VOLUME I

1975 PIPELINE BORROW INVESTIGATIONS
YUKON COASTAL PLAIN

Northern Engineering Services Company Limited

CALGARY ALBERTA

Northern
Engineering Services

ENGINEERS FOR

Arctic Gas

VOLUME I
1975 PIPELINE BORROW INVESTIGATIONS - YUKON COASTAL PLAIN

Prepared for
Canadian Arctic Gas Study Limited

By
Northern Engineering Services Company Limited
Calgary, Alberta

May, 1976

Project 13011

Northern Engineering Services Company Limited

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14 May 1976

Canadian Arctic Gas Study Limited
1270 Calgary House
550 - 6 Avenue S.W.
Calgary, Alberta
T2P 0S2

Attention: A.W. Wirth
Vice President & General Manager
Engineering & Construction

Reference: Volume I; 1975 Pipeline Borrow Investigations
- Yukon Coastal Plain

Dear Mr. Wirth,

We are pleased to submit this report which contains information on 33 borrow sources along the Yukon coastal plain from the Alaska -Yukon border to the western edge of the Mackenzie Delta in the Northwest Territories.

This work was undertaken as part of budget item 13011.

Yours truly,

NORTHERN ENGINEERING SERVICES COMPANY LIMITED

PH Dau

P.H. Dau
President

DAO:lh

PROJECT 13011

CANADIAN ARCTIC GAS STUDY LIMITED
CALGARY ALBERTA

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1. SUMMARY

Granular material in excess of one billion cubic yards have been identified along the Yukon coastal plain near the proposed Arctic Gas Coastal and Cross Delta pipeline routes. During the summer of 1975, Northern Engineering Services Company Limited investigated 33 granular deposits along proposed gas pipeline routes between the Alaska/Yukon border and the west side of the Mackenzie Delta. Geological and environmental reconnaissance combined with geophysical investigations, test pitting, and drilling were used to obtain information on the location and extent, quantity, quality, environmental factors, and development parameters for each of the 33 borrow sources.

This report contains descriptions of the field and laboratory results that pertain to each borrow source investigated. The detailed site specific information for each borrow source is presented as a complete report in the respective "Individual Site Report." It also has sections describing the regional geological and environmental setting of the Yukon coastal plain, the geophysical methods used to investigate the borrow deposits, and the logistics of the program.

2. INTRODUCTION

During the summer of 1975 a borrow exploration program was undertaken by Northern Engineering Services Company Limited (NESCL) for Canadian Arctic Gas Study Limited (CAGSL) along the proposed gas pipeline route north of latitude 60° in Canada.

Territory covered by the program included the Yukon coastal plain portion of the Coastal Route, the Cross Delta Alternative Route, and the Main Canadian Route with the East of Fort Simpson realignment.

The program was oriented toward obtaining preliminary site specific information on potential granular borrow deposits along the pipeline. Emphasis was placed on investigating sources that were outside areas covered by the DIAND Granular Materials Inventory and on gathering further information on granular deposits in previously documented areas where shortages of good quality borrow have been identified. In addition, field visits were made to borrow sources which appear in the pipeline application and further information was gathered on surface and subsurface aspects of terrain along the pipeline.

Prior to this borrow field study, airphotos, published surficial geology maps, and DIAND Granular Materials Inventory reports were assessed to obtain information on potential borrow sources that could be used in pipeline construction. Preliminary choices of borrow sources for the pipeline and its facilities are shown in the pipeline application and in two NESCL reports titled Pipeline Related Borrow Studies (July 1974) and Pipeline Related Borrow Studies Cross Delta Alternative Route and East of Fort Simpson Realignment (November 1975).

The study reported on here represents the beginning of site specific field investigations of pipeline construction material sources. As final design progresses, more detailed examination of granular borrow and quarry sites designated for specific pipeline right of way and facilities will be undertaken prior to their development.

The borrow field program consisted of a geologic and environmental reconnaissance of granular material sources followed by ground geophysical investigation, test pitting and drilling of promising deposits selected during the reconnaissance. The borrow investigation was carried out concurrently with the wharf site drilling investigation from Richards Island to latitude 60° to optimize the use of helicopters, tugboats, and fuel barges. Along the Yukon coastal plain only the borrow field investigations were done during the summer program.

The assignment of field staff, organization, management, and supervision for this project was provided by NESCL. Engineering field support, field geophysical activities, and the geological reconnaissance from Fort Good Hope to latitude 60° was also done by NESCL personnel. The geological reconnaissance along the Yukon coastal plain and from Richards Island to Fort Good Hope was done by Dr. V.N. Rampton, P. Eng., of Terrain Analysis and Mapping Services Ltd. Environmental reconnaissance and analysis was the responsibility of Mr. D.R. Wooley, Wildlife Biologist, Renewable Resources Consulting Services Ltd. Laboratory testing of samples collected in the field was done by R.M. Hardy and Associates Ltd., Calgary, Alberta. Drilling crews and equipment were supplied by Kenting Big Indian Drilling, helicopter support on the Yukon coastal plain by Bow Helicopter Ltd. and Kenting Aviation Ltd., and barge facilities by Northern Transportation Company Limited. Other groups that provided support for the borrow field program are listed in the Equipment and Personnel section of this report.

The field investigation for the borrow study was carried out as a single operation beginning at the Alaska/Yukon border July 12, 1975, and continuing to the Fort Simpson, N.W.T. area, where it was completed September 21, 1975. The report has been divided into three volumes on the basis of geographical regions within the area studied, for ease in handling the data gathered during the program. The three volumes are:

Volume I:	1975 Pipeline Borrow Investigations - Yukon Coastal Plain
Volume II:	1975 Pipeline Borrow Investigations - Richards Island to Fort Good Hope, N.W.T.
Volume III:	1975 Pipeline Borrow Investigations - Fort Good Hope, N.W.T. to Latitude 60°

This report is the first volume describing the borrow investigation. It covers the Yukon coastal plain portion of the pipeline from the Alaska/Yukon border on the west to the western side of the Mackenzie Delta on the east. This area was not covered by the DIAND Granular Materials Inventory. A total of 33 sites were investigated during this phase of the borrow study, of which 29 sites were drilled and test pitted and 4 sites were investigated on a reconnaissance basis.

3. EQUIPMENT AND PERSONNEL

3.1 Equipment

3.1.1 Drills and Ancillary Equipment

The Kenting Big Indian Heli-Drill was used to drill test holes in selected borrow sites. The Heli-Drill is a helicopter-transportable Mayhew 200 drilling rig mounted on a detachable base which can be levelled by means of three hydraulic jacks. The power units for the drill and air compressor consist of two Wisconsin VH4D 30-horsepower air-cooled gasoline engines which operate independently of each other. The Heli-Drill is usually transported as two packages. The first package consists of the drill frame, rotary table, draw works, mast assembly, and one power unit, and the second package consists of the drill base upon which the air compressor and the second power unit are mounted. Each of these two components weighs approximately 3400 pounds and is equipped with custom slinging cables to ensure a properly balanced load for transportation by helicopter.

Photo 3.1.1
View of Kenting Big Indian Heli-Drill drilling by means of airflush to prove out depth of granular materials deposit on the Yukon coastal plain.

All ancillary drilling equipment and tools such as drill rods, drilling bits, hand tools, and spare parts were carried in a steel mesh tool basket weighing approximately 3500 pounds. A mud pump complete with power unit was also taken into the field to provide wet drilling capabilities for the Heli-Drill. The air compressor and mud pump units are easily interchangeable.

The Kenting Big Indian Heli-Drill was selected for this borrow investigation because it can be used either with the compressed air or water circulation modes for drilling. In addition, the Heli-Drill has more versatility for handling a greater number and variety of downhole sampling tools and drill bits. The Kelly and Sand line cables were modified by double lining to provide better pulling capabilities in the event that either the drill bit or sampling tools became lodged during removal.

3.1.2 Test Pitting Equipment

Two 150-cfm gas-powered Ingersol-Rand air compressors were used along the Yukon coastal plain portion of the borrow source study to facilitate the test pit excavations. Each air compressor was equipped with two 60-pound air hammers, 200 feet of steel reinforced rubber air hose, and an assortment of 3-inch wide clay spades and 2-inch wide asphalt spades. The air compressors and associated equipment were supplied by Modern Industrial Rentals Ltd., Calgary, Alberta and were equipped with an upper hook for slinging by helicopter. The air compressor with its complete complement of tools weighed approximately 3000 pounds.

Each test pitting crew of four men was provided with air compressor equipment, two long handled spades and two picks.

Photo 3.1.2
Test pit crew beginning to excavate a test pit on the Yukon coastal plain. An air compressor outfitted with jackhammers is located on site for use in excavating into the permafrost.

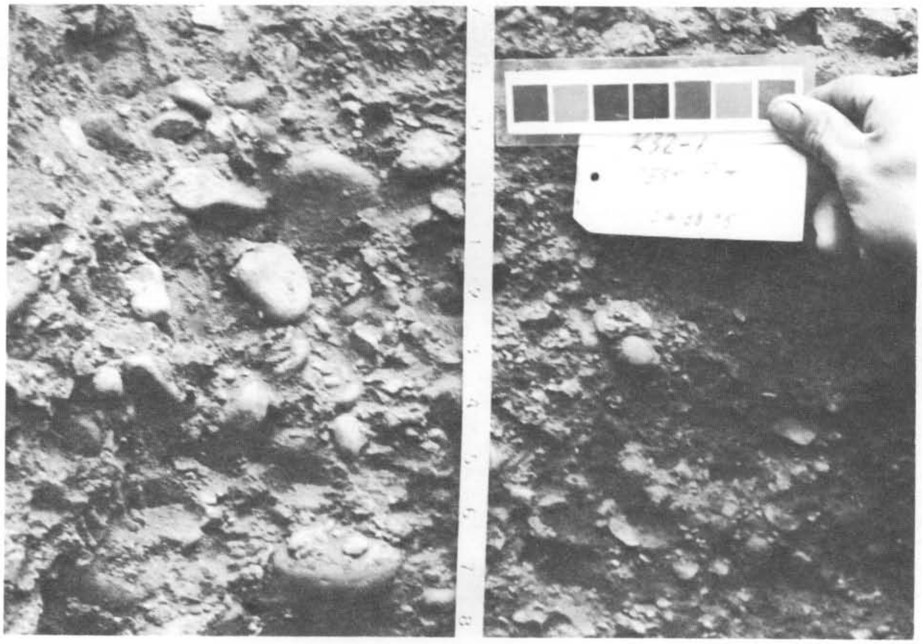


Photo 3.1.3
Typical view of a test pit side wall at deposit N75-117A-B12 on the Yukon coastal plain.

Photo 3.1.4
Test pit crew filling in a test pit after the soil was logged, samples were collected, and photographs were taken on the Yukon coastal plain.

3.1.3 Geophysical Equipment

A complete description of the geophysical equipment used in this portion of the borrow source investigation is presented in Section 6 of this report entitled "Geophysical Investigations of Granular Deposits."

3.1.4 Helicopters

A Bell 206B Jet Ranger helicopter supplied by Bow Helicopter Ltd. from its Inuvik, N.W.T. base was used for the geological reconnaissance crew. This helicopter is turbine-powered and has a capacity to carry four passengers or sling up to 1100 pounds of cargo. In addition to ferrying the geological reconnaissance party, on occasion, the Bell 206B Jet Ranger helicopter was used to position the geophysical crew and equipment.

A Sikorsky S58E gasoline-powered helicopter provided by Kenting Aviation Ltd. with a maximum rated sling load lifting capacity of 4000 pounds was selected to transport the Heli-Drill components, air compressors, bulky gravel samples, and the crews for the geophysical, test pitting, and drilling activities. The Sikorsky S58E helicopter has a very large cabin configuration which provides a very convenient, efficient and economical mode for transporting passengers, small equipment, and samples in a single air lifting operation.

3.1.5 Sampling Equipment

Since the test pitting operations constituted the principal method for obtaining representative granular material samples, and drilling was used primarily to establish or confirm the depths of selected granular material borrow sites, sophisticated sampling and coring tools were not required. The air return cuttings and observation of the drilling action were the main criteria used to evaluate and assess the downhole conditions and quality of the material being drilled.

However, thick-walled 3-inch I.D. Shelby tubes and 2-inch O.D. split spoon Raymond-type samplers were taken to the field in case they were needed. These sampling devices could be driven into the appropriate strata by a 140-pound drop hammer.

3.1.6 Radio Communications Equipment

The number of separate crews working concurrently at scattered locations away from the base camp necessitated a good communications network for both emergency purposes and efficient coordination of crew movements. Motorola Model PT300 lunch bucket type FM radios powered by rechargeable nickel-cadmium batteries were issued to the geological reconnaissance party, the geophysical party, the drilling crew, two test pitting crews, the Sikorsky S58E helicopter, and the base camp.

The S58E helicopter was used, almost entirely, to move the crews and their related equipment. As a result of this, the Motorola radio connected into the helicopter's intercom system became the field control centre for maintaining and coordinating the daily program logistics. These portable radios proved to be invaluable for maintaining efficient operations during the course of the field program.

In addition, the base camp was equipped with "Very High Frequency" (VHF) and "High Single Side Band" (HSSB) radios to provide communications to the outside and southern population centres.

3.1.7 Accommodation and Support Facilities

The 24-man barge camp, 150-ton supply barge, Mark I Jetboat and casual tugboat charter were provided by Northern Transportation Company Limited (NTCL). The 24-man camp was specifically built and equipped to be mounted on a 300-ton river barge and contained sleeping quarters, kitchen, dinette, recreation area, radio room, washroom, laundry facilities, power plant, and general shop.

Support facilities consisted basically of fixed-wing aircraft charters. Light fixed-wing charters, consisting of Cessna 185 flights, were provided by Corridor Air Ltd. of Inuvik, N.W.T. Fixed-wing charters for larger crew changes and bulkier supply transportation were provided by Kenn Borek Airways Ltd. of Inuvik, N.W.T., in their Twin Otter.

3.2 Personnel

The following personnel were involved during the borrow source investigation along the Yukon coastal plain:

Personnel	Affiliation
1 Project Manager	NESCL
1 Project Engineer	NESCL
1 Project Geologist	Terrain Analysis & Mapping Services Ltd.
1 Junior Geologist	NESCL
1 Geophysicist	NESCL
2 Junior Geophysicists	NESCL
2 Geotechnical Engineers	NESCL
1 Intermediate Soils Technician	NESCL
6 Test Pitting Northern Labourers	NESCL
1 Driller	Kenting Big Indian Drilling
1 Driller's Helper	Kenting Big Indian Drilling
Helicopter Pilots:	
1 Bell 206B	Bow Helicopters Ltd.
1 Sikorsky S58E	Kenting Aviation Ltd.
2 Helicopter Engineers	Kenting Aviation Ltd.
1 Cook	NTCL
1 Cook's Helper	NTCL
1 Camp Attendant	NTCL
1 Camp Mechanic/Radioman	NTCL

The entire field party was billeted on the NTCL Camp Barge for the duration of the field program.

