
No. 200	97

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
 EDMONTON, ALBERTA
 Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
 CALGARY, ALBERTA
 Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 50.9 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-21

Borehole Number: BH 37

Depth: 5.0 m

Soil Description: SILT - some clay, trace of sand

Cu: _____

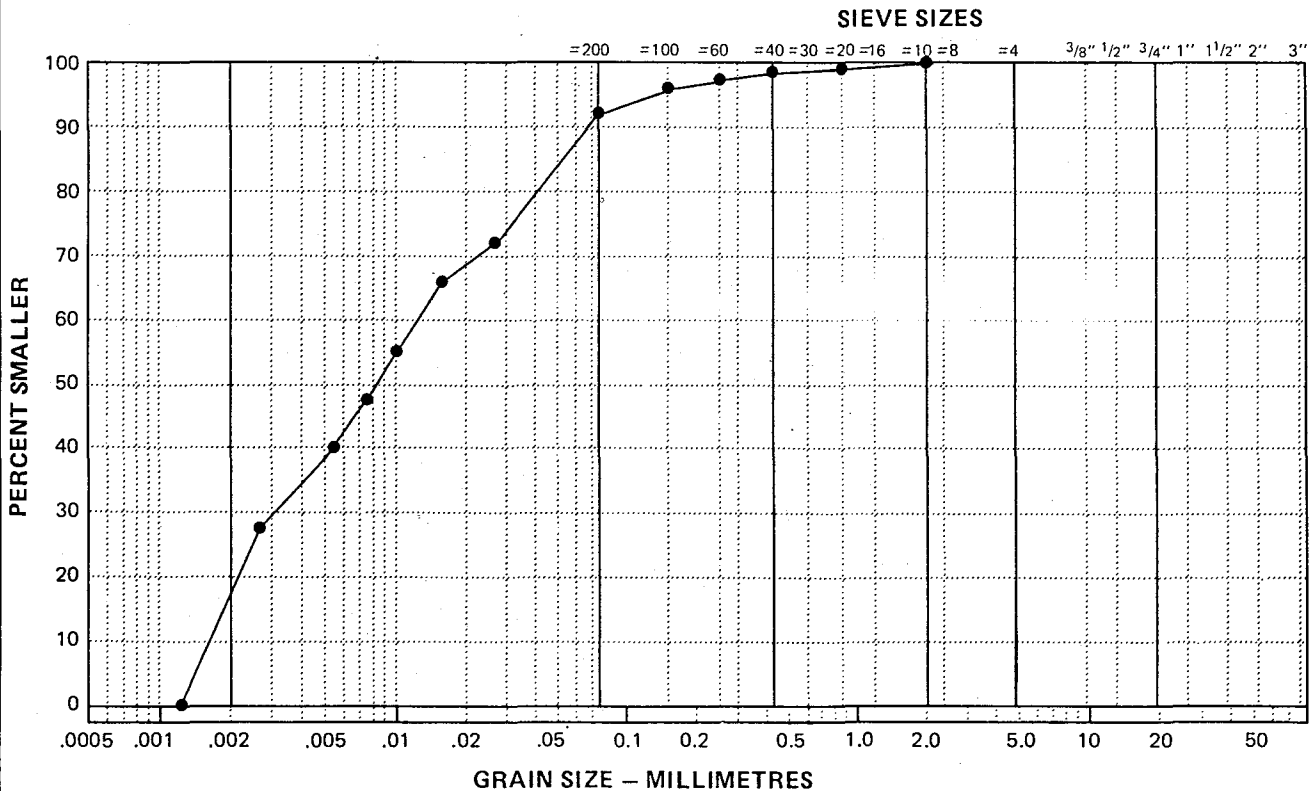
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	99
No. 40	98
No. 60	97
No. 100	96
No. 200	93

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

APPENDIX F
km 227.2, Dempster Highway, N.W.T.

F-1	General
F-2	Investigation Program
F-3	Results and Conclusions
F-4	Recommendations

Site Plan

Borehole Logs (BH 38 to BH 42, BH 45, and including moisture contents, Atterberg Limits, bulk densities and ground temperatures)

Photographs (Plates 15, 16 and 17)

Ground Temperature Profile (Cable H-19-15)

Grain Size Curves

APPENDIX F

km 227.2, Dempster Highway, N.W.T.

F-1 General

The road at km 227.2 cuts through a small sandy knoll, and a large (approximately 5.0 m diameter) sinkhole has developed in the right-hand ditch. Boreholes were required at this location to investigate the cause of the hole, and to recommend measures for repairs. Plate 15 shows a general view of the sinkhole in the ditch.

F-2 Investigation Program

Six boreholes were drilled at this site on October 18 and 19, 1985, at the locations shown on the enclosed Site Plan. Borehole No. 38 was drilled in the centre of the sinkhole but could not penetrate below 3.8 m depth, due to auger refusal in water and ice.

The other five holes were drilled to a maximum depth of 10.7 m below grade on both sides of the sinkhole and road, to investigate subsurface conditions in the immediate vicinity of the failure. A ground temperature (thermistor) cable was installed in BH 45, to a depth of 9.5 m below existing grade.

F-3 Results and Conclusions

The borehole logs are attached, following the Site Plan. The roadway consists of a thin gravel surface overlying the silt/sand subgrade, with permafrost located at an average depth of 2.0 m. Massive ice was encountered in all holes, but only BH 41 and BH 45 completely penetrated to the base of the ice layer, and into mineral soils below. Progressive melting of a section of this ice lens is the cause of the sinkhole noted

in the ditch. If not stabilized, this thaw will eventually undermine the road surface. The depth to the ice surface was very irregular, and was noted to range from 1.8 m in the bottom of the sinkhole, to 5.5 m in BH 45. The average depth to ice was 3.8 m, with the average thickness being 5.0 m. Plates 16 and 17 show photos of ice samples taken from the CRREL core barrel and on the augers.

The soils above and occasional interspersed with the ice were primarily frost-susceptible silts interbedded with fine sands. It is believed that the small knoll at this location has an ice core, but that the ice does not extent too far along the highway in either direction.

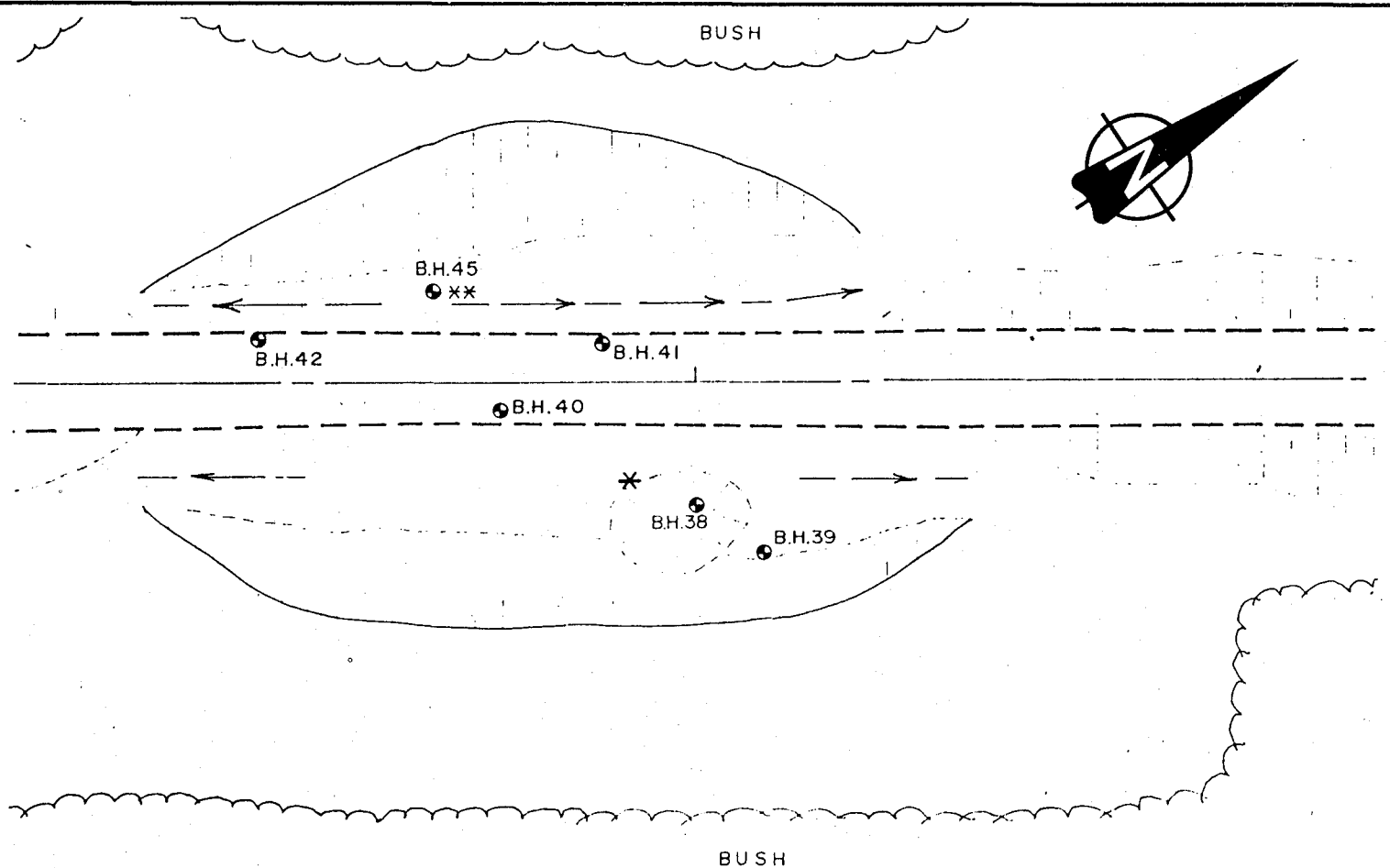
The melting of the ground was probably initiated in the ditch by the ponding of water in a small depression. The water acted as a 'heat sink', creating further thaw, and a larger depression, etc.