4. LOGISTICS AND METHODOLOGY OF FIELD OPERATIONS

4.1 Logistics

The detailed criteria regarding the logistics for the borrow source field program on the Yukon coastal plain have been documented separately in a report entitled "1975 Summer Wharf and Borrow Investigation Logistics Summary" dealing with planning, expediting, and logistics. The logistics and organization for the field program along the Yukon coastal plain were almost entirely directed towards the execution of the borrow source study. The borrow source program became fully integrated with the wharf site drilling program when the borrow source program was located on the Richards Island side of the Mackenzie Delta.

Although the detailed, chronological documentation of the logistics for the borrow study has been compiled separately under the above title, a brief description of the logistical planning and execution for the Yukon coastal plain portion of the borrow study is listed as follows:

a) The staging of all NTCL equipment such as the barge camp, 150-ton supply barge, Mark I boat and river tugboat was mobilized at Hay River, N.W.T. Field supplies, tools, and equipment required by NESCL were staged into Hay River, N.W.T. The NTCL and NESCL equipment departed from Hay River, N.W.T. on July 12, 1975.

b) Drill rigs, air compressors and ancillary equipment were staged into and mobilized from the Keen Industries Ltd. yard in Fort Simpson, N.W.T. This equipment was picked up by the NTCL barge train on July 14, 1975.

c) The NTCL barge train took on the ordered supply of 100/130 octane aviation fuel, regular gasoline and jet fuel from the Imperial Oil bulk dealer at Norman Wells, N.W.T. on July 16, 1975.

d) The fully equipped and supplied barge train arrived in Inuvik, N.W.T. on July 18, 1975. Catering personnel contracted from NTCL, and grocery supplies were taken on at the NTCL docks on July 19, 1975. The NESCL party chief and assistant arrived on July 19, 1975 to check out all equipment, accommodation and catering facilities.

e) The NTCL barge camp and related equipment departed Inuvik on July 20, 1975 with an ocean-going tug for a mooring on the Arctic coast at Catton Point, Yukon Territories.

f) The Sikorsky S58E helicopter departed Calgary International airport on July 21, 1975 with a projected ETA for Inuvik, N.W.T. of 3:00 pm, July 22, 1975.

g) The NESCL field group and the contract staff arrived in Inuvik on July 21, 1975.

h) Six northern labourers for the test pitting crew were hired in Inuvik, N.W.T. on July 22, 1975.

i) The entire project field group including engineers, technicians, drilling personnel, helicopter personnel, and northern labourers was positioned by fixed or rotary wing aircraft into the barge camp base at Catton Point, Y.T. on July 23, 1975.

j) The field work commenced from the Catton Point base camp at 12:00 noon on July 23, 1975 and continued from this location until July 30, 1975.

k) On July 30, 1975 the barge camp was moved from Catton Point, Y.T., to Tiktalik Channel, N.W.T. The remainder of the borrow source field program along the Yukon coastal plain was completed from this base location.

l) The field work on the Yukon coastal plain was completed on August 7, 1975.

4.2 Methodology

4.2.1 Literature Review and Office Study

Pertinent geological information from various studies such as the Geological Survey of Canada maps and reports, pipeline alignment sheets, private industry reports and previous NESCL project reports were compiled and assessed for the Yukon coastal plain study area. This data served as a focus for airphoto interpretation to map and delineate favorable areas of prospective granular material sites. Deposits were selected for further investigation according to their position relative to the proposed pipeline right of way, their position relative to major stream valleys, the amount of overburden covering the granular material, and the anticipated quality of the insitu granular material. Special efforts were made to prove out granular deposits near the western edge of the Mackenzie Delta.

4.2.2 Geological Field Reconnaissance

The airphoto interpretation and office studies served as a focus for planning and conducting the preliminary geological field reconnaissance. A senior geologist and a geological technician carried out the site by site ground check of each potential borrow source selected by airphoto interpretation. The outlines of the prospective borrow sites were carefully delineated on the corresponding airphoto along with any additional salient features of the deposit. The exact location of the test pits, drill holes, and transects for ground geophysics was also specified and designated during this reconnaissance for each borrow site selected for additional detailed investigation.

A project environmentalist accompanied the geological reconnaissance group to provide the required site by site environmental assessment and critique. A more detailed documentation of the "Environmental Analysis" is provided under Section 7.

4.2.3 Field Investigation

On the basis of the geological reconnaissance and the time period available to complete the detailed field investigation along the Yukon coastal plain, a total of 29 borrow sites were selected for test pitting, drilling and geophysics. This schedule was based on the completion of two borrow sites each work day. An additional four borrow sites were ground checked during the geological reconnaissance.

Generally, two to three test pits per borrow site were completed by the two test pitting crews consisting of three northern labourers for each crew. The supervision of the two test pitting crews, sampling and logging was carried out by a junior geotechnical engineer. The test pits excavated were generally 4 by 6 feet in area and extended from 4 to 10 feet in depth. The 60-pound hammers, powered by compressed air, were used to extend these test pits beneath the permafrost table. In general, the test pits were selected in areas where the active layer was thought to be the deepest. All organic peat and/or vegetation material on the surface of the test pit location was carefully removed and replaced after the test pit had been backfilled.

When the test pit had been excavated to the desired depth, a representative sample of granular material was taken from the exposed vertical wall of the test pit. These samples generally weighed 400 to 500 pounds and consisted of six to ten sample bags. The granular material was retained in heavy plastic bags in order to minimize the loss of moisture content and fines. In addition to the samples, a photographic record was made by photographing one vertical face of the test pit in a series of frames from the surface to the bottom of the pit.

The depth of each borrow site was checked in detail by drilling. A helicopter-portable "Heli-Drill", which is described in detail in Section 3 of this report, was used. In general, the drill hole locations were selected where the active layer was shallowest in order to minimize caving and "blow out" problems during the drilling operations. An open-hole air circulation technique was used primarily, although a wet circulation capability was available on this drilling rig. The detailed subsurface logging was established by observing the air flushed cuttings and the downhole drill action.

The ground geophysics conducted at each borrow site were carried out by a three-man crew. The details and the results of the geophysical investigation are included in Section 6.2 of this report.

4.2.4 Laboratory Testing

The entire series of test pit samples obtained for this portion of the borrow study were forwarded to R.M. Hardy and Associates Ltd. Calgary, Alberta. The following laboratory tests were carried out:

a)	Mechanical Grain Size Analysis	ASTM C 136 - 71
b)	Moisture Content	ASTM C 566 - 67
c)	Petrographic Analysis	ASTM C 295 - 65
d)	Los Angeles Abrasion Test	ASTM C 131 - 69
e)	Sulphate Soundness Test	ASTM C 88 - 73
f)	Organic Content	ASTM C 40 - 73

The schedule of samples to be tested and the types of tests to be conducted on each sample were provided to R.M. Hardy and Associates Ltd. by NESCL. The results of the laboratory tests are included in the individual site reports.

4.2.5 Report Format

The site specific information for each potential borrow site is incorporated in the "Individual Site Reports" in Section 10 of this report.

5. REGIONAL GEOLOGY AND GEOMORPHOLOGY OF THE YUKON COASTAL PLAIN

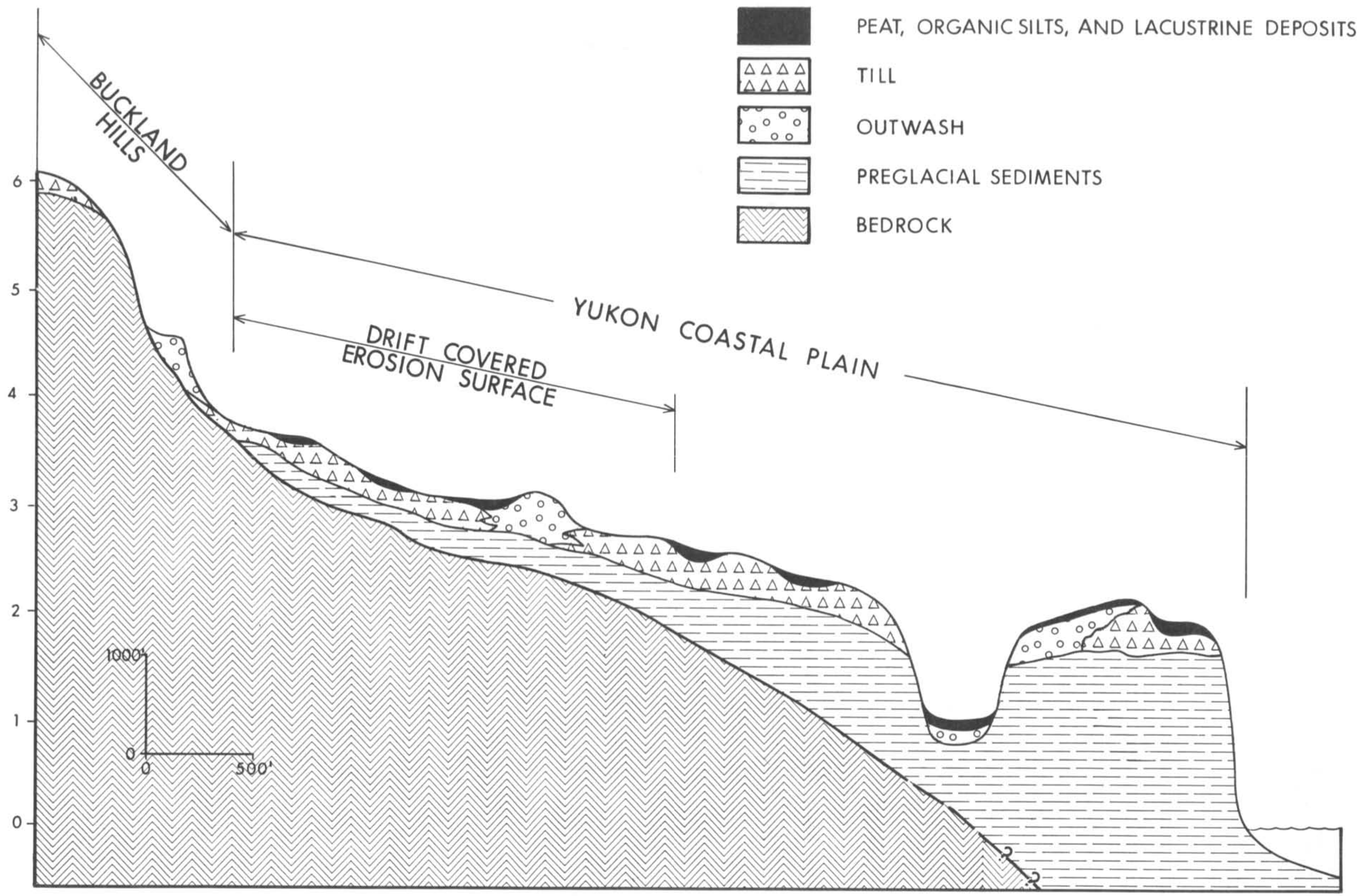
5.1 General

The study area covered by this volume lies mainly within the Yukon coastal plain, although some borrow sites were on the edge of Buckland Hills. The Buckland Hills consist of bedrock-cored ridges and valleys containing varying thicknesses of unconsolidated deposits. The Yukon coastal plain is a complex physiographic unit consisting of the following two parts:

a) a part bordering the coast and underlain by unconsolidated deposits more than 200 feet in thickness, and

b) a part bordering the mountains and consisting of a pediment overlain by unconsolidated deposits of moderate thickness.

The northeastern edge of the study area is covered by the Mackenzie Delta, which is separated from the Yukon coastal plain by a prominent escarpment.



SCHEMATIC CROSS-SECTION ACROSS YUKON COASTAL PLAIN SHOWING TYPICAL STRATIGRAPHIC AND GEOMORPHIC RELATIONS. PREGLACIAL SEDIMENTS LOCALLY CONSIST OF GRAVEL AND SAND. GROUND ICE HAS BEEN EXCLUDED.
FIGURE 5.1.1.

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5.2 Bedrock

Bedrock along the northern edge of the Buckland Hills consists mainly of interbedded argillites and sandstones of the Precambrian Neroukpuk Formation. Locally, late Paleozoic and Mesozoic quartzitic conglomerates, quartzites and shales are present. The Yukon coastal plain is underlain mainly by Cretaceous shales with smaller amounts of lithic sandstones, often high in chert content. All units have been folded and faulted. In general, the bedrock surface under the coastal plain rises gently to the south and southeast. Near the coast, bedrock is exposed southeast of Shingle Point in the escarpment separating the Yukon coastal plain and the Mackenzie Delta.

5.3 Surficial Deposits

On the coastal plain west of Firth River surficial deposits are primarily nonglacial terraced alluvial fans consisting of gravel and lacustrine deposits overlying marine silts and clays. Upper levels of the alluvial fans often have covers of ice-rich organic silt and peat up to 10 feet thick, but rarely exceeding 5 feet. Younger parts of the alluvial fans at lower levels have only localized veneers of silt and peat, and braided patterns of bars and abandoned channels can be easily distinguished on their surface. In intervening areas not covered by alluvial fans the lacustrine deposits are silty colluvium, eolian and marine deposits that have been re-worked by thermokarst processes. The lacustrine deposits are fine-grained with occasional lenses of peat and moderate ice contents.

The adjacent Buckland Hills are covered by colluvium, mainly pebbly silts having traces of organic matter and high ice contents. Colluvium may be coarser where the hills are underlain by more resistent bedrock. Valleys generally have mixed deposits consisting of colluvium near their edges and washed fluvial deposits along their axes.

East of the Firth River, the geology is more complex because of thicker unconsolidated materials and glaciation. The coastal plain and adjacent mountains were glaciated by Laurentide glacier ice moving from east to west. This ice extended northwest to just beyond the Firth River and pushed up a number of river valleys in the mountains south of the coastal plain. The limit of glaciation is marked by meltwater channels, patches of outwash and morainal ridges. During deglaciation the glacier margin simultaneously retreated toward the coast from its southwest margin and eastward from its western limit. During that time drainage was northwestward, parallel to the glacier margin, because the glacier ice blocked direct northward drainage to the ocean. Thus, meltwater channels and kame deltas mark a number of glacier retreatal positions along the hills and mountains flanking the coastal plain, and broad outwash fans mark different locations of the glacier terminus at its northwestern edge where the meltwater finally flowed north to the Beaufort Sea. On the coastal plain itself a prominent still-stand produced a large meltwater channel that extends from just opposite Coal Mine Lake to near Kay Point, and generally runs within 2 to 5 miles of the coast. Its coastward edge is marked by numerous individual and coalescing outwash and kame deltas formed by meltwater flowing off the glacier to the southwest. Shallow active layers have impeded drainage on broad flat areas of outwash and resulting in build-up of ice-rich silt and peat in many areas.

Hummocky topography underlain by till or till-like sediments covers much of the coastal plain. The till and till-like deposits generally vary between 2 and 30 feet and overlie a complex of preglacial and often deformed marine, lacustrine and fluvial deposits. Often the till and underlying materials have high ice contents. Preglacial gravels and sands are present in the subsurface west of King Point opposite the mouth of the Crow River, and near the lower Blow River valley and Shingle Point. Interspersed throughout the hummocky topography are flat lacustrine plains of thermokarst origin. The lacustrine deposits consist of thinly bedded and organic silty clays, silts, and silty fine sands and are generally capped by peat.

A number of streams have formed terraces and floodplains inset into the preglacial and glacial deposits. Most terrace systems are aligned in a northeast direction perpendicular to the coast, although locally they may parallel the coast following old meltwater channels. Similar to the glacial deposits, broad fluvial terraces often have a cover of ice-rich organic silt and peat.

The Mackenzie Delta is composed of fine-grained sediments with numerous peaty layers. A complex of lakes and channels covers its surface.

5.4 Permafrost and Ground Ice

The study area lies within the zone of continuous permafrost. Taliks exist in lake basins and under some streams and floodplains. The active layer varies from less than 1 foot on peat-covered surfaces to more than 4 feet on south-facing slopes showing bare gravels.

Ground ice is present on the Yukon coastal plain and on the flanks of the Buckland Hills in a number of forms: pore ice, ice lenses and veins, tabular bodies of massive ice, and ice wedges. Pingos are present, but rare. Pore ice and narrow lenses and veins exist in all frozen sediments, although fluvial and glaciofluvial deposits often will not contain excess ice, if thawed. Fine-textured lacustrine sediments, colluvium, and some till generally contain moderate amounts of ground ice, mainly in the form of ice lenses. Tabular bodies of icy sediment with high ice contents and massive pure ice are present in a number of stratigraphic positions; primarily under thin silty colluvium on gentle to moderate bedrock slopes, within till and fine-grained preglacial sediments underlying hills in hummocky terrain, in irregular layers in deformed preglacial sediments, and rarely at the base of kame deltas and terraces. Ice wedges are ubiquitous throughout the region; on flat areas underlain by peat or fine-grained deposits they are reflected at the surface by polygons. Except for active floodplains, most deposits composed of sand or gravel contain a network of ice wedges. However, they appear to be less frequent and smaller where sand and gravel is bare of peat or organic silt.

5.5 Drainage

Most streams crossing the Yukon coastal plain have their sources in the British and Richardson Mountains to the south. Most of their discharge originates in these areas with only small contributions from the small poorly developed drainage basins on the coastal plain. The major streams that cross the coastal plain at its eastern end plain near Shingle Point are more deeply incised than those to the west. The flatness of the Yukon coastal plain relative to the hills and mountains to the south has caused the streams to construct alluvial fans on the coastal plain where the streams are not confined in bedrock canyons. This is especially evident to the west of the glacial limit. East of the glacial limit, alluvial fans are in an incipient stage of development.

Local drainage on the coastal plain is a poorly developed maze of small beaded streams and interconnected lakes. On relatively flat terraces and alluvial fans, surface drainage is mainly by seepage through the active layer, along shallow trenches outlining ice-wedge polygons, and along the traces of abandoned stream channels. On broad alluvial fans this seepage and shallow surface flow is enough to keep channels bare of vegetation and give them the appear--ance of being periodically flooded. Extensive flat areas of gravel have near-surface water tables because of shallow permafrost and low surface gradients.

5.6 Granular Materials

Granular materials in the study area are concentrated in the following environments:

1) Terraced alluvial fans adjacent to the Firth River, Malcolm River, Fish Creek, and Clarence Lagoon.
2) Terraces adjacent to major rivers and creeks east of the Firth River.
3) Floodplains of major rivers and creeks.
4) Broad outwash fans on the coastal plain south of Herschel Island.
5) Kame deltas and terraces along the edge of the Buckland Hills, especially near the limit of glaciation.
6) Isolated kame and esker complexes on the Yukon coastal plain.
7) Coalescing and individual outwash and kame deltas that flank a major meltwater channel paralleling the coast from near Coal Mine Lake to Kay Point.
8) On escarpments exposing preglacial gravels along the coast near King Point and Shingle Point and along the lower reaches of the Walking and Blow River valleys.
9) On ridges underlain by sandstones, conglomerates, and other competent rock types.

Photo 5.6.1
Aerial view of a kame terrace located 2 miles west of the Firth River on the Yukon coastal plain numbered as Deposit N75-117D-B3.

Photo 5.6.2
Aerial view of a fluvial terrace on the east side of the Firth River on the Yukon coastal plain numbered as Deposit N75-117D-B5.

6. GEOPHYSICAL INVESTIGATIONS OF GRANULAR DEPOSITS

6.1 General

Gravel deposits can often be delineated from surrounding soils by measuring the electrical resistivity of the ground. Figure 6.5.1 shows the resistivity ranges of the soil types of the Unified Soil Classification System. Clean gravels (GP) have a resistivity in excess of 1000 ohm-m, gravels with fines (GC) have lower resistivities. It is often difficult to differentiate sands from gravels by resistivity measurements.

This relatively simple situation shown in Figure 6.5.1 becomes considerably more complex in permafrost regions. Figure 6.5.2 shows the variation in resistivity with temperature for several soil types; when the ground freezes the resistivity increases, and for gravels this increase is sudden. The trend of a resistivity increase in going from clay to silt to gravel is maintained in the frozen state. However, in addition to temperature the ice content of ground also influences resistivity, as is illustrated in Figure 6.5.3. High resistivity (>5000 ohm-m) in permafrost regions can, therefore, be due to low ground temperatures, high ice content and frozen gravel.

Two geophysical methods were employed in the borrow program; galvanic (four) probe resistivity measurements, and VLF radiohm measurements. At most sites there was insufficient time to make enough measurements to outline gravel deposits by geophysical methods.

Photo 6.1.1
Geophysics crew taking geophysical readings on the Yukon coastal plain.

The results of the geophysical measurements are discussed on a regional basis. This approach allows us to make general recommendations about the use of certain geophysical methods on a regional scale.

6.2 Resistivity Results

The electrical soundings with the four probe galvanic methods were analyzed by computer to obtain the resistivity layering in the ground. Examples of the data on the Yukon coastal plain are shown in Figures 6.5.4, 6.5.5, 6.5.6, and 6.5.7. These graphs are the composite of several spreads. Shown on the graphs are upper and lower bounds of computer modeled curves. For example in Figure 6.5.4 the upper bound is the computed results for a ground profile consisting of a thawed surface layer, 0.25 m in depth, and with a resistivity of 1000 ohm-m. The underlying ground has a resistivity of 23,000 ohm-m, at least, to the depth of exploration, which is approximately 30 meters in this case.

If sands and gravels occur at the surface, the thawed surface layer can be expected to have a resistivity in excess of 1000 ohm-m. This is the case in Figures 6.5.4 and 6.5.5. When the overburden is peat or silt, the thawed surface layer will have resistivities less than 500 ohm-m, and examples are Figures 6.5.6 and 6.5.7.

The apparent resistivity of the frozen ground under the active layer, in most profiles on the Yukon coastal plain was in excess of 5000 ohm-m. Resistivities in excess of 5000 ohm-m can be due to frozen gravel, or silts with high ice content. In this environment it is very difficult to classify ground by resistivity methods. In addition to soil type, temperature and ice content also influences the data.

6.3 VLF Radiohm Data

The Yukon coastal plain consists mainly of frozen sediments overlying Cretaceous conglomerate, sandstone and shale. The bedrock is rarely found near the surface. The frozen surface materials are, invariably of high resistivity (75,000 ohm-m). The VLF radiation has a large depth of exploration when high resistivities are found near the surface. Figure 6.5.8 is a computer model curve which shows the apparent resistivity measured, ρ_a, as a function of the depth of frozen overburden over Cretaceous bedrock. The bedrock has been assigned different values of resistivity, 30,100 and 500 ohm-m. Values for the bedrock between 30 and 100 ohm-m are realistic.

The VLF radiohm values obtained on the Yukon coastal plain varied between 6000 ohm-m and 80 ohm-m, and showed no apparent relation to the existence of near-surface gravel. The VLF radiohm data mainly reflected depth to bedrock and bedrock type.

6.4 Conclusion - Geophysics on Yukon Coastal Plain

The soils on the Yukon coastal plain are invariably frozen, below a shallow active layer. In this environment all soil types have high values (>5000 ohm-m) of resistivity, and geophysical resistivity techniques appear of no help in delineating sands and gravel deposits.

6.5 Figures

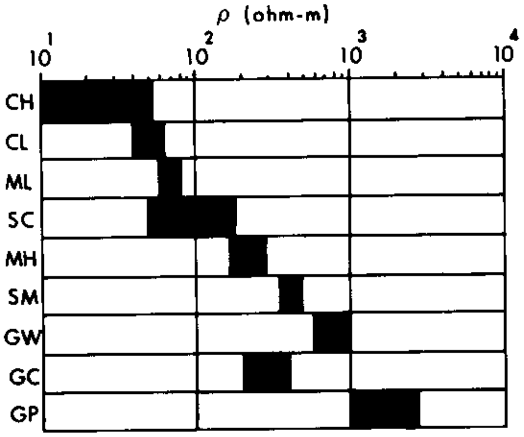


FIGURE 6.5.1

The ranges in resistivity associated with the soil types of Unified Engineering Soil Classification System. (CH - fat clay; ML - silty clay; SC - sandy clay; MH - silt; S, - sand; GW - well sorted gravel; GC - gravel with clay; GP - poorly sorted gravel).

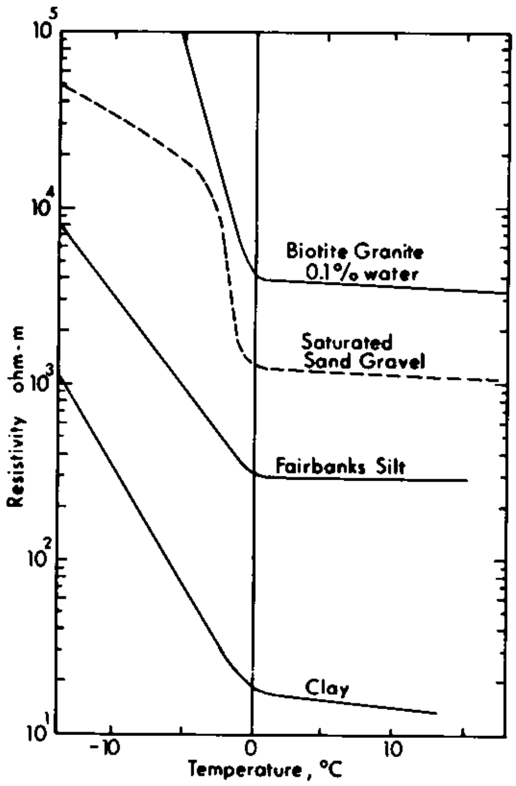


FIGURE 6.5.2

The Resistivity of Several Soils and One Rock Type as a Function of Temperature (Hoekstra et al., 1975)[2]

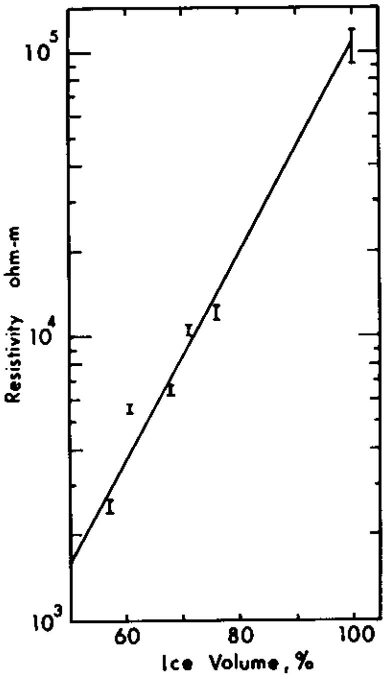
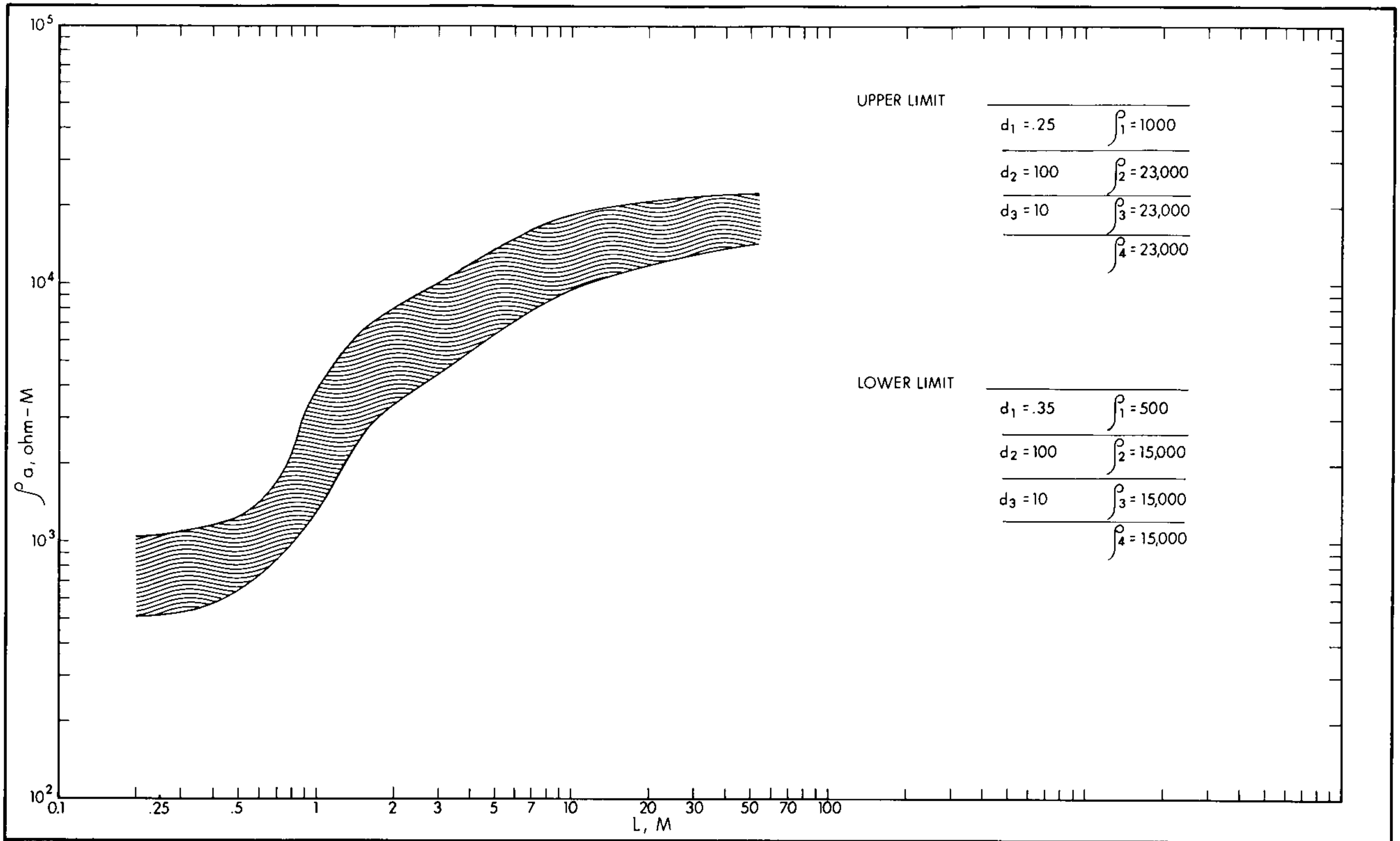