F-4 Recommendations

It ideal solution at this site is to restore the permafrost to a stable condition. This is best accomplished by:

- (i) Request highways maintenance staff to not pile snow in the depression this winter. This measure will ensure a deep frost penetration, and minimize snowmelt water in the spring.
- (ii) As soon as practical in the late winter or spring, fill the hole with fine grained soil and contour the ditch so that water is directed away from the depression.
- (iii) Monitor the depression next summer, and keep adding fill as necessary to keep water out of the hole.



- (iv) If this method proves to be unsuccessful, it is believed that one or two heat pipes ('cryo-anchors') will restore the permafrost and maintain it in a stable condition. Further details on the design and installation of these 'cryo-anchors' can be presented, upon request.



SITE PLAN AND BOREHOLE LOCATIONS
 SINKHOLE SITE
 km 227.2, DEMPSTER HIGHWAY, N.W.T.

SCALE 1:500

NOTE: Drawing provided by Nordzone Consultants Ltd.

EBA Engineering Consultants Ltd. 	
JOB NO. 0201-4426	DATE: 1985-12-16
DRAWN BY:	DRAWING NO.: 4426-F1
REVIEWED BY: 	

BOREHOLE LOG -- PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	SILT(ML)-some sand, trace of clay, uniform, soft, wet, olive brown, non-plastic - saturated at 1.5 m - coarse grained sand lens		SEASONAL FROST						
		G	UNFROZEN						
2	ICE	G	FROZEN ICE 100%						
3		G	ICE 100%						
4	END OF HOLE								
5	Auger and CRREL barrel refusal (too much water in hole)								
6	NOTE: Hole in centre of sinkhole, water in hole below 1.5 m								
7									



SFC. ELEVATION (m)	DATE DRILLED 1985-10-18
COMPLETION DEPTH (m) 3.8	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 227.2 (NWT)

BOREHOLE No. 38
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	SILT (ML) - some sand, trace of clay, wet below seasonal frost, uniform in appearance, olive brown - some sandy zones - faint cross-bedding evident	C	SEASONAL FROST						
			UNFROZEN						
2		C	FROZEN Vx, Vr trace						
3	ICE	C	ICE 100%						
4									
5	- some silty inclusions	C	T = -0.72°C						
6									
7	END OF HOLE Auger refusal in ice								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-18
COMPLETION DEPTH (m) 6.9	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km ² 227.2 (NWT)

BOREHOLE No. 39
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND-ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
	GRAVEL (ROAD FILL)		SEASONAL FROST					
	SAND(SM)-silty, damp, olive brown		UNFROZEN					
1	- some silt	G						
2	SILT(ML)-sandy, moist near surface, olive brown		FROZEN Vx trace					
	- interbedded with sand							
3	SAND(SM)-silty, olive brown	G	Nbn					
	- interbedded with silt							
4	ICE	G	ICE 100%					
5								
6								
7	END OF HOLE Auger refusal-lost bit in hole, ruined auger.							



SFC. ELEVATION (m)	DATE DRILLED 1985-10-18
COMPLETION DEPTH (m) 6.6	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 227.2 (NWT)


BOREHOLE No. 40
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
	GRAVEL (ROAD FILL) (GM)-sandy, olive brown		SEASONAL FROST					
			UNFROZEN					
1	SAND (SM)-silty, olive brown							
2	SILT (ML)-sandy							
	- interbedded with sand		FROZEN Vx trace Nbn					
3								
4								
5	ICE		ICE 100%					
6								
	- occasional silty inclusions							
7								

	SFC. ELEVATION (m)	DATE DRILLED 1985-10-18	BOREHOLE No. 41
	COMPLETION DEPTH (m) 10.7	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 227.2 (NWT)	PAGE 1 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
8	ICE - occasional silty zones and inclusions		ICE 100%					
10	SILT(TILL) (ML)-sandy, rounded gravel sizes, dark grey		Vx trace					
11	END OF HOLE (Augers grinding) NOTE: Probe hole only, no samples taken.							
12								
13								
14								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-18
COMPLETION DEPTH (m) 10.7	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 227.2 (NWT)


BOREHOLE No. 41
PAGE 2 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
	GRAVEL (ROAD FILL) (GM)-sandy, olive brown		SEASONAL FROST					
			UNFROZEN					
1	SAND (SM)-silty, damp, olive brown							
2	SILT (ML)-sandy, olive brown		FROZEN					
	- some sandy interbeds		Vx trace					
3			Nbn					
4								
	ICE		ICE 100%					
5								
	END OF HOLE (Auger refusal-bit clogged)							
6								
7								

	SFC. ELEVATION (m)	DATE DRILLED 1985-10-18	BOREHOLE No. 42
	COMPLETION DEPTH (m) 5.3	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 227.2 (NWT)	PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
1	SAND(SM)-silty, olive brown - silt interbeds		SEASONAL FROST UNFROZEN						
2	SILT(ML)-sandy, olive brown - sand interbeds		FROZEN Vx trace Nbn						
6	ICE - occasional silty inclusions		ICE 100%						

EBA THERMISTOR
CABLE
H-19-15



SFC. ELEVATION (m)	DATE DRILLED 1985-10-19
COMPLETION DEPTH (m) 9.5	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 227.2 (NWT)

BOREHOLE No. 45
PAGE 1 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲					
				1.4	1.6	1.8	2.0	2.2	
				MOISTURE CONTENT					
				10	20	30	40	50	
8	ICE - occasional silty inclusions		FROZEN ICE 100%						
9	SILT(ML)-sandy, olive brown non-plastic	G							
10	END OF HOLE NOTE: EBA Thermistor Cable H-19-15 installed in this borehole.								
11									
12									
13									
14									



SFC. ELEVATION (m)	DATE DRILLED 1985-10-19
COMPLETION DEPTH (m) 9.5	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 227.2 (NWT)

BOREHOLE No. 45
PAGE 2 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.



PLATE 15

General view of sinkhole at km 227.2.



PLATE 16

km 227.2 - Ice core from Borehole No. 39,
2.4 m to 2.8 m depth.