FIGURE 6.5.3
The Resistivity of Frozen Silt as a
Function of Ice Content (Hoekstra et al., 1975)[2]



13011	WENNER SOUNDING
FIGURE 6.5.4	BORROW - YUKON COASTAL PLAIN

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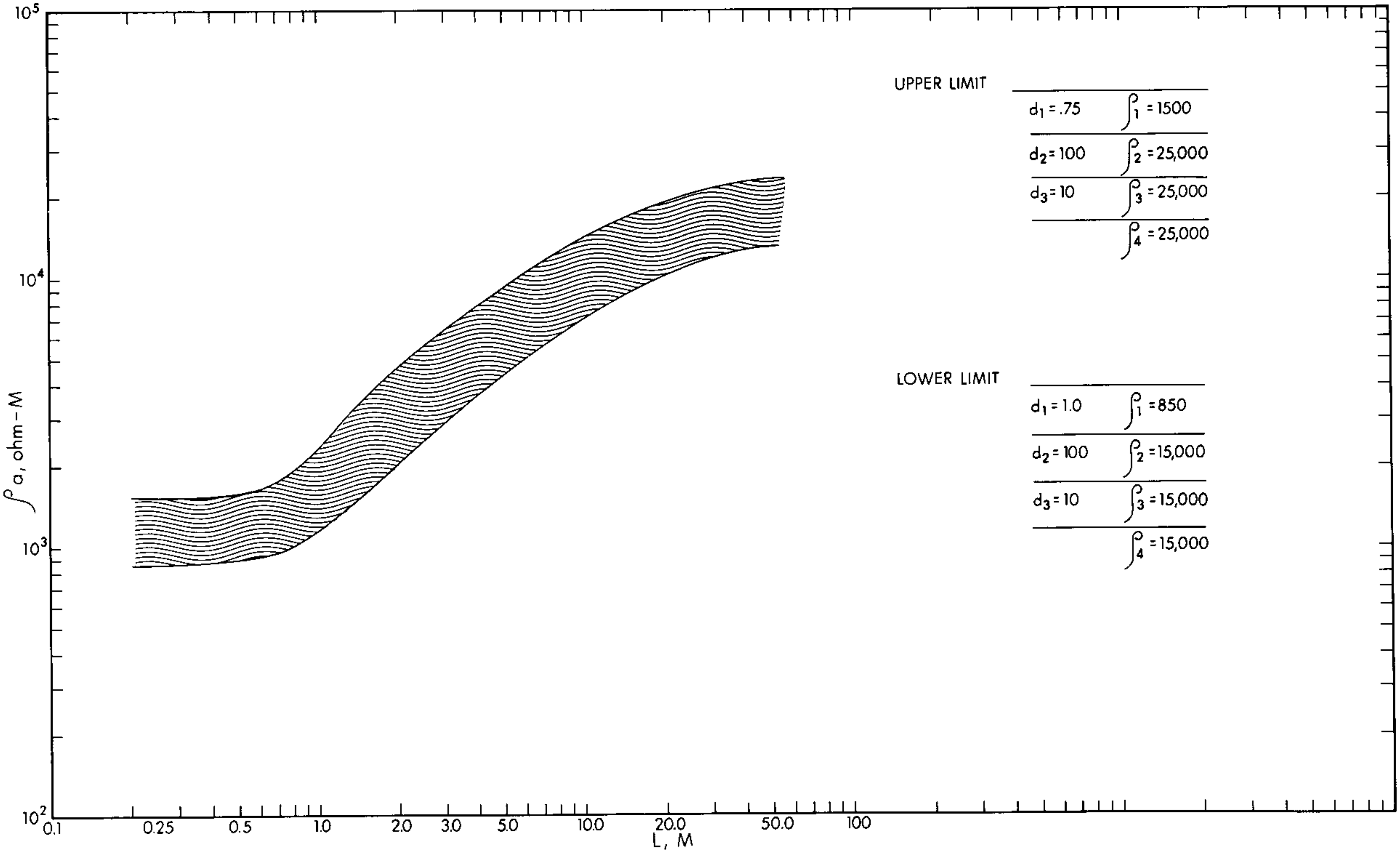
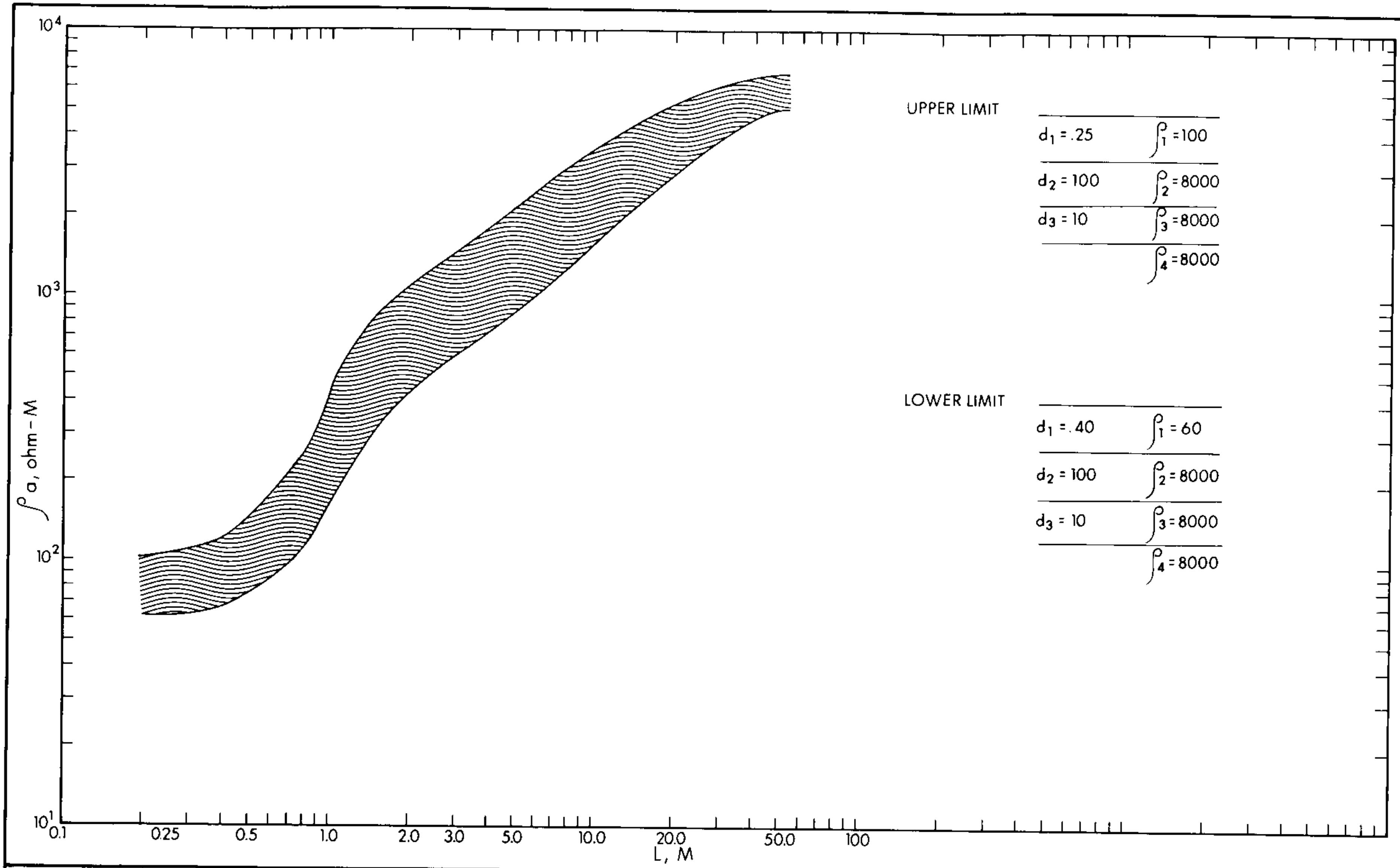


13011	WENNER SOUNDING
FIGURE 6.5.5	BORROW – YUKON COASTAL PLAIN

NORTHERN
Engineering Services
Company Limited



13011

WENNER SOUNDING

FIGURE 6.5.6

BORROW - YUKON COASTAL PLAIN

NORTHERN
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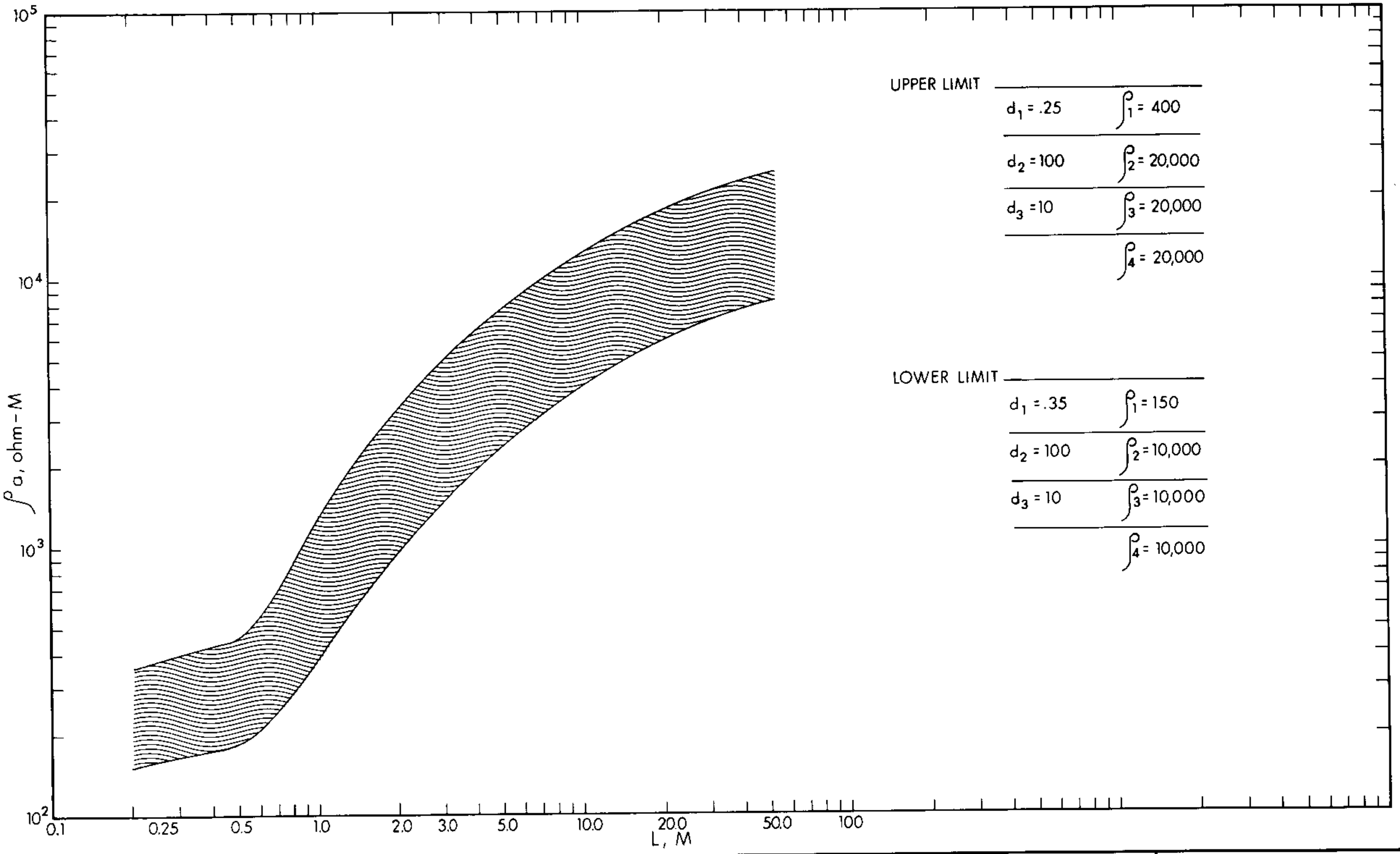

13011	WENNER SOUNDING
FIGURE 6.5.7	BORROW - YUKON COASTAL PLAIN

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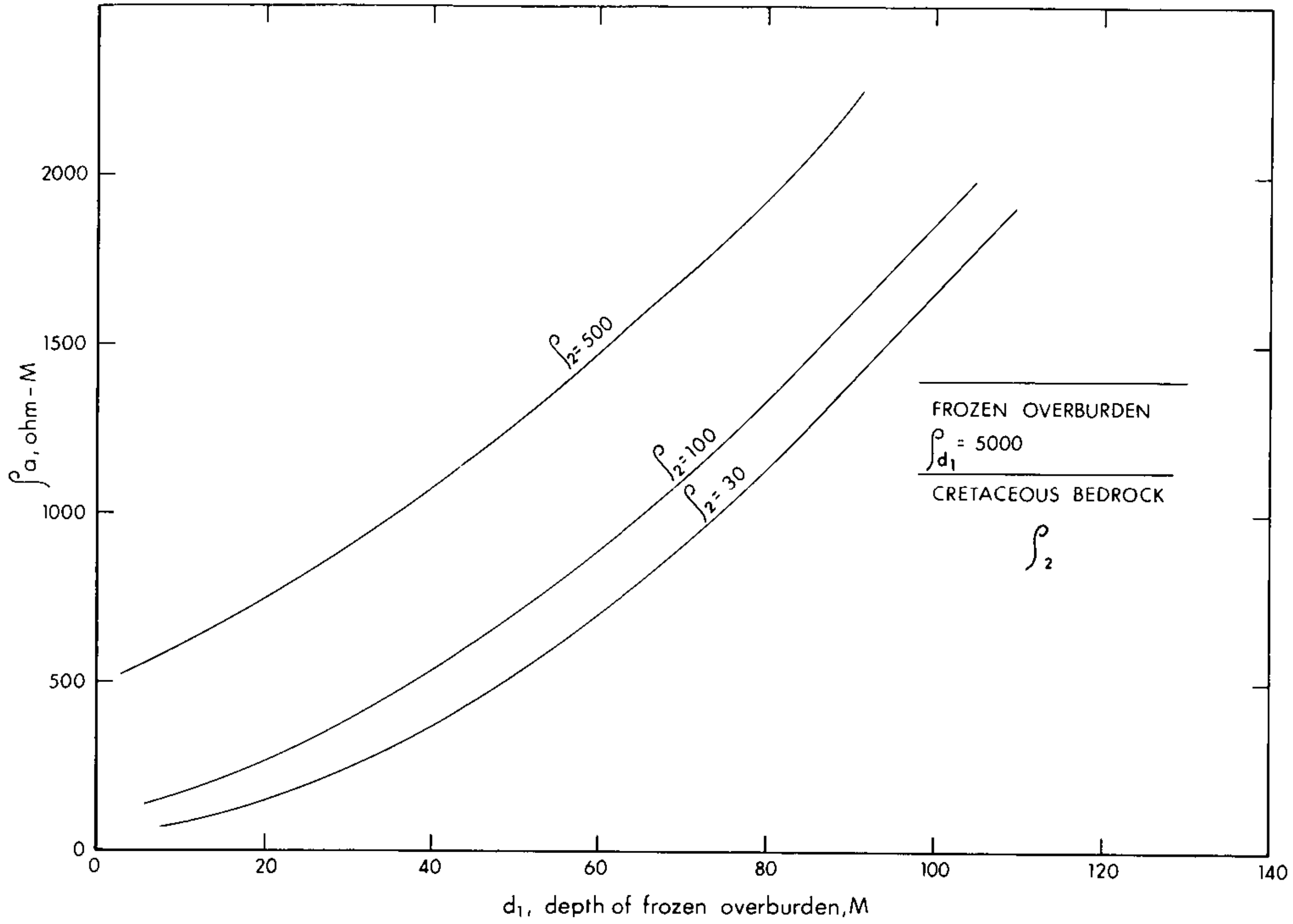

13011

VLF RADIOHM TRAVERSE

FIGURE 6.5.8

BORROW - YUKON COASTAL PLAIN

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7. ENVIRONMENTAL ANALYSIS OF YUKON COASTAL PLAIN BORROW DEPOSITS

7.1 Vegetation

The Yukon coastal plain is characterized by "tundra vegetation". Much of it is covered by a tussock tundra community. Cotton grass and moss are the dominant plants with dwarf willow (*Salix* spp.) and mountain avens dominant on better drained sites.