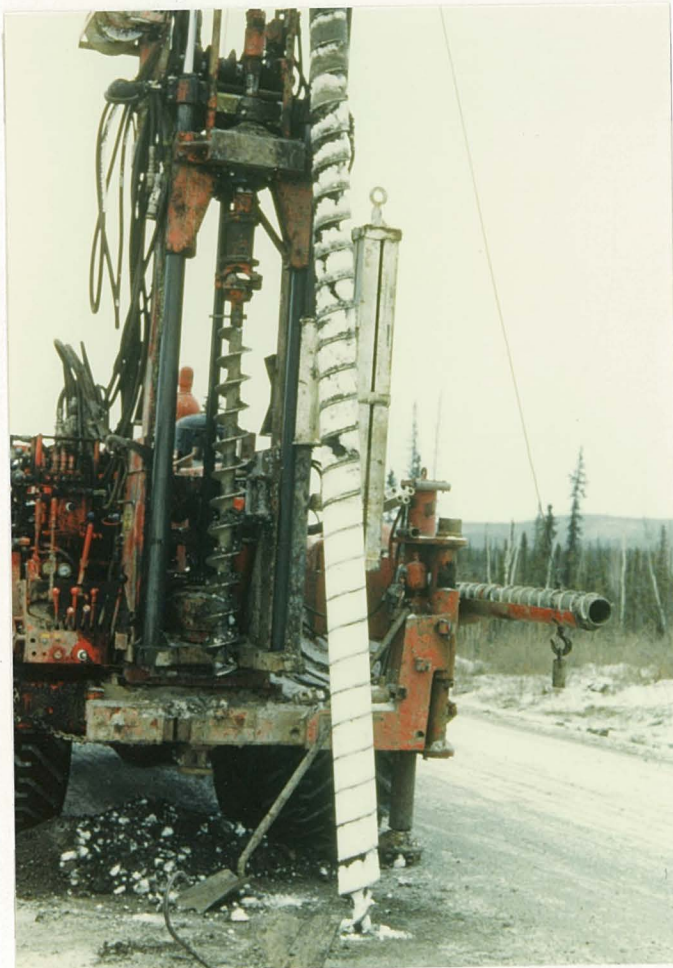
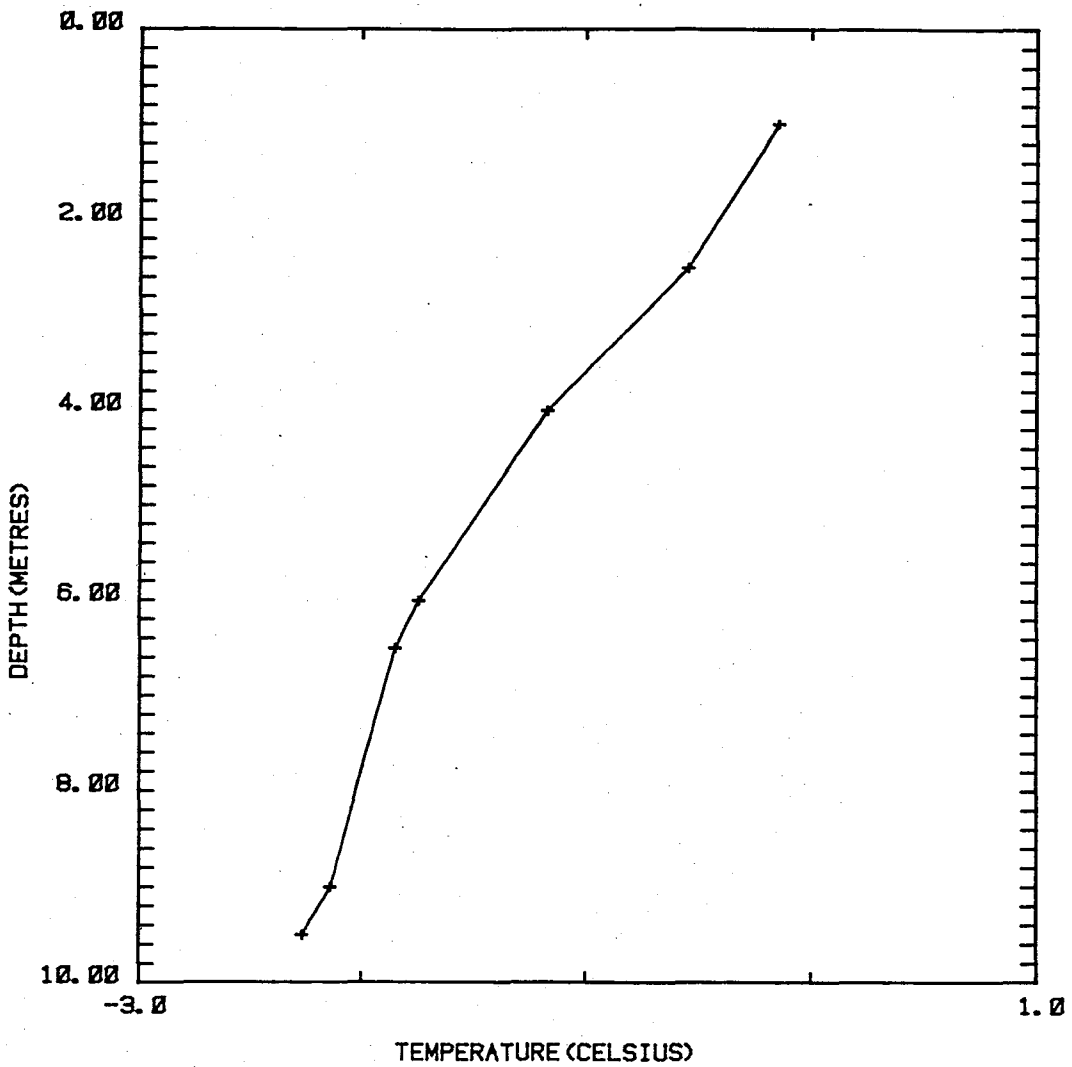


PLATE 17



km 227.2 - Massive
ice in Borehole No. 41:
bottom of auger in 5.7 m
depth.



THERMISTOR NUMBER H-19-15

DATE INSTALLED 85-10-20

+ 85-10-20

EBA Engineering Consultants Ltd. 	
JOB NO. 0201-4426	DATE: 1985-12-16
DRAWN BY:	DRAWING NO.:
REVIEWED BY: 	4426-F2

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 227.2 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-20

Borehole Number: BH 38

Depth: 0.4 m

Soil Description: SILT - trace of sand, trace of clay

Cu: _____

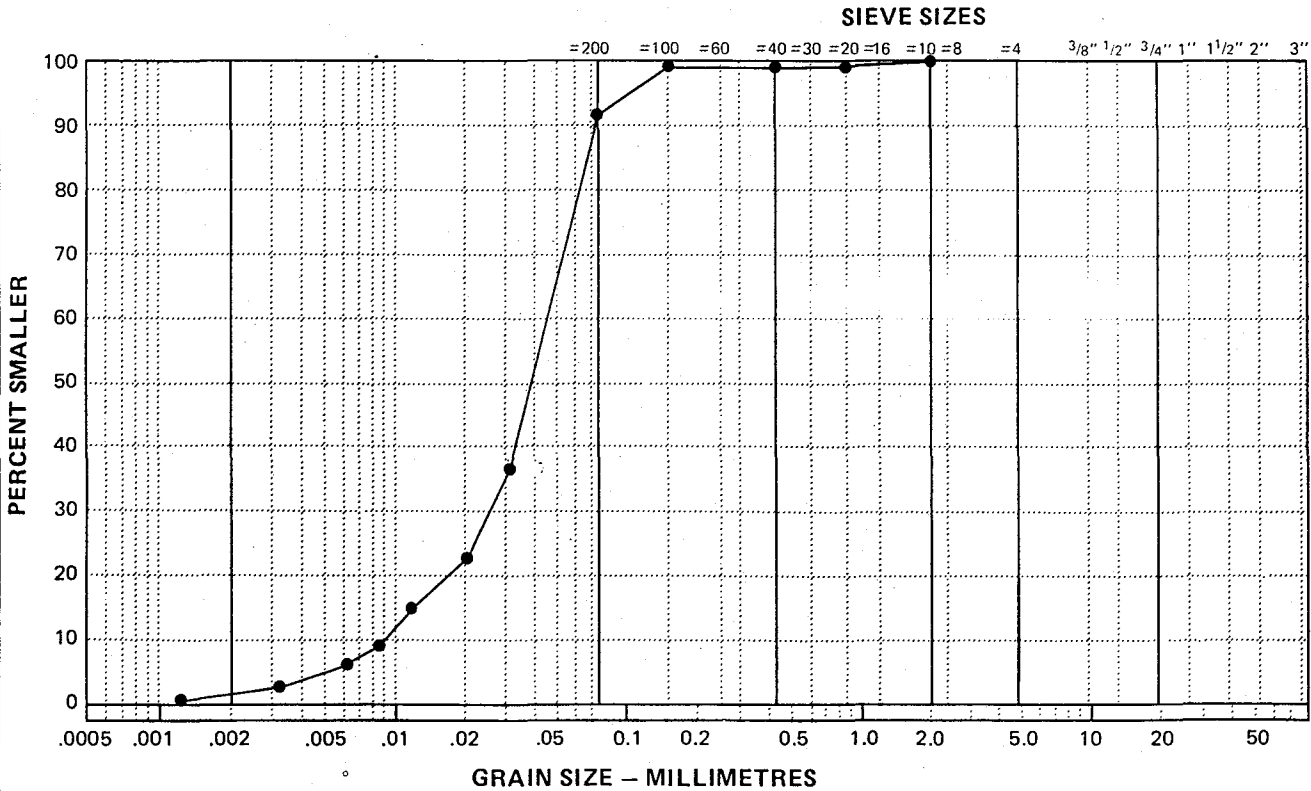
Cc: _____

Natural Moisture Content: _____ %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	99
No. 40	99
No. 60	99
No. 100	99
No. 200	92

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 227.2)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-18