The terraces of some streams in the area support an open dwarf shrub community of dwarf willow (*S. reticulata)* and pussytoes with a closed ground cover of alpine bearberry, mosses, and lichens. Low terraces bordering many of the larger streams of the southeastern part of the coastal plain support a closed community of tall shrubs including green alders and willow (*S. pulchra)*. Well drained alluvial fan surfaces often have a plant cover of scattered dwarf willow and mountain avens with an open ground cover of lichen. Poorly drained areas of terraces and alluvial fans are usually covered by tussock tundra or sedge meadows.

Many of the ridgetops along the Buckland Hills are covered by a community of scattered mountain avens and dwarf willow (*S. phlebophylla*) with an open ground cover of lichen. On the tops of gravelly slopes the plant cover is sparse with scattered dwarf willow and mountain avens. Details of the vegetation of the Yukon coastal plain is provided in Hettinger *et al.* (1973).

7.2 Mammals

A vital component of the mammalian fauna on the Yukon coastal plain is the migratory barren ground caribou of the Porcupine caribou herd. Normally this herd winters in the Ogilvie and Richardson mountains and near Arctic Village in Alaska in some years. In spring they migrate northward to the coastal plain and by the end of May the cows reach their calving grounds which extend along the coastal plain from the Babbage River west into Alaska. Calving activity peaks at the end of the first week of June and is completed by the middle of the month. After calving most of the animals coalesce into a large herd in Alaska. They then move back into the Yukon via the British Mountains. During early July, some of these animals may be found on the coastal plain. Details of movements have been discussed by Jakimchuk *et al.* (1974), McCourt *et al.* (1974), Doll *et al.* (1974), and Roseneau *et al.* (1975).

Potential impacts of borrow activities on caribou movements include disruption of movements and interference with calving. To avoid these problems it is recommended that no borrow activities take place during the months of May, June and July along the Yukon coast. If summer activity is necessary it should be restricted to the period after June 15.

Moose on the coastal plain are primarily restricted to stream valleys. Most moose move further inland to winter but occasionally a few remain on the coastal plain. Potential conflicts could occur with borrow activities if significant portions of willow communities along river valleys were removed during borrow operations. Construction activity in river valleys on the coastal plain could disrupt moose activities, both in summer when numbers are high and in winter when they are lower, but when consequences of disturbance may be greater.

Borrow removal and associated operations should avoid destroying large areas of willow vegetation in river valleys.

Arctic foxes utilize portions of the Yukon coastal plain as a maternal denning area. Den sites in the eastern Canadian Arctic are known to be reused sometimes for many years (Macpherson, 1969) and presence of suitable den sites may be limiting to the Arctic fox population. Pups are born in spring in the dens and are raised there until the young foxes disperse in summer. In winter most foxes move onto the sea ice where they scavenge at bear kills. The majority of dens found by Ruttan (1974) on the Yukon coastal plain were between the Crow River and the Alaska, Y.T. border with a concentration on Herschel Island and the Firth River Delta. No dens were found at the borrow sites examined during this brief survey.

Construction of access roads and other ancillary facilities used in borrow activities may conflict with fox dens, if detailed on site surveys are not conducted prior to the activity. Strict controls of garbage will tend to discourage foxes around camps.

Grizzly bears venture onto the coastal plains in summer after emerging from their dens further inland where they spend the winter. The status of the grizzly bear population was not determined in this survey, but many borrow site areas had signs of bear diggings. Grizzly bears may come into contact with any borrowing activities during summer, but winter construction will mitigate this problem to a great degree.

Other furbearers are not abundant on the Yukon coastal plain. Wolves, red foxes and wolverine are low in numbers and wide ranging in movements. Arctic ground squirrels are present in many gravel deposits but they are likely adaptable to disturbance.

7.3 Birds

With the exception of the ptarmigan and gyrfalcon, birds are required to undergo very long migrations due to the inaccessibility of food during winter. The summer season is so short that timing of breeding and rearing of young is very critical.

The most important habitat for a diverse number of birds is the coastline complex of barrier beaches, lagoons, shoreline, islands, and beaches. These areas are used for migration, nesting, moulting, and feeding.

Inland on the coastal plain several species of waterfowl including swans, pintail and oldsquaw, and shorebirds are found nesting on lakes and potholes. These species are susceptible to disturbance. Lakes near the borrow site areas examined generally had few birds on them.

Construction activities including low level aircraft flights and coastal shipping operations may have deleterious effects on breeding waterfowl populations. It is recommended that borrow operations be confined to the winter period to avoid such effects. If summer construction is necessary, it should be terminated by August 15.

Terrestrial habitats are occupied by a variety of species including ptarmigan, Lapland logspur, jaegers, and plovers. These species are widely dispersed and their populations are not as prone to disturbance as those species with restricted nest sites or colonial habits.

During the bird migration period the number of birds that are on the coastal plain for feeding increases substantially. The most conspicuous bird and the most susceptible to disturbance during this critical period from August 15 through September 30, is the snow goose. Aircraft and construction activity could have a particularly severe impact on migrating and staging waterfowl. It is important that no activities be carried out in the vicinity of areas used by these birds during this period.

Raptors, including the bald eagle, golden eagle and gyrfalcon use nest sites found in cliffs on the coastal plain and adjacent foothills and mountains. They are particularly sensitive to human activity during the nesting period, February 1 to August 31.

One eagle nest was found near a probable borrow source, however others may be present. Raptors are particularly sensitive to disturbance during the nesting period. For this reason it is important that further study of the location of raptor nests in relation to borrow sources and access be carried out prior to construction.

7.4 Fish

The Beaufort Sea drainages contain only 13 species of fish. The most common of the economically important species are Arctic char and grayling.

The Malcolm, Firth, Babbage, Big Fish, Spring, and Crow rivers have groundwater sources in the form of perennial springs and are important to populations of anadromous Arctic char. Char undertake annual spring migrations to the Beaufort Sea but return to freshwater every autumn to spawn and/or overwinter (McCart *et al.* 1974). No borrow sites are proposed near known overwintering areas. Grayling often utilize the same areas. Whitefish and ciscoes are found during the summer in the estuaries and deltas of many north slope streams.

Streams without groundwater sources include the Craig, Kugaryuk, Okpioyuak, Phillip, Deep, Conglomerate, Tundra and Rapid Creeks, and the Blow and Walking Rivers. These streams constitute the major spawning and summer feeding habitat for Arctic grayling. Typically these streams freeze solid during the winter, and the fish that occupy them during the ice-free season must migrate elsewhere to overwinter. Overwintering can occur either in lakes or in the vicinity of perennial springs.

Most lakes on the Yukon coastal plain are unsuitable for fish because of their shallowness. They either freeze to the bottom, or the amount of oxygen available in the remaining water is below the lethal limit for fish. Of 17 lakes examined, only 9 had fish populations ranging from 1 to 4 species.

Recommendations to avoid deleterious effects of borrow activities on fish populations relate primarily to the prevention of siltation in streams and rivers, avoiding gravel removal from the active stream channel, and preventing creation of artificial ponds adjacent to rivers where fish could be trapped.

8. DATA PRESENTATION

8.1 Individual Site Reports

8.1.1 General

The data has been presented so that all information related to a given borrow source is available as an individual package. The information includes:

(1) Airphoto and Summary
(2) Site Report
(3) Test Pit and Test Hole Logs
(4) Laboratory Test Data

8.1.2 Airphoto and Summary

A site airphoto and synoptic page introduces each individual site report. The physical outline of the borrow source, location of test pits and/or test holes, and the proposed pipeline route are noted on the site airphoto. A brief summary outlining the Physical Setting, Volume, and Assessment for each individual site is denoted on the airphoto page.

8.1.3 Site Report

All pertinent data and assessments which have been compiled for the potential borrow sources investigated along the Yukon coastal plain are discussed and presented on a site specific basis under the following headings:

(a) Physical Setting - location of deposit in relation to the pipeline right of way and the geologic structure where the deposit is located. Drainage is given (ref. Appendix A) as well as geomorphology, ice contents and organic soil cover.

(b) Biological Setting - description of vegetative cover is given for the area studied as well as description of wildlife present. Sensitivity of the environment to primary activity in the area is also given. Refer to Appendix C for scientific names.

(c) Materials - description of soils in the deposit according to the testhole logs which are classified according to the Terms and Symbols Section in Appendix A. Also a classification designating type of construction material is given in the text of each Materials Section write-up. (See Appendix A for definition).

(d) Volume - total volume of granular material as calculated by planimetering the outline of the deposit and using a depth of the deposit according to drill hole logs and airphoto interpretation.

(e) Development and Rehabilitation - the sections on Physical Setting, Biological Setting, Materials, and the Volume were used to describe the potential development of the deposit. A brief general plan for development of the deposit was formulated provided that the environmental concerns were taken into consideration.

8.1.4 Test Pit and Test Hole Logs

An individual test pit or test hole log has been prepared on the standard NESCL form and in accordance with the standardized "Terms and Symbols" section which is included in Appendix A. The test pit and/or test hole log data are presented within the respective individual site reports.

8.1.5 Laboratory Test Data

The grain size information for each sample tested is presented on the "Grain Size Distribution Curve" plotted and produced by R.M. Hardy and Associates Ltd. The remaining laboratory tests such as Los Angeles abrasion, sulphate soundness, organic content and petrographic analyses are summarized and tabulated on the form titled "Summary of Laboratory Tests to Determine Aggregate Suitability in Concrete". Each individual site report includes all test results which are pertinent to that specific borrow source.

8.2 Strip Maps

In addition to the site specific airphotos, the location and shape of each potential borrow source which has been investigated along the Yukon coastal plain have been plotted on the Project Strip Maps at a scale of 1:250,000. These project strip maps were produced using the National Topographic Surveys map series. The strip maps are presented in Appendix B.

9. RECOMMENDATIONS AND CONCLUSIONS

The 1975 CAGSL-NESCL borrow field program has shown that abundant granular material is present along the Yukon coastal plain portion of the Coastal and Cross Delta pipeline routes. Thirty-three deposits were investigated between the Alaska/Yukon border and the west side of the Mackenzie Delta. At least one billion cubic yards of borrow material were found in these deposits and considerable quantities of material exist in other deposits which were not investigated in detail during the summer field program.

The DIAND Granular Materials Inventory did not cover the Yukon coastal plain, and therefore, the 1975 borrow field program has added to the available information on granular deposits that have been shown on Geological Survey of Canada surficial geology maps and terrain-typed CAGSL pipeline alignment sheets.

Granular deposits along the Yukon coastal plain are concentrated in alluvial fans, river terraces, floodplains of rivers and creeks, outwash fans, kame deltas, kame terraces, esker complexes, and in escarpments along the Arctic coast where preglacial gravels are exposed. Also bedrock borrow sources are exposed in ridges at some localities along the coastal plain.

Granular deposits were investigated by airphoto analysis, field reconnaissance methods, geophysics, and test pitting and drilling. Geophysical investigation included use of two geophysical methods: the galvanic (four) probe resistivity method and VLF radiohm measurements. Gravels and sands on the Yukon coastal plain were frozen and sometimes these materials had high ice content. Using electrical resistivity to determine depth and extent of granular deposits in permafrost was difficult as high resistivities can result from frozen gravels or frozen silts with high ice content. Also VLF radiohm measurements were not able to provide detailed depth and delineation observations on granular deposits because surface materials on the Yukon coastal plain are high ice content fine-grained soils with high resistivities. The VLF radiation penetrated these high resistivity surface soils and probably reflected depth to bedrock and bedrock type. Other geophysical techniques, including dipole-dipole and inductive coupling tried recently in Calgary, have shown more promise for use in describing properties of granular deposits and will probably be used during final design borrow investigations.

Development of borrow sources on the Yukon coastal plain potentially could have serious effects on the environment. However, with implementation of strict scheduling and other mitigative procedures, impact can be localized and minimized to a great extent. Granular deposits are located on the calving grounds and migration routes of the Porcupine caribou herd, but construction after August and before May will avoid most interaction with this herd. No dens of Arctic fox were found on borrow sites. Summer construction could have serious consequences with regard to nesting, moulting and staging waterfowl and raptors but again, scheduling of construction to begin after October 15 and to end before May, will avoid problems.

If summer construction is necessary it should be restricted to the period June 15 to August 15 with precautions to avoid coastal bird species and other waterfowl.