Borehole Number: 40

Depth: 1.3 m

Soil Description: SAND - some silt

Cu: _____

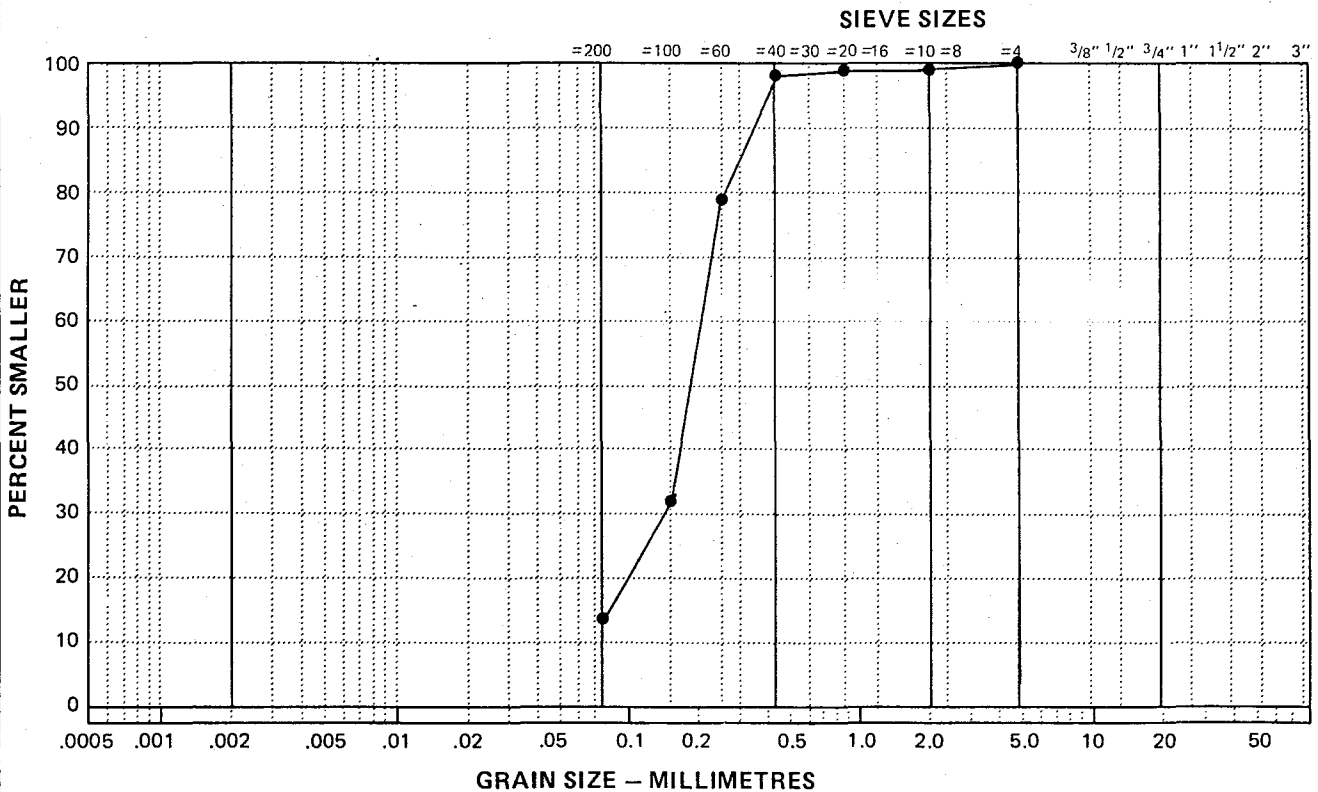
Cc: _____

Natural Moisture Content: 9.7 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	100
No. 10	99
No. 20	99
No. 40	98
No. 60	79
No. 100	32
No. 200	14

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 227.2)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-18

Borehole Number: 45

Depth: 9.3 m

Soil Description: SAND & SILT - trace of clay

Cu: _____

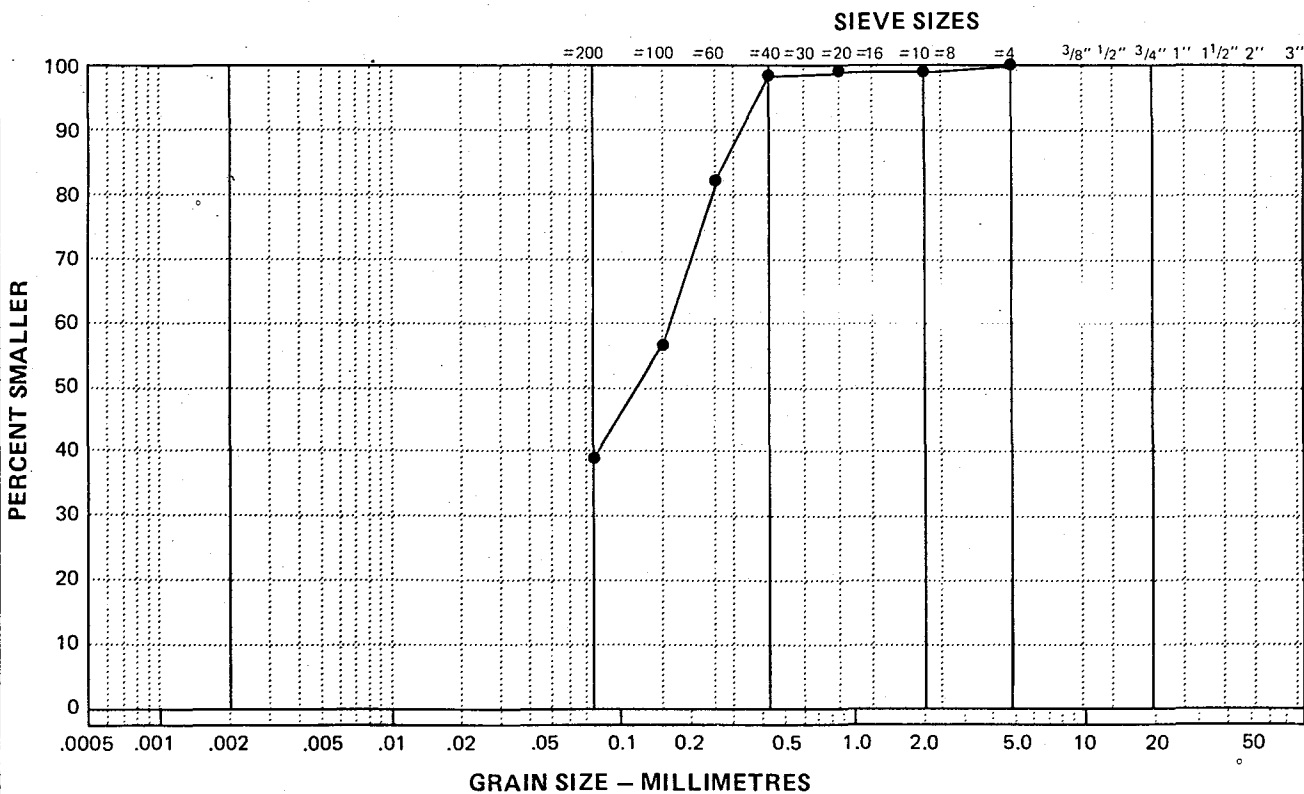
Cc: _____

Natural Moisture Content: 22.7 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	100
No. 10	99
No. 20	99
No. 40	98
No. 60	82
No. 100	57
No. 200	39

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

APPENDIX G

km 229.8, Dempster Highway, N.W.T.

- G-1 General
- G-2 Investigation Program
- G-3 Results and Conclusions
- G-4 Recommendations

Site Plan

Borehole Logs (BH 43 and BH 44, including SPT data, moisture contents, ground temperatures)

Photographs (Plates 18 and 19)

Grain Size Curves

APPENDIX G

km 229.8, Dempster Highway, N.W.T.

G-1 General

The large multiplate culvert at km 229.8 was observed to be moderately 'bowed' in the centre (under the road) and boreholes were required to ascertain the cause of this deflection. It is understood that this culvert may have to be replaced.

G-2 Investigation Program

Two boreholes were drilled at the site on October 19, 1985, at the approximate location shown on the Site Plan, attached. Plate 18 shows the location of BH 44. One hole was drilled at each end of the culvert, on opposite sides. The maximum hole penetration was 9.2 m, and both holes were terminated in a dark grey frozen till, considered to be relatively thaw stable at depth. Standard penetration tests were completed in the unfrozen soils above the permafrost, to evaluate in situ density.