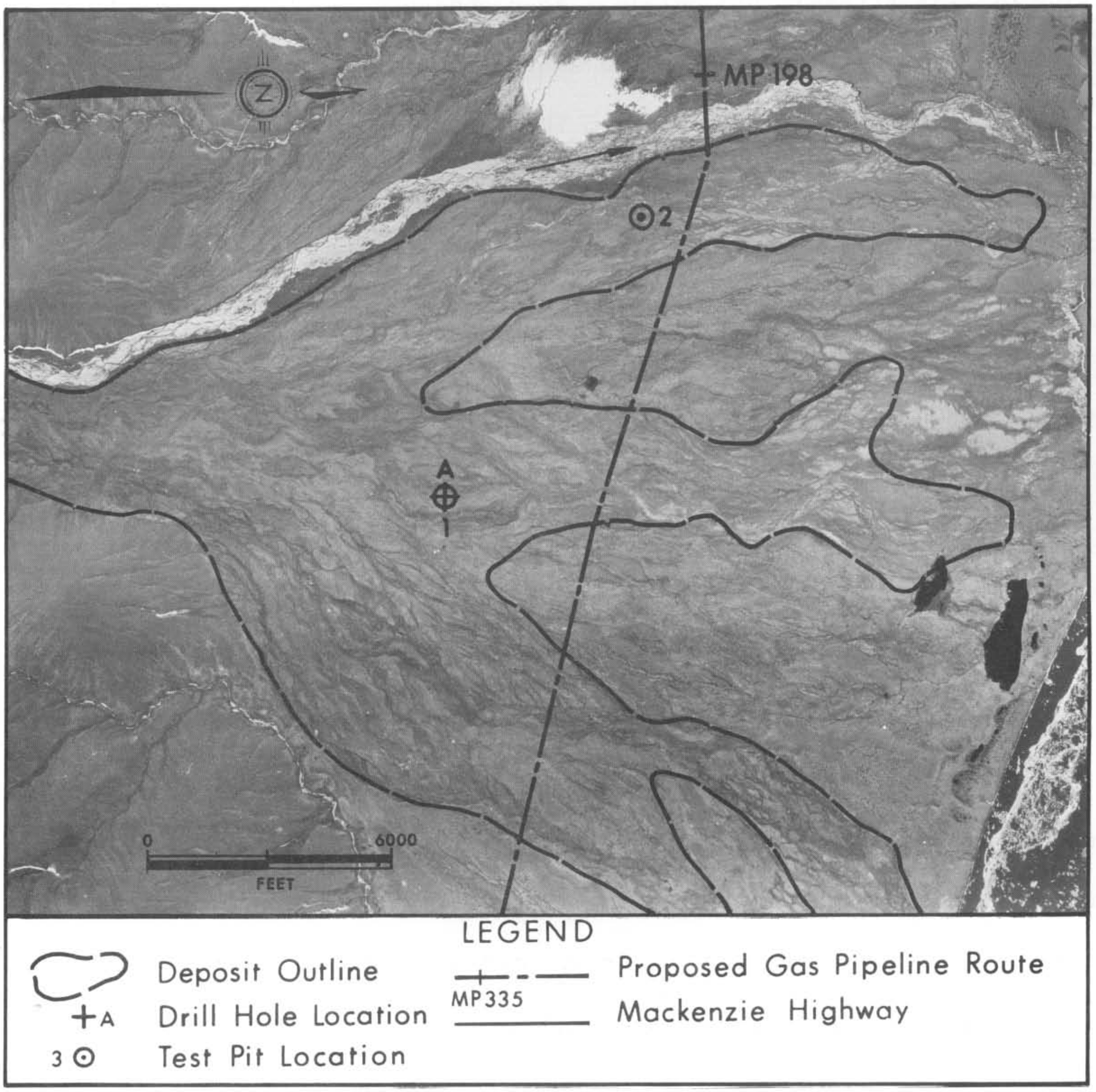
Fish will only be affected by borrow activity in floodplain deposits. Borrow pit development of floodplain borrow deposits is proposed for late autumn and winter and will be kept out of active channels. Creeks and rivers where perennial springs allow overwintering of fish have been identified and care should be taken in developing floodplain sources in the vicinity of any such creek or stream.

The 1975 summer field investigations have made it possible to present some preliminary borrow development plans which appear with each borrow source report. As part of final design, more detailed site specific investigation of granular material sources and quarry sites will be undertaken and will include collection of data on depth, quality, and quantity of granular materials, environmental assessment, and detailed development plans for each borrow source ultimately chosen for use.

10. The following is a list of individual site reports that follow in this section.

DEPOSIT 117C-B1

Physical Setting:	Deposit 117C-B1 is part of a large alluvial fan on the Arctic coast 5 miles east of Clarence River at mile 250 of the proposed gas pipeline route.
Material:	Gravel; well graded, coarse to fine, subangular to subrounded, some sand, coarse to fine.
Volume:	240,000,000 cubic yards.
Assessment:	Deposit 117C-B1 is a good source of granular material. Access along the proposed gas pipeline route is good and materials would be suitable for general fill, backfill in pipeline construction, and building pad subgrade.



Airphoto No. A13138-153

Approximate Scale: 1" = 5250'

Latitude: 69° 34' N

Longitude: 140° 47' W

DEPOSIT 117C-B1

PHYSICAL SETTING

Deposit 117C-B1 is part of a large alluvial fan on the Arctic coast extending 2 to 7 miles south of Clarence Lagoon. Mile 250 of the proposed pipeline is in the centre of the fan. The fan slopes gently for 8 miles from its apex to its foot at the Beaufort Sea. A stream occupies a channel 5 feet below the fan surface along its western margin. An aufeis field, approximately ½ mile in diameter, is present on the west side of this stream's floodplain. Abandoned stream channels and bars form a braided pattern on the fan surface. Small terrace scarps to 5 feet in height are also present on the fan.

Gravel is exposed on many bars and terrace scarps. Abandoned stream channels and shallow broad depressions may have 1 to 2 feet of peat and silt overlying gravel. Surface drainage is generally good, although marshy areas exist in some abandoned channels. The groundwater table is at a depth of 1 to 4 feet in summer. The ice content of the gravel is low.

BIOLOGICAL SETTING

In imperfectly drained areas, the ground is covered by tundra consisting mainly of moss and lichen. In well drained areas the ground is bare with patches of tundra vegetation. Ptarmigan and Arctic fox may frequent the area occasionally. Arctic cisco, four horn sculpin, and arctic flounder utilize Clarence Lagoon.

MATERIALS

The fan contains good quality granular material consisting of clean, well graded, subrounded, dense gravel and sand with frequent cobbles. Material type is very uniform across the deposit, and the deposit is generally saturated below 1 foot in depth.

VOLUME

The deposit has an area of about 6500 acres and a total volume, based on a minimum depth of 30 feet, of approximately 240,000,000 cubic yards. This volume could be greatly enlarged by extending the deposit to include areas of less favorable drainage and overburden.

DEVELOPMENT AND REHABILITATION

Deposit 117C-B1 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Excavations would be kept away from the active stream channel to prevent siltation and to protect its natural setting. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate. The gravel would require further testing before being used in concrete production.

Access to the deposit with equipment could be achieved by barge to Komakuk Beach and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled separately around the edge of the excavation away from drainage channels.

Development would involve excavating borrow material evenly from well drained areas so that good drainage would be maintained over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by using blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditons might also make it necessary to dry the gravel in heated dryers to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Snow roads crossing stream channels would be broken at the stream crossing to avoid damming of the streams when spring runoff starts. Reseeding and revegetation of the recontoured pit areas may be carried out to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment, and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.3 PEAT— fibrous, spongy, excess water dark brown.		UF							0	19:30 4¼'' Tricone
1	OL		1.1 SILT—(organic) gravelly, light to medium grey, wet, roots.										
	GW		GRAVEL— coarse to fine, silt and sand matrix, wet, cobbles to 6."										
2			2.0 End of hole									2	hole filling with water.

LOGGED BY: J.J.S.
CHKD: W.W.
DRWN. BY: A.M.
CHKD: D.O.
START: D 26 M 07 Y 75 TIME: 19:30

FACILITY:
LAT. & LONG: 69°33'34''N,140°45'38''
AIRPHOTO No.: A 13138-153
RIG: HELI-DRILL
METHOD: AIR
FINISH: D 26 M 07 Y 75 TIME: 19:45

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 6°C

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES
COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117C-B1-A
SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117C-B1-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL - coarse and fine, subangular, little sand, coarse to medium, little peat, dark brown, damp, numerous fibres.		UF								Using jack-hammer and shovels
1			(1.0) GRAVEL - fine to coarse, subrounded, some sand, coarse to fine, dark grey, wet, stratified, frequent cobbles to 7'', dense.				MA, combined samples 1 - 5 Oversize = 2.4% G = 75% S = 23% F = 2% (GW)	B1	☒			1	
2								B2	☒			2	
3								B3 B4	☒ ☒			3	
4			4.0 Bottom of pit					B5	☒			4	Water level

LOGGED BY:	J.G.R.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	69°33'30''N, 140°45'38''W	ELEVATION:	
DRWN. BY:	G.C.B.	AIRPHOTO No.:	A 13138-153	PIPE MILEAGE:	
CHKD:	D.O.	RIG:		AIR TEMP.:	2°C
		METHOD:	TEST PIT		

START: D 26 M 07 Y 75 TIME: 16:25 **FINISH:** D 26 M 07 Y 75 TIME: 20:10

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

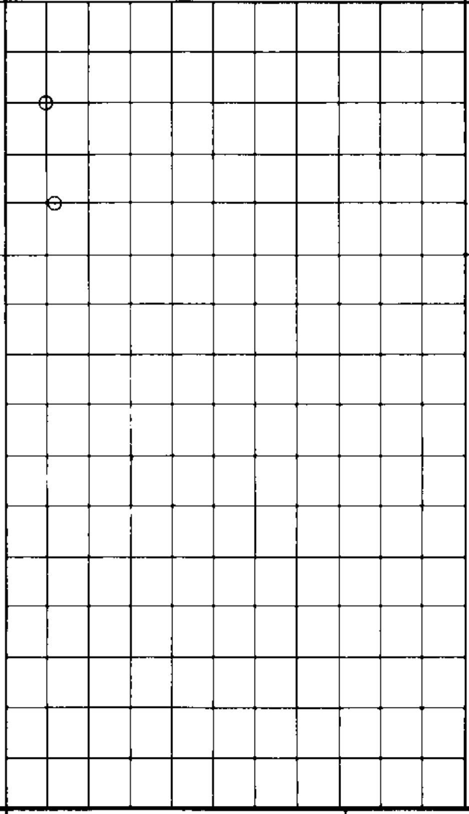
TEST HOLE No. N75-117C-B1-1

SHEET 1 **OF** 1

PC-9,SK373

TEST HOLE No. N75-117C-B1-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL - fine to coarse, some cmf sand, clean, grey, unstratified, occasional cobble to 4''		UF		w%					0.5	
1							10.5 MA, combined samples 1 & 2 G = 69% S = 30% F = 1%	B1	☒			1.5	
2							11.5	B2	☒				
			2.5 Bottom of pit									2.5	

LOGGED BY: D.O.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 69°34'26''N, 140°49'54''W	ELEVATION:		
DRWN. BY: D.J.M.	AIRPHOTO No.: A 13138-153	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-117C-B1-2
CHKD: D.O.	RIG:	AIR TEMP: 4°C		
	METHOD: TEST PIT			
START: D 26 M 07 Y 75 TIME:	FINISH: D 26 M 07 Y 75 TIME:		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

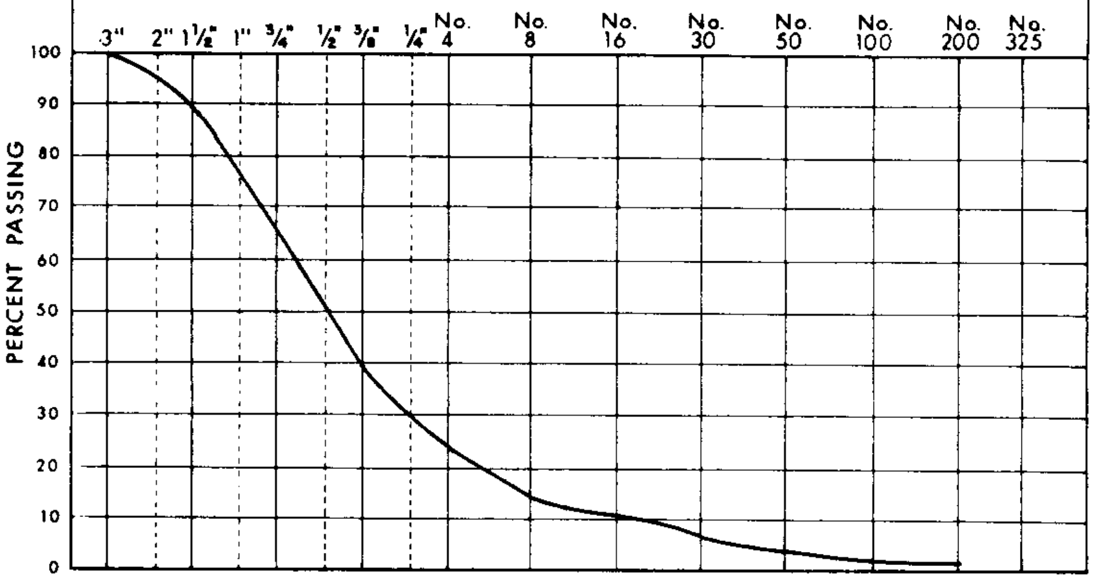
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-117C-B1-1 DEPTH 1.0 - 4.0
DATE SAMPLED July 26, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 105

GRAVEL SIZES		SAND SIZES			FINES
35 %	40 %	12 %	8 %	3 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	94.6
1½"	88.9
1"	75.5
¾"	65.0
½"	50.6
⅜"	39.8
¼"	
No. 4	24.7
No. 8	16.5
No. 16	10.7
No. 30	6.7
No. 50	3.9
No. 100	2.5
No. 200	1.9

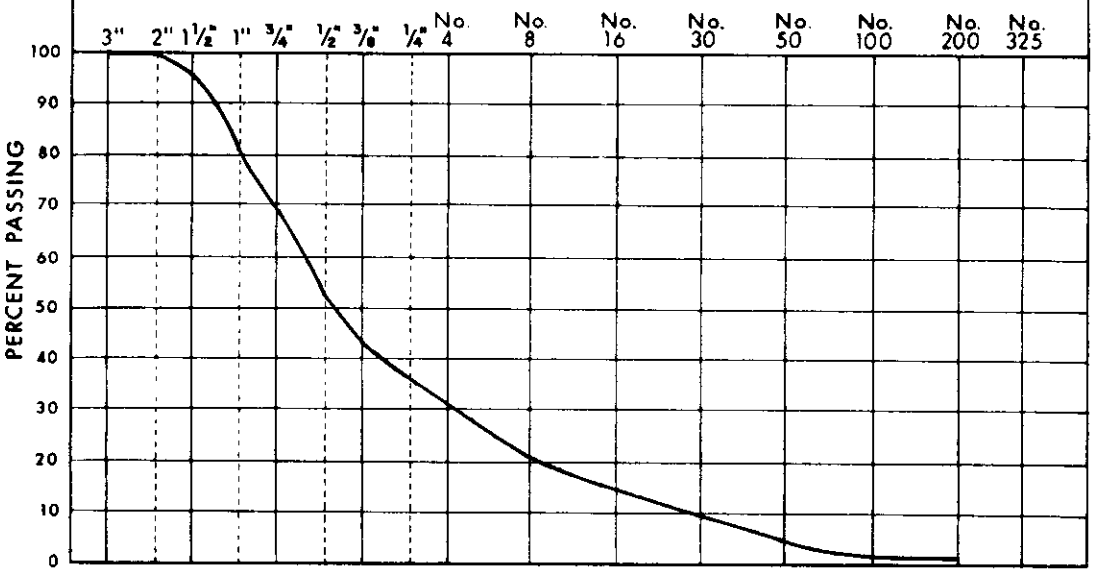
COMMENTS

OVERSIZE (>3") = 2.4%

SAMPLE N75-117C-B1-2 DEPTH 0.5 - 2.5
DATE SAMPLED July 26, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 99

GRAVEL SIZES		SAND SIZES			FINES
31 %	38 %	11 %	13 %	6 %	1 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	96.1
1"	80.0
¾"	68.8
½"	52.9
⅜"	43.2
¼"	
No. 4	30.5
No. 8	20.4
No. 16	14.9
No. 30	9.4
No. 50	4.2
No. 100	1.9
No. 200	1.3

COMMENTS

OVERSIZE (>3") = 0.0%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services
Company Limited

DEPOSIT No.
N75-117C-B1

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. : N75-117C-B1-1
DATE SAMPLED : July 26, 1975
SAMPLED BY : NESCL
DEPTH (FT.) : 1 - 4
DATE TESTED : February , 1976
TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 1.73 %
FINE AGGREGATE : LOSS = 13.29 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 23.5 %

ORGANIC IMPURITIES TEST

NUMBER : 4
COAL REMOVED : 3+
COAL & ROOTLETS REMOVED : 3
COAL CONTENT : Trace
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Very strong, Good	6.55
Sandstone	Strong, Good	18.45
Siltstone		12.1
Limestone	Medium strong, Fair	29.3
Chert	Potentially reactive, Fair	1.15
Flint		0.65
Weathered Limestone	Weak, Weathered, Poor	7.7
PN = 233	INTERPRETATION : Unsuitable aggregate for use in concrete.	75.9

COMMENTS :

Northern Engineering Services Company Limited

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

DEPOSIT No.
N75-117C-B1

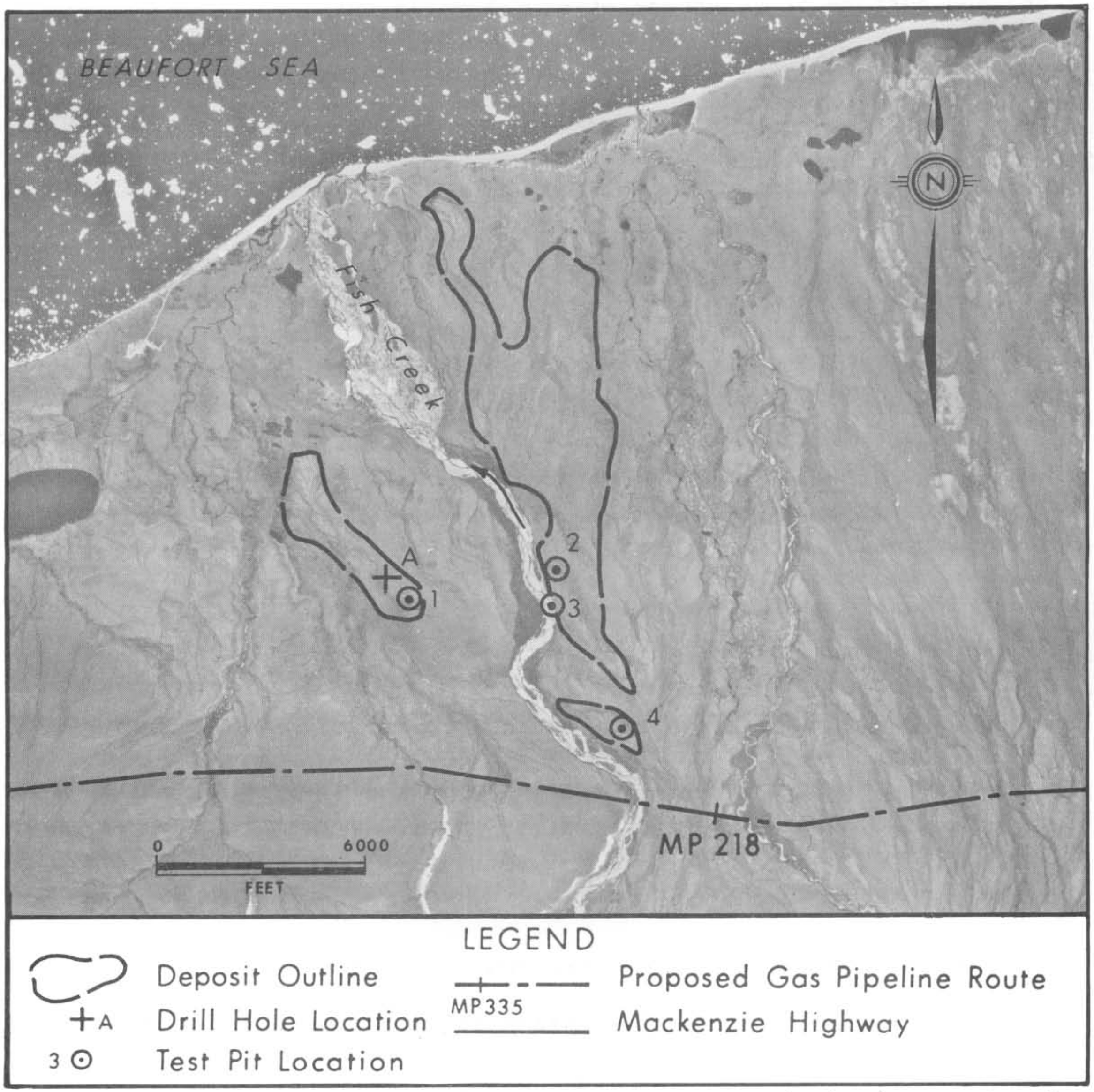
DEPOSIT 117C-B2

Physical Setting: Deposit 117C-B2 consists of fluvial terraces adjacent to Fish Creek. Mile 217 of the proposed gas pipeline route is adjacent to the southern tip of the deposit.

Material: Gravel; generally well graded, coarse to fine, some coarse, medium, and fine sand, clean.

Volume: 34,000,000 cubic yards.

Assessment: Deposit 117C-B2 is a good source of granular material which may be used for general fill, backfill in pipeline construction, subgrade material for building pads, and concrete and asphalt aggregate.



Airphoto No. A14361-86

Approximate Scale: 1" = 5250'

Latitude: 69° 34' N

Longitude: 140° 05' W

DEPOSIT 117C-B2

PHYSICAL SETTING

Deposit 117C-B2 consists of fluvial terraces adjacent to Fish Creek. Mile 217 of the proposed pipeline is at the southern tip of the deposit. The large terrace on the east side of Fish Creek and the terrace on the west side are remnants of a former alluvial fan which presently stands 15 feet above the current level of the Fish Creek floodplain. The fan slopes gently for 3 miles from its apex north toward the Beaufort Sea. A braided pattern of abandoned stream channels and large bars are responsible for local relief of 2 to 5 feet on the surface of the fan. The small terrace remnant on the east side of Fish Creek is about 5 feet above the level of the present floodplain.

Surface drainage is generally fair to moderate, although some abandoned stream channels are poorly drained. The water table is within 2 feet of the ground surface in the summer.

Gravel is exposed in patches on the higher bars and edges of terraces. In most areas there is less than 1 foot of peat cover overlying gravel, though some shallow depressions may have up to 5 feet of peat and silt overburden. The active layer is 6 inches thick in areas of peat cover, but more than 2 feet where gravel is exposed. Ice contents of the gravel are low.

The terrain south of the western terrace toward the pipeline right of way is an imperfectly to poorly drained alluvial fan surface with patches of ice-wedge polygons. A moderately well drained alluvial fan surface lies between the right of way and terraces on the east side of the creek.

BIOLOGICAL SETTING

Well drained areas have a broken cover of sedge tundra vegetation composed of sedge tussocks, mosses and lichens. Poorly drained areas are covered by sedge meadows.

The area provides good summer habitat for grizzly bear, wolf and Arctic fox. Fish Creek is a major spawning and overwintering area for char. The springs immediately north of the western terrace are signigicant to fish populations and care should be taken so as not to interfere with their flow. Snow geese have previously been sighted in the area and could be expected to use the area again.

MATERIALS

The terraces contain good quality granular material consisting of subrounded, dense, stratified, generally well graded gravel with some sand, a trace of silt in some strata, and frequent cobble layers.

VOLUME

Total volumes are based on medium ice contents and an estimated average thickness of 30 feet, even though the drill hole on the western terrace encountered gravel to a depth of more than 60 feet.

The larger area east of Fish Creek covers 650 acres and has a total volume of 25,000,000 cubic yards. The smaller area east of Fish Creek which is closest to the pipeline alignment, has an area of 45 acres and a total volume of 1,500,000 cubic yards. The western terrace covers 200 acres and has a total volume of 7,500,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117C-B2 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Excavations would be kept away from Fish Creek stream channel to prevent siltation and to protect the natural setting. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Komakuk Beach and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. Fish Creek would not necessarily be crossed during development as the deposit extends on both sides of it.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation away from natural drainage channels.

Development of this deposit would involve excavating borrow material evenly from well drained areas so that good drainage would be maintained over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to dry the gravel in heated dryers to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.5 PEAT—fibrous, wet, dark brown 0.5		UF							0	13:00 4¼'' Tricone (new)
	ML		SILT—trace sand, light grey 1.5		F 15								
2	GP		GRAVEL—fine, trace sand, trace silt, exidized coating on some cuttings at 1.5'.										
4			5.0										
6	GW		GRAVEL—fine to coarse, trace fine to medium sand, trace silt.										
8													
10					10								
12												12.5	13:30
14													
16													

LOGGED BY: J J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: W.W.	LAT. & LONG. 69°34'12'' N, 140°07'10'' W	ELEVATION:		
DRWN. BY: A.M.	AIRPHOTO No.: A 14361-88	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-117C-B2-A
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 4°C		
	METHOD: AIR			
START: D 26 M 07 Y 75 TIME: 13:00	FINISH: D 26 M 07 Y 75 TIME: 15:40		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117C-B2-A

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit

40 60 80 100 120 140 ▲

0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GW				F								
18			increase in fine sand and silt content										
												19.0	13:45 change to new 3 7/8'' Walmac
20													
22													
24			fine, little fine to coarse sand, trace silt									24.0	cuttings wet. indicating melt of lining.
26													
					20								14:00
28													
												29	
36			coarse, little sand									36	
38													

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011
CHKD: W.W.	LAT. & LONG: 69°34'12'' N, 140°07'10'' W	ELEVATION:
DRWN. BY: A.M.	AIRPHOTO No.: A 14361-86	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.: 4°C
	METHOD: AIR	

START: D 26 M 07 Y 75 TIME: 13:00 FINISH: D 26 M 07 Y 75 TIME: 15:40

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75.117C-B2-A

SHEET 2 OF 3

PC-9.SK373

TEST HOLE No. N75-117C-B2-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL (cont'd)		F								
39			39.0 cobble										
40												40	14:30
41												41	
47												47	
48													
			49.0 little sand, occasional cobble										
50													
52			52.0 cobble										
54												54	
58			58.0 cobble									58	
60												60	
64												64	15:40 hit hard cobble or boulder - 3 7/8'' Walmac damaged.
			65.0 End of hole									65	

LOGGED BY: J.J.S.

CHKD: W.W.

DRWN. BY: A.M.

CHKD: D.O.

FACILITY:

LAT. & LONG: $69^{0}34'12''$ N, $140^{0}07'10''$ W

AIRPHOTO No.: A 14361-86

RIG: HELI-DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: $4^{0}C$

START: D 26 M 07 Y 75 TIME: 13:00

FINISH: D 26 M 07 Y 75 TIME: 15:40

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117C-B2-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117C-B2-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.5 PEAT—black, wet, fibrous, numerous pebbles— coarse to fine, subangular.		UF								Using jack-hammer and shovels.
1	GW-GM		GRAVEL—coarse to fine, subrounded, some medium sand, trace silt, wet, stratified, isolated cobbles to 7.5", dense. ▼1.5				MA, combined samples 1–3 oversize = 4.5% G = 62% S = 31% F = 7% (GW-GM)	B1 B2 B3	☒ ☒ ☒			1	
2												2	water table at depth 1.5'
3			3.0 Bottom of pit.									3	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: R.J.S.
CHKD: D.D.

FACILITY:
LAT. & LONG: $69^0$34'05'N. $140^0$07'06'' W
AIRPHOTO No.: A 14361-86
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 4^0C

START: D 26 M 07 Y 75 TIME: 12:00
FINISH: D 26 M 07 Y 75 TIME: 14:40

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117C-B2-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117C-B2-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
1	GW		PEAT cover, dark brown GRAVEL - coarse to fine, some cmf sand, large cobbles 1.0 Bottom of pit water table		UF	⊙	w% 7 MA, sample 1 G = 71% S = 26% F = 3%	B1	☒			1.0	Water level

LOGGED BY: D.O.	FACILITY:	PROJECT: 130 11
CHKD: D.O.	LAT. & LONG: 69°33'58''N, 140°04'57''W	ELEVATION:
DRWN. BY: D.M.	AIRPHOTO No.: A 14381-86	PIPE MILEAGE:
CHKD: R.H.	RIG:	AIR TEMP: 4.5°C
	METHOD: TEST PIT	

START: D 25 M 07 Y 75 TIME: 21:00

FINISH: D 25 M 07 Y 75 TIME: 21:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117C-B2-2

SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT— little silt, dark brown, dry, fibrous. 0.7		UF								Using shovels
1	GW		GRAVEL— fine to coarse, subrounded; some medium to fine sand, light brown, damp, stratified, isolated cobbles to 5'', loose.				MA, combined samples 1-14	B1	☒			1	
2							Oversize (+ 3'') = 6.0%	B2	☒			2	
3							-3'' G = 64% S = 32% F = 4%	B3	☒			3	
4								B4	☒			4	
5								B5	☒			5	
6								B6	☒			6	
7								B7	☒			7	
8			cont'd									8	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: $69^0 33'49''N, 140^0 05'15''$	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
DRWN. BY: A.M.	AIRPHOTO No.: A 14361-86	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP.: Approx. 2^0C	
	METHOD: TEST PIT (EXPOSURE)		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 25 M 07 Y 75 TIME: 22:03 FINISH: D 26 M 07 Y 75 TIME: 13:05

TEST HOLE No. N75-117C-B2-3

SHEET 1 OF 2

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL (cont'd)		UF		MA, combined samples 1-14 (cont'd)	B8					Using shovels
9			9.0 wet					B9				9	
10								B10				10	
11								B11				11	
12								B12				12	
13								B13				13	
14								B14				14	
15			15.2 Bottom of exposure									15	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°33'49'N, 140°05'15'' W
AIRPHOTO No.: A 14361-86
RIG:
METHOD: TEST PIT (EXPOSURE)

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: Approx. 2°C

START: D 25 M 07 Y 75 TIME: 22:00
FINISH: D 26 M 07 Y 75 TIME: 13:05

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES
COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117C-B2-3
SHEET 2 OF 2

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL - coarse to fine, some cmf sand, high moisture content, numerous cobbles, 4'' - 8''										
1							MA, combined samples 1 - 3 oversize = 24.0% G = 64% (-3'') S = 34% F = 2%	B 1 - 3	☒			1	
2												2	Gravel seems too coarse for easy workability Water level (running)
			2.9 Bottom of pit										

LOGGED BY: D.O.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 69°33'15''N, 140°04'30''W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-117C-B2-4
DRWN. BY: D.J.M.	AIRPHOTO No.: A 14361-86	PIPE MILEAGE:		
CHKD: D.O.	RIG:	AIR TEMP.: 4°C		
	METHOD: TEST PIT			
START: D 26 M 07 Y 75 TIME: 14:20	FINISH: D 26 M 07 Y 75 TIME:		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117C-B2-4