G-3 Results and Conclusions

The observed culvert deflection is believed to be caused by permafrost thaw and subsequent settlement. The culvert appears to be founded on the silt till stratum, and was probably placed at or near the original permafrost table. The permafrost was subsequently thawed by the 'warm' water being channelled through the culvert (approximately 3.0 m of thawed till encountered in BH 43, below culvert base). The ground ice content in the permafrost is typically low (Vx trace); however, there are some localized ice-rich zones as evidenced by the high moisture content (66%) at the 7.0 m depth in BH 44. In general, however, it is believed that the

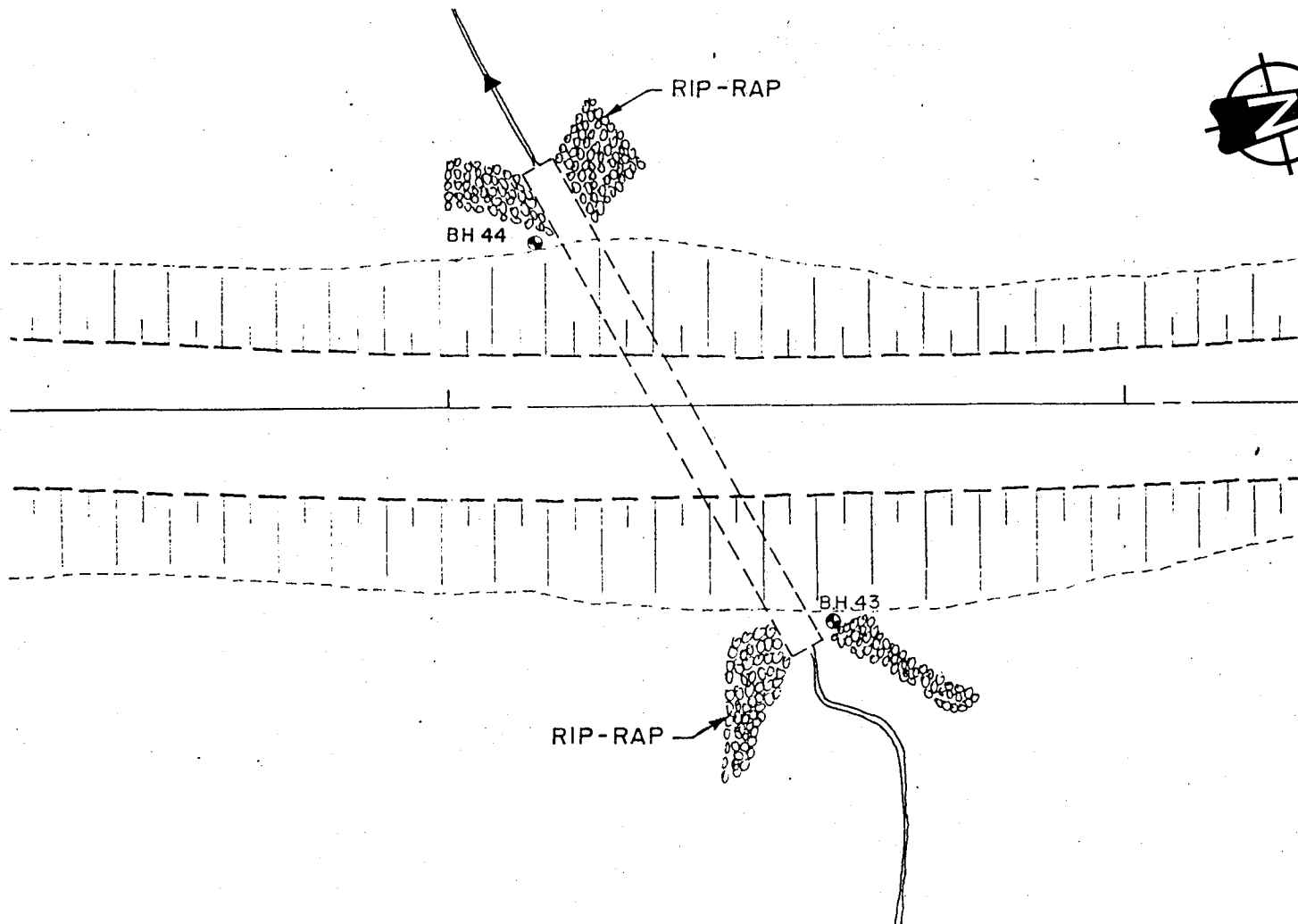
0201-4426

till in this vicinity is thaw-stable, as the adjacent creek bed (see Plate 19) shows no typical signs of high ice-content terrain.

G-4 Recommendations

It is recommended that an elevation survey be completed along the top and bottom of the culvert, from the inside, to determine if only the top is collapsing. The deflection noted in the top of the culvert could also be partly caused by lack of lateral support (soil compaction) on the outsides of the culvert. Construction records should also be checked to determine the quality and degree of compaction of the backfill.



To assist in determining the cause of the settlements, a one-dimensional thermal analysis has been completed, utilizing soil and temperature conditions from this site, and from km 247.0. The results are summarized in Appendix H.



SITE PLAN AND BOREHOLE LOCATIONS
 CULVERT SITE
 km 229.8, DEMPSTER HIGHWAY, N.W.T.

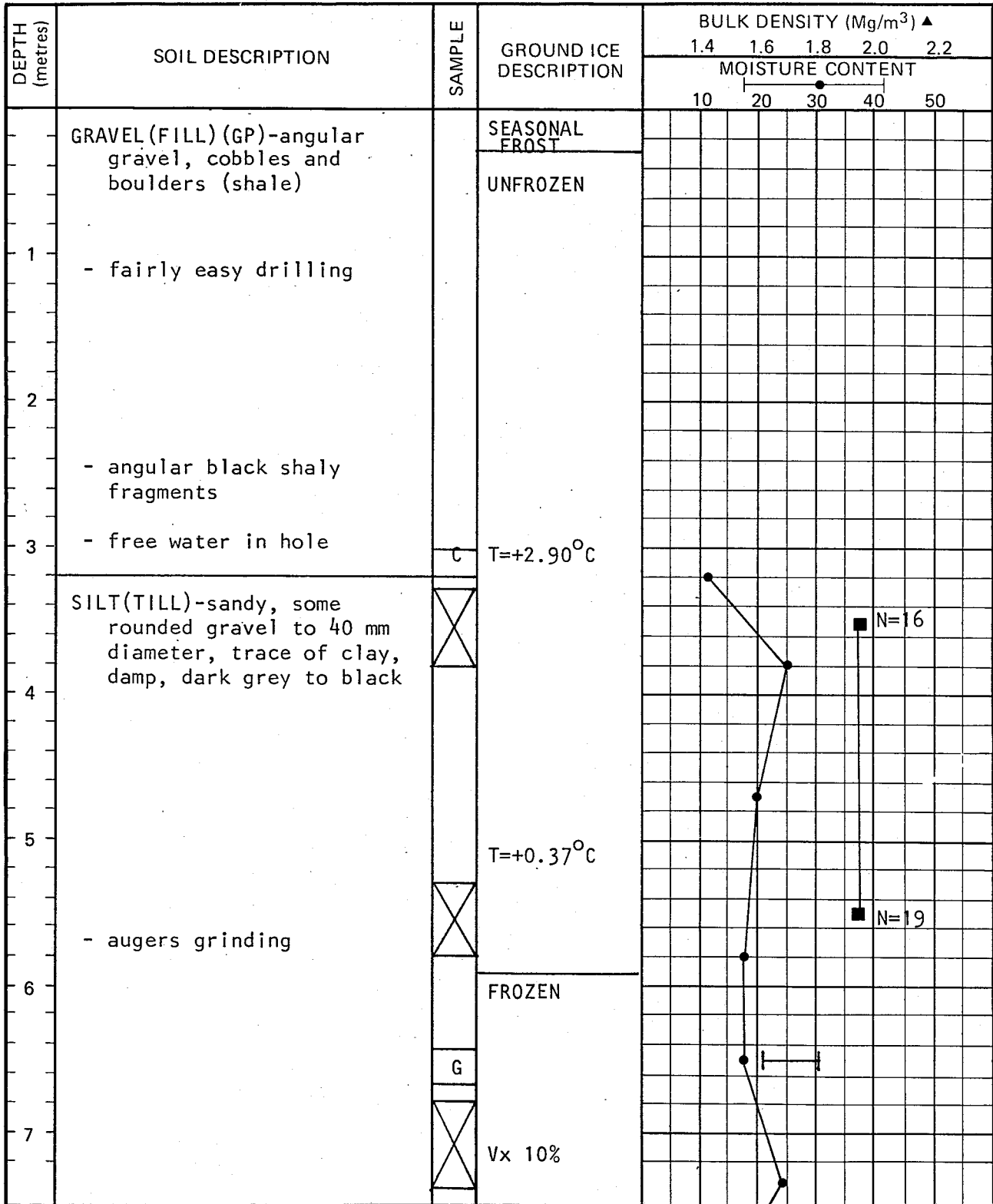
SCALE 1:500


NOTE: Drawing provided by Nordzone Consultants Ltd.

EBA Engineering Consultants Ltd. 	
JOB NO. 0201-4426	DATE: 1985-12-16
DRAWN BY:	DRAWING NO.:
REVIEWED BY: 	4426-G1

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY



	SFC. ELEVATION (m)	DATE DRILLED 1985-10-19	BOREHOLE No. 43
	COMPLETION DEPTH (m) 9.2	LOGGED BY JRT	
	DRILLING RIG CME 750	LOCATION km 229.8 (NWT)	PAGE 1 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
8	SILT(TILL)-sandy, some rounded gravel to 75 mm diameter, dark grey to black		FROZEN Vx, Vr trace					
9	- augers grinding							
10	END OF HOLE							
11								
12								
13								
14								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-19
COMPLETION DEPTH (m) 9.2	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 229.8 (NWT)

BOREHOLE No. 43
PAGE 2 OF 2

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				1.4	1.6	1.8	2.0	2.2
				MOISTURE CONTENT				
				10	20	30	40	50
1	GRAVEL (FILL) (GP)-angular gravel, cobbles and boulders (shale) - fairly easy drilling		SEASONAL FROST					
2			UNFROZEN					
3	- angular, black shaly fragments - free water in borehole							
4								
5	SILT (TILL)-sandy, some rounded gravel sizes, dark grey to black							
6		X	FROZEN					■ N=14
7	- augers grinding		Vx trace					
		X	T=-0.94°C					
END OF HOLE (8.3 m)-augers grinding								



SFC. ELEVATION (m)	DATE DRILLED 1985-10-19
COMPLETION DEPTH (m) 8.3	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 229.8 (NWT)

BOREHOLE No. 44
PAGE 1 OF 1

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

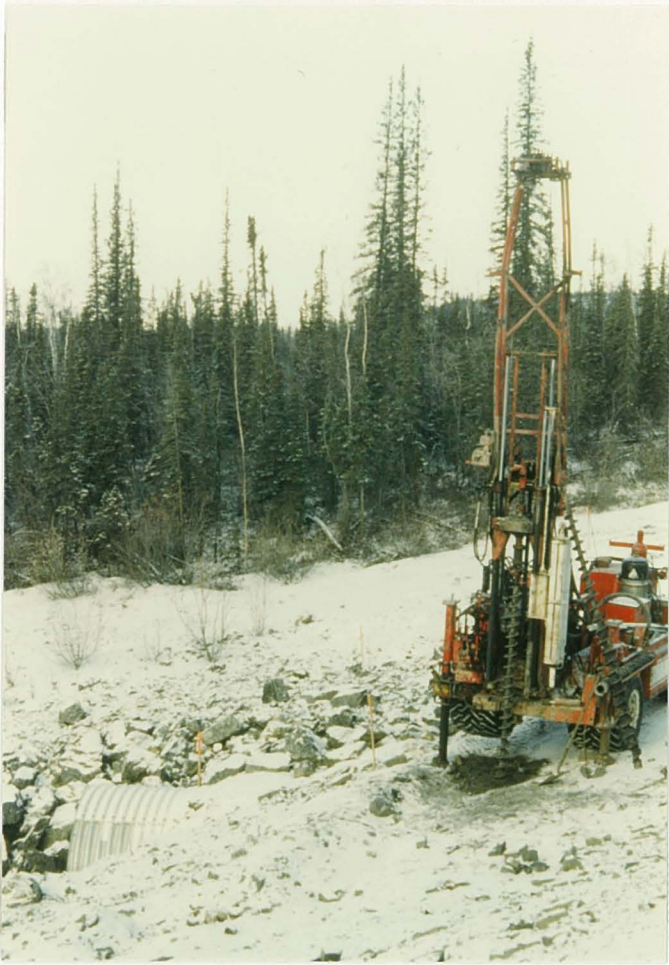


PLATE 18

km 229.8 - drilling
at Borehole No. 44.

PLATE 19

km 229.8 - General view of
end of culvert and creek,
near Borehole No. 44.



EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 229.8)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-18

Borehole Number: 43

Depth: 6.5 m

Soil Description: SILT & SAND - gravelly, trace of clay

Cu: _____

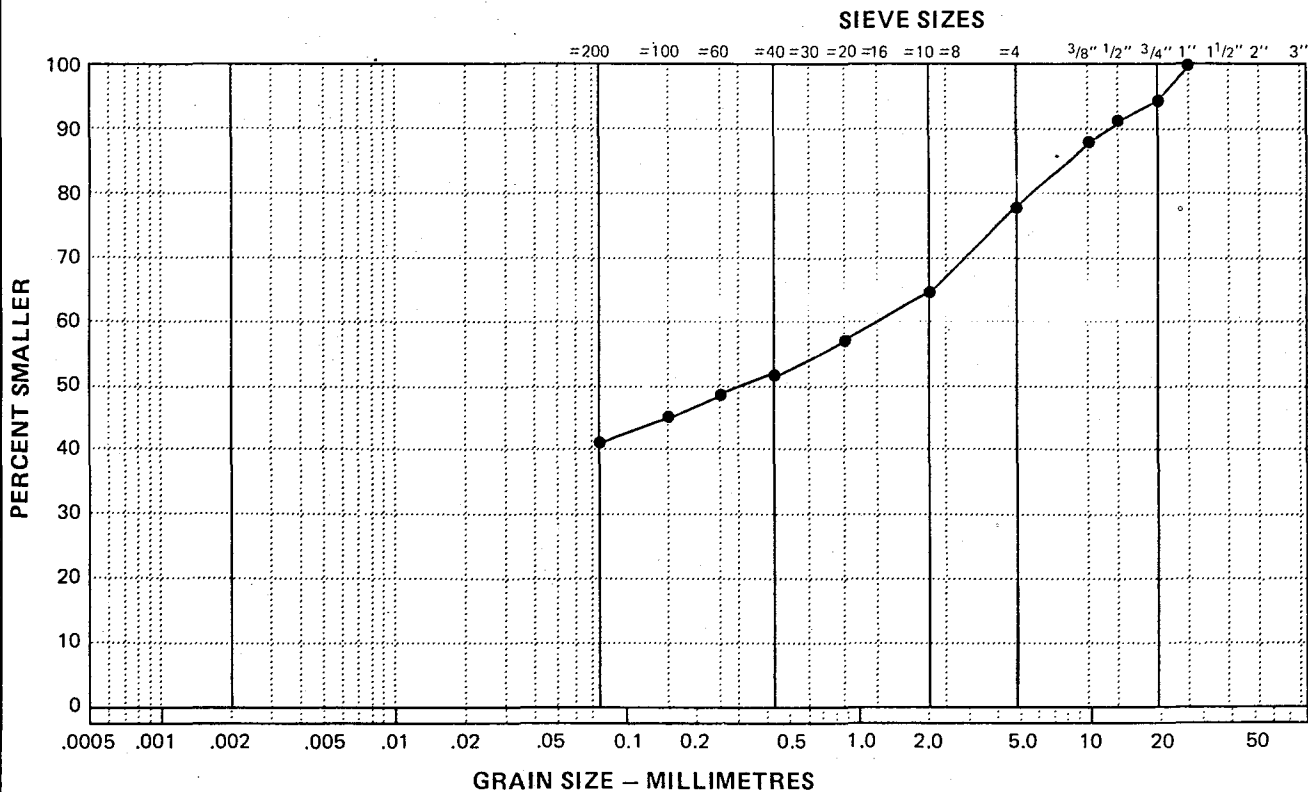
Cc: _____

Natural Moisture Content: 18.5 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	100
3/4"	95
1/2"	91
3/8"	88
No. 4	78
No. 10	65
No. 20	57
No. 40	52
No. 60	49
No. 100	45
No. 200	41

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 229.8)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-18

Borehole Number: 44

Depth: 5.3 - 5.8 m

Soil Description: SILT - sandy, some clay, trace of gravel

Cu: _____

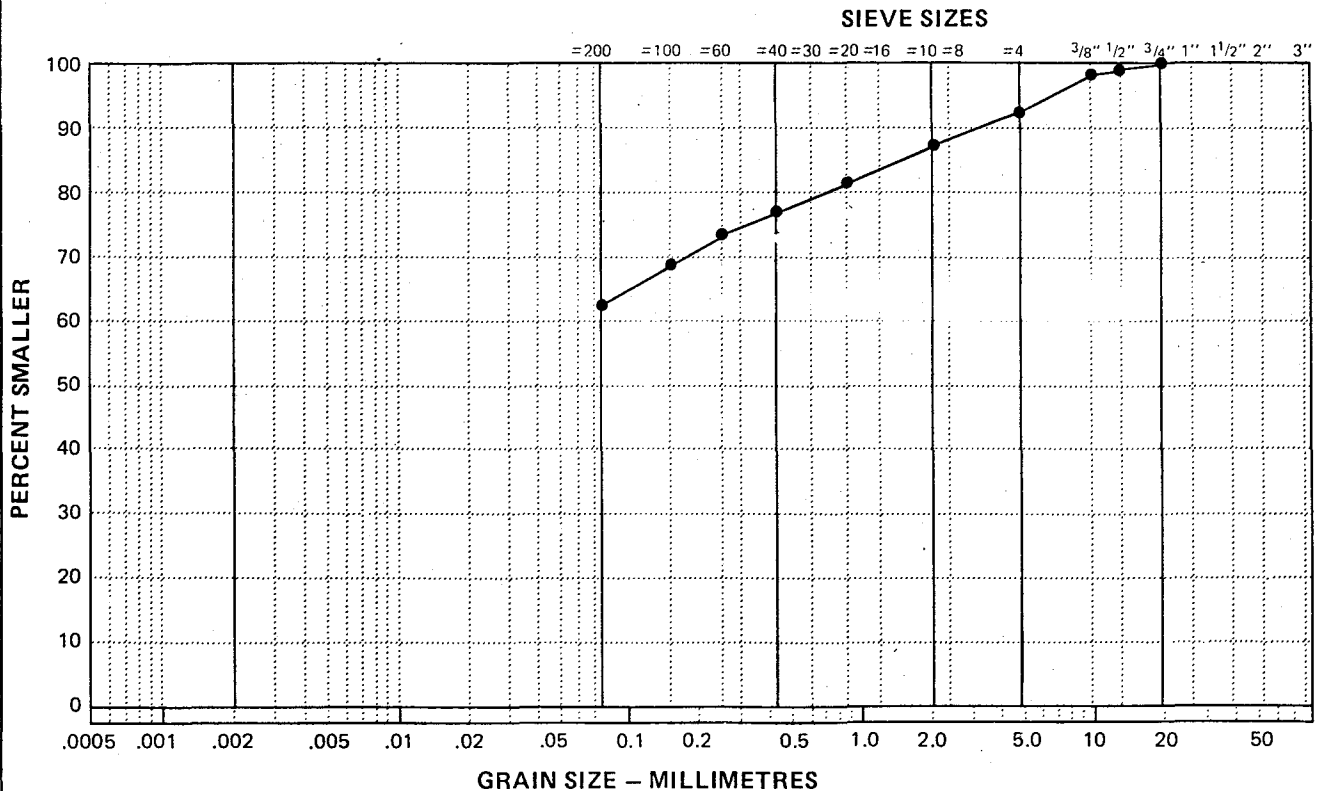
Cc: _____

Natural Moisture Content: 16.5 %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	100
1/2"	99
3/8"	98
No. 4	93
No. 10	87
No. 20	81
No. 40	77
No. 60	74
No. 100	69
No. 200	63

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.

APPENDIX H

km 247.0, Dempster Highway, N.W.T.

- H-1 General
- H-2 Investigation Program
- H-3 Results and Conclusions

Site Plan

Borehole Logs (BH 46, showing moisture contents, Atterberg Limits, SPT data, ground temperatures and bulk densities)
Grain Size Curves

APPENDIX H

km 247.0, Dempster Highway, N.W.T.

H-1 General

The two culverts at km 247.0 are experiencing some minor settlement under the roadway. Boreholes were required here to evaluate existing soil conditions, and to determine the cause of the culvert settlements.

H-2 Investigation Program

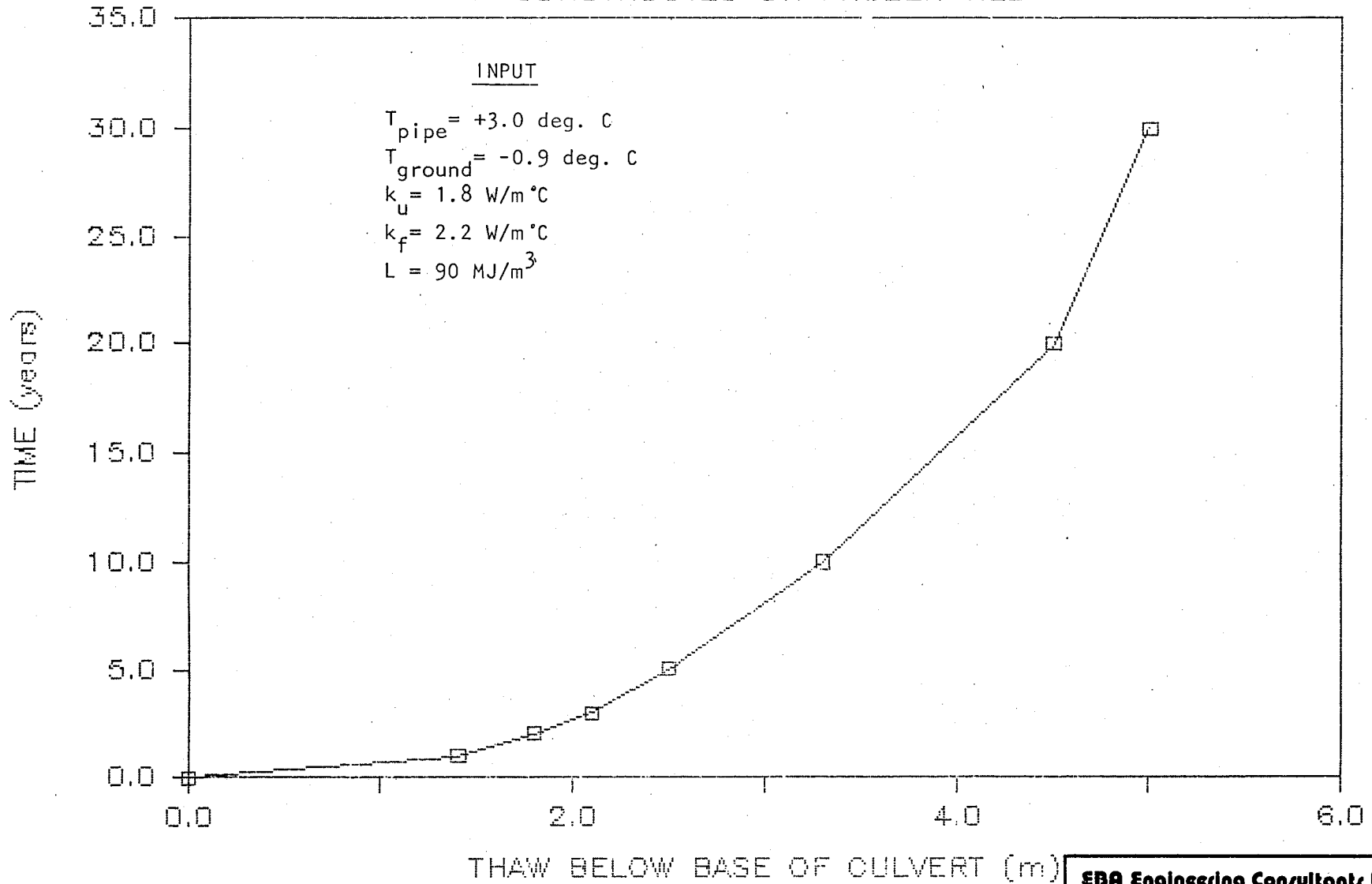
It was originally proposed to drill two boreholes at this location; however, only one hole on the upstream side could be drilled, due to the difficult access. Also, holes could not be drilled through the top of the embankment due to the narrowness of the road at this point. The one hole (BH 46) that could be completed was drilled through a sand bar, as close as possible to the upstream end of the culverts. The borehole location is shown on the Site Plan, attached, and was drilled to a depth of 6.3 m.

H-3 Results and Conclusions

The culverts at this location appear to be founded on the silt till stratum. The observed culvert settlements appear to be very minor, and are probably again related to thaw-settlement of the till, as in km 229.8 (Appendix G). The thaw was probably initiated by construction disturbance at the site. The borehole log indicates that there is a potential for minor additional future settlement, due to melting of localized higher ice content zones in the till.

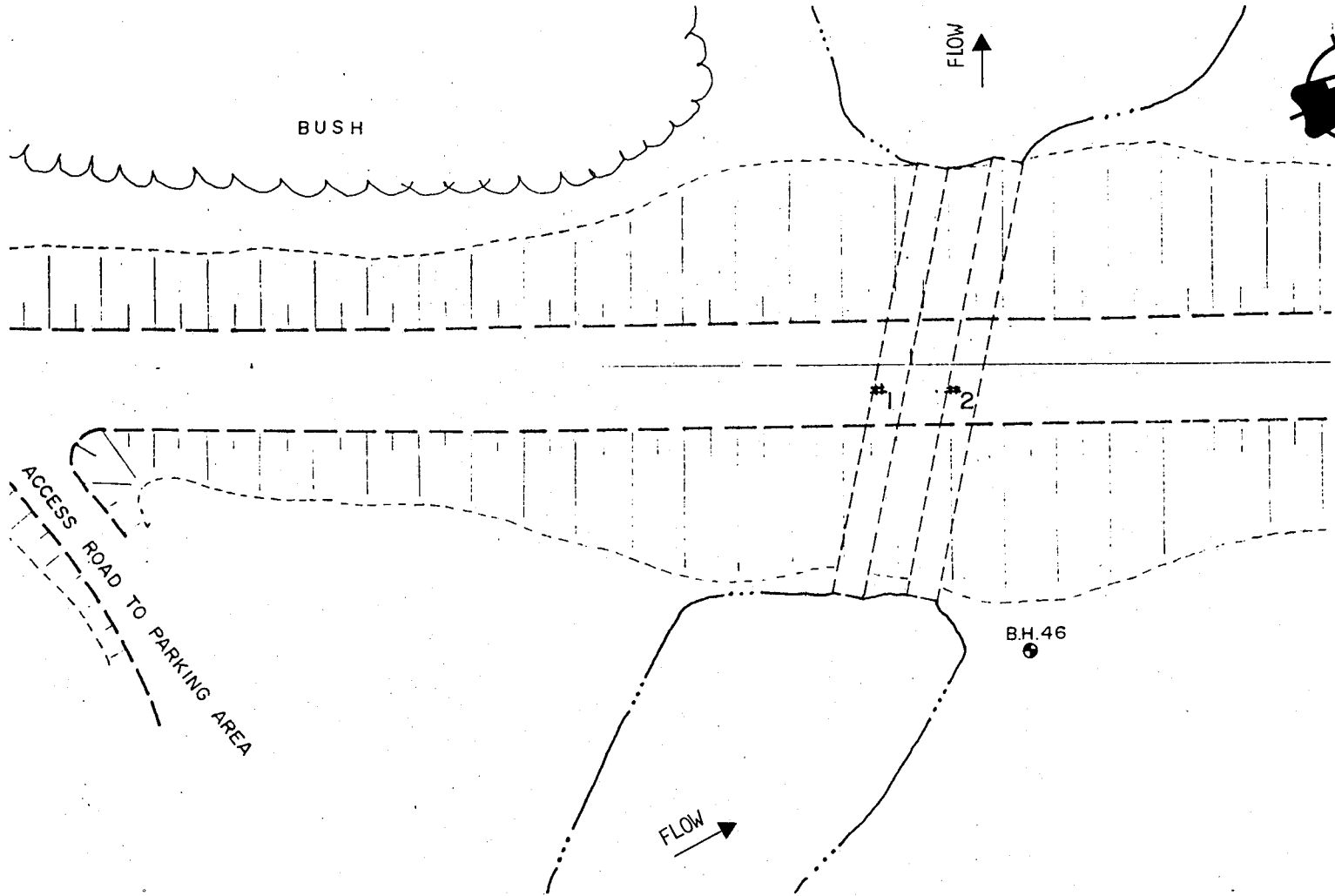
For reference purposes, a graph showing the penetration of thaw beneath a single culvert in this type of soil is presented as Figure 1 (next page). This calculation is applicable to both this site and to the culvert at km 229.8 (Appendix G). The thaw depth predicted from this calculation correlates very well with the thaw observed in the boreholes (BH 43).

THAW BELOW 2.2 m DIAMETER CULVERT CONSTRUCTED ON FROZEN TILL



EBA Engineering Consultants Ltd.	
JOB NO.: 0201-4426	DATE: 1985-12-16
DRAWN BY:	FIGURE 1
REVIEWED BY:	


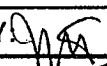
Ref. Hwang, C.T., 1977 On Quasi-Static Solutions for Buried Pipes in Permafrost



SITE PLAN AND BOREHOLE LOCATIONS
 CULVERT SITE
 km 247.0, DEMPSTER HIGHWAY, N.W.T.

SCALE 1:500

NOTE: Drawing provided by Nordzone Consultants Ltd.

EBA Engineering Consultants Ltd. 	
JOB NO. 0201-4426	DATE: 1985-12-16
DRAWN BY:	DRAWING NO.:
REVIEWED BY: 	4426-HI

BOREHOLE LOG – PERMAFROST

0201-4426
DEMPSTER HIGHWAY

DEPTH (metres)	SOIL DESCRIPTION	SAMPLE	GROUND ICE DESCRIPTION	BULK DENSITY (Mg/m ³) ▲				
				MOISTURE CONTENT				
				1.4	1.6	1.8	2.0	2.2
				10	20	30	40	50
	SAND & GRAVEL (GM)-trace of silt		SEASONAL FROST					
			UNFROZEN					
1	SILT (ML)-sandy, wet below 0.8 m, olive brown to dark grey							
	- some organic zones, wood fibres	X						
2			FROZEN					
	SILT (TILL) (ML)-sandy, some rounded gravel to 75 mm diameter, dark grey	X	T=-0.59°C					
3								
		G						
4			T=-0.71°C					
	- dark grey to black colour	C						
5			Vx, Vs 10% lenses to 3 mm thick					
	- water on top of all core barrels	C	T=-0.88°C					
6			Vx trace					
	- hard drilling	C	T=-0.81°C					
7	END OF HOLE							
	<u>NOTE:</u> Hole drilled on sand bar, near outlet of culvert.							



SFC. ELEVATION (m)	DATE DRILLED 1985-10-19
COMPLETION DEPTH (m) 6.3	LOGGED BY JRT
DRILLING RIG CME 750	LOCATION km 247.0 (NWT)

BOREHOLE No.	46
PAGE 1 OF 1	

This log is a compilation of subsurface conditions and soil or rock classification obtained from the field as well as from laboratory testing of samples from the boreholes. Soil zones have been interpreted according to commonly accepted practice. The change from one zone to another, as indicated on the log, may be transitional and approximate in nature. Groundwater conditions refer only to those observed at the times and places indicated and that may vary with time, geologic conditions, and construction activity.

EBA Engineering Consultants Ltd.

14535 - 118th AVENUE
EDMONTON, ALBERTA
Phone (403) 451-2121



5664 BURLEIGH CRES. S.E.
CALGARY, ALBERTA
Phone (403) 253-7121

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Dempster Highway (km 247.0 NWT)
Northwest Territories

Project Number: 0201-4426

Date Tested: 85-11-19

Borehole Number: BH 46

Depth: 5.4 - 5.5 m

Soil Description: SILT - trace of clay, trace of sand

Cu: _____

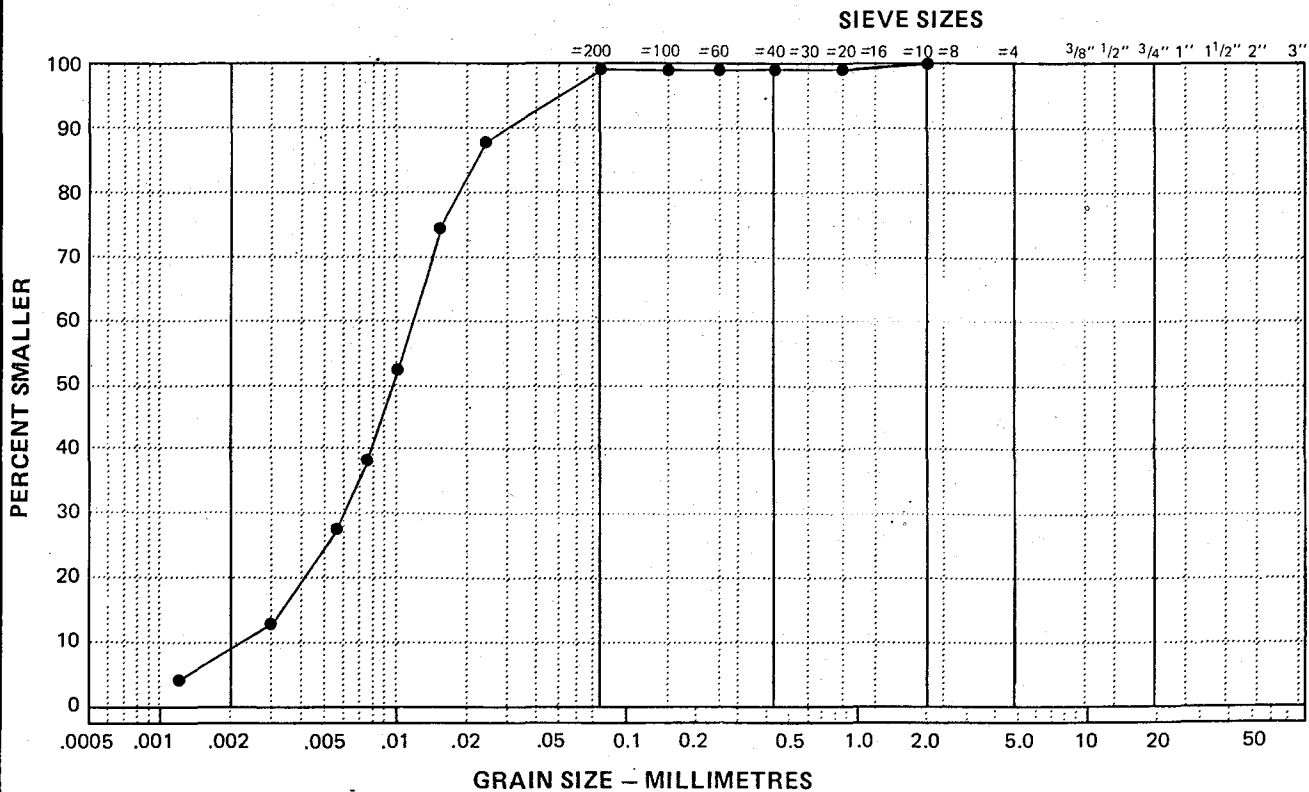
Cc: _____

Natural Moisture Content: 26% %

Remarks: _____

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	
No. 10	100
No. 20	99
No. 40	99
No. 60	99
No. 100	99
No. 200	99

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Tested in accordance with ASTM D422 unless otherwise noted.