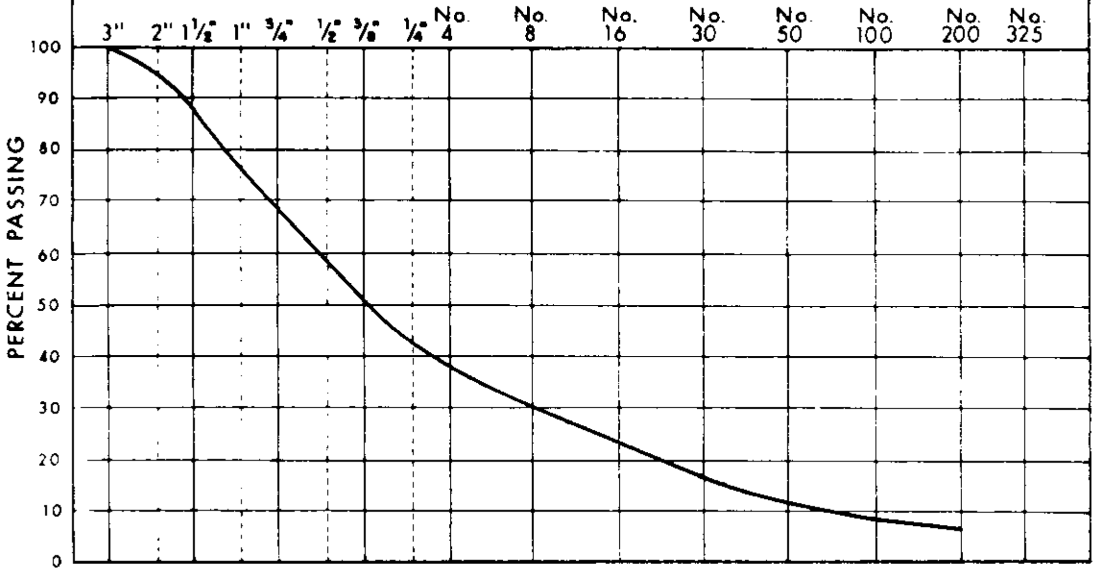
SIEVE ANALYSIS REPORT

SAMPLE N75-117C-B2-1 DEPTH 0.5 - 1.5

DATE SAMPLED July 26, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 125

GRAVEL SIZES		SAND SIZES			FINES
31 %	31 %	8 %	14 %	9 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	95.9
1½"	88.2
1"	77.0
¾"	69.3
½"	58.5
⅜"	51.1
¼"	
No. 4	38.3
No. 8	31.0
No 16	24.0
No. 30	17.5
No. 50	12.0
No. 100	8.7
No. 200	7.1

COMMENTS

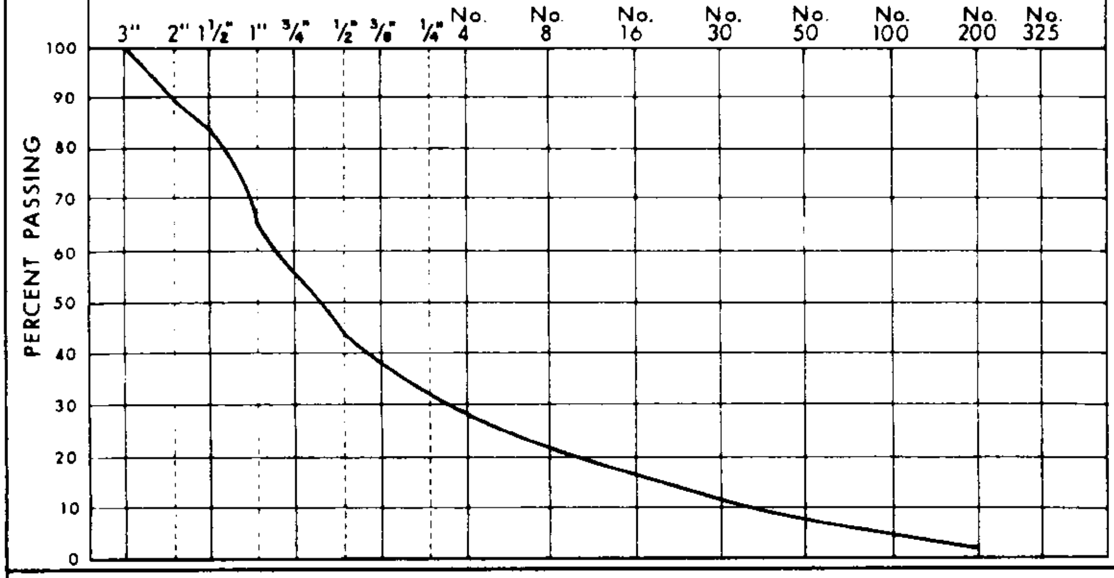
OVERSIZE (>3") = 4.5%

SAMPLE N75-117C-B2-2 DEPTH 0.0 - 1.0

DATE SAMPLED July 25, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 57

GRAVEL SIZES		SAND SIZES			FINES
45 %	26 %	9 %	10 %	7 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	89.1
1½"	83.7
1"	65.1
¾"	55.4
½"	44.7
⅜"	38.8
¼"	
No. 4	29.0
No. 8	22.0
No. 16	16.6
No. 30	11.7
No. 50	7.1
No. 100	4.6
No. 200	3.4

COMMENTS

OVERSIZE (>3") = 3.9 %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117C-B2

PAGE
78

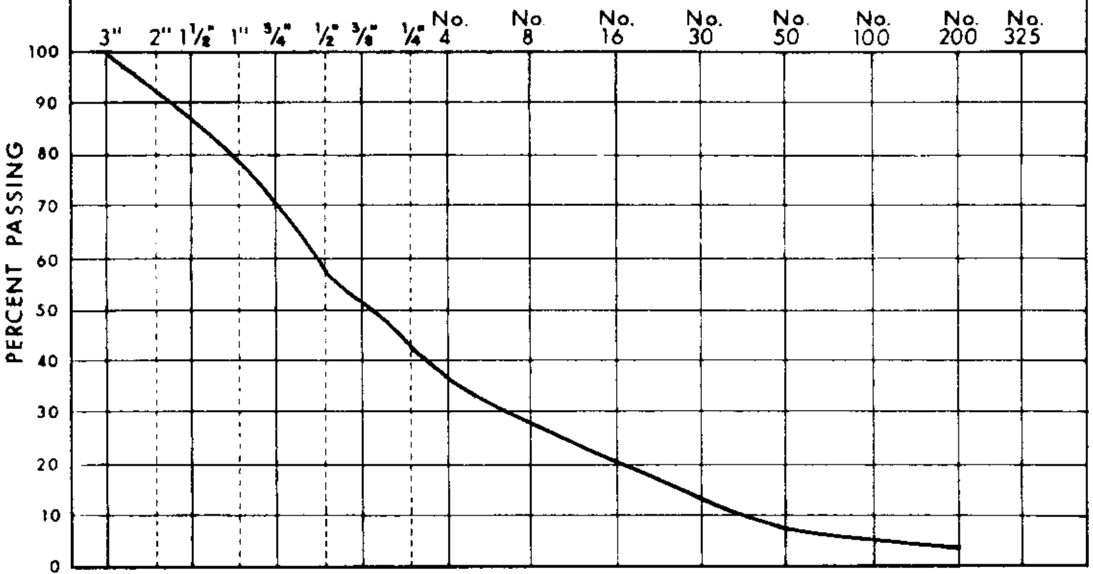
SIEVE ANALYSIS REPORT

SAMPLE N75-117C-B2-3 DEPTH 1.0 - 15.5

DATE SAMPLED July 25, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 138

GRAVEL SIZES		SAND SIZES			FINES
30 %	34 %	9 %	15 %	8 %	4 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.1
1½"	87.1
1"	79.3
¾"	70.1
½"	58.4
⅜"	50.9
¼"	
No. 4	36.2
No. 8	27.8
No 16	20.1
No. 30	13.0
No. 50	7.2
No 100	4.8
No. 200	4.0

COMMENTS

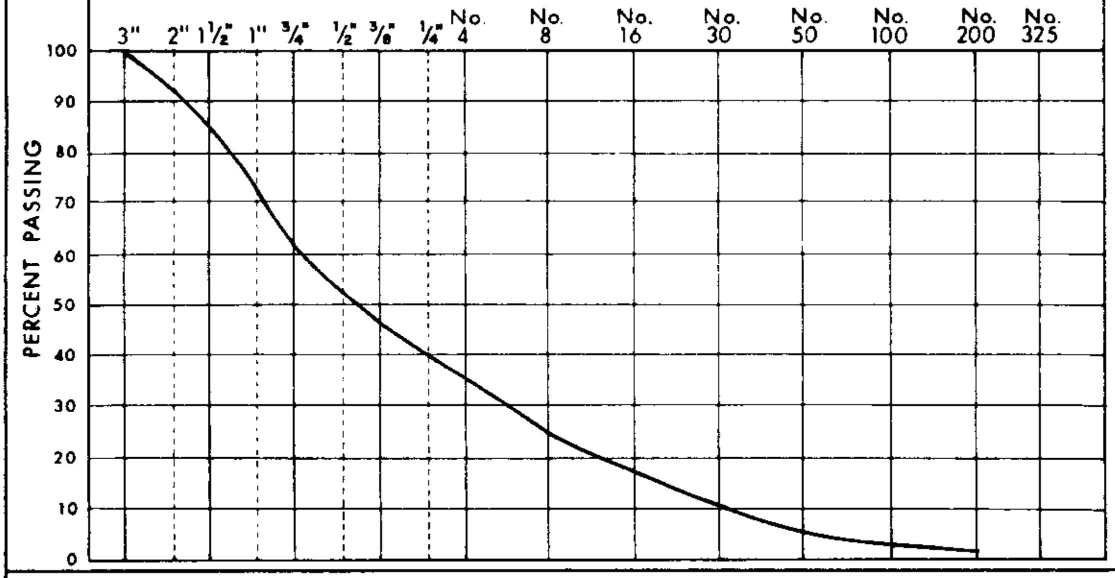
OVERSIZE (>3") = 6.0%

SAMPLE N75-117C-B2-4 DEPTH 1.0 - 3.0

DATE SAMPLED July 26, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 86

GRAVEL SIZES		SAND SIZES			FINES
37 %	27 %	14 %	14 %	6 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	92.0
1½"	84.8
1"	71.2
¾"	63.3
½"	53.3
⅜"	47.0
¼"	
No. 4	36.2
No. 8	25.1
No. 16	17.6
No. 30	10.8
No. 50	5.3
No 100	2.9
No. 200	2.1

COMMENTS

OVERSIZE (>3") = 24.0%

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-117C-B2

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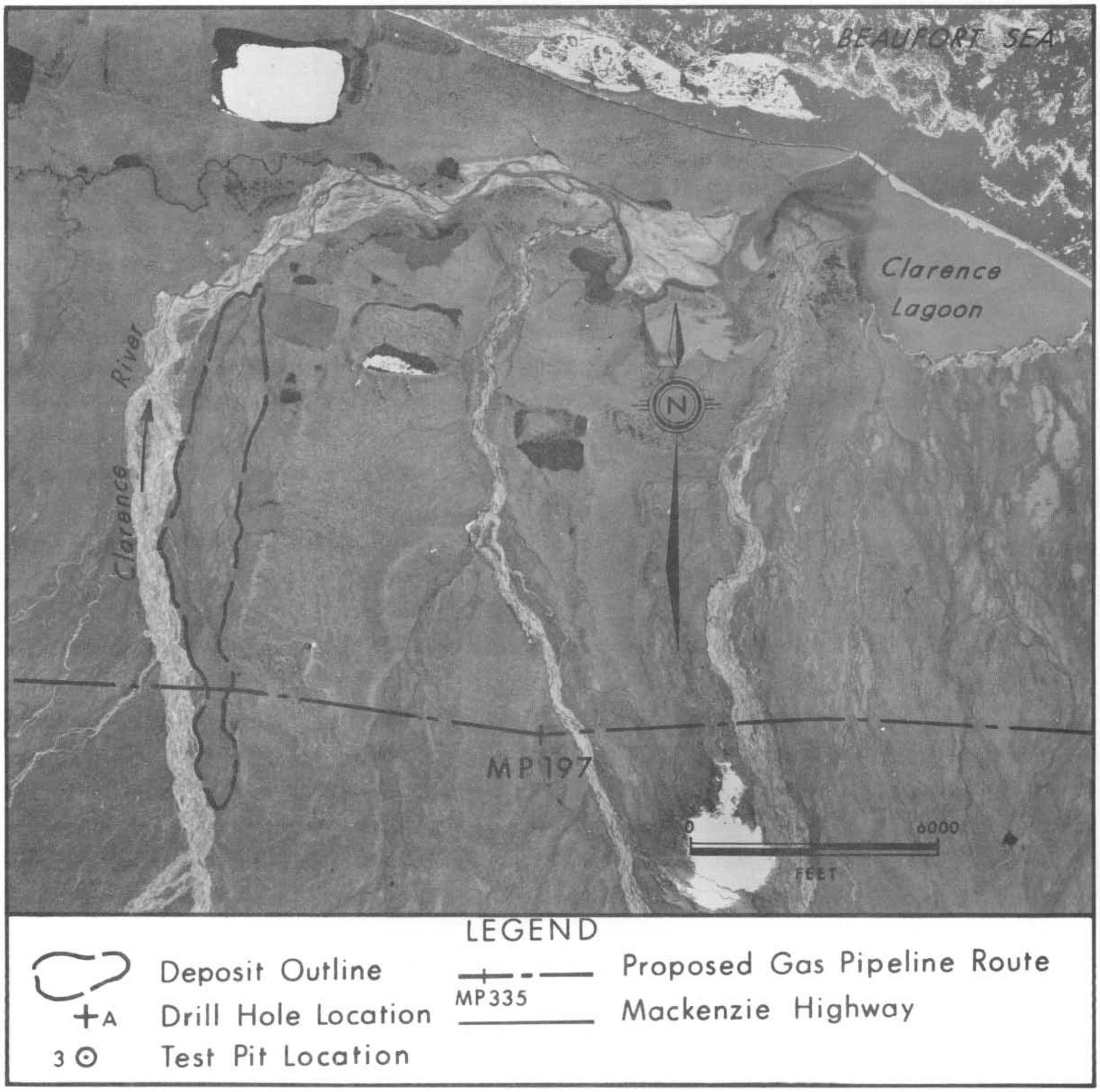
DEPOSIT 117C-B3

Physical Setting: Deposit 117C-B3 is a low terrace bordering the east edge of Clarence River at the Yukon/Alaska boundary. The pipeline right of way crosses the deposit at mile 195.

Material: Well graded gravel.

Volume: 16,000,000 cubic yards.

Assessment: Deposit 117C-B3 is a good source of granular material but the available volume may be limited by drainage and overburden thickness. Haul distance would be short as the pipeline actually crosses the deposit . The granular material from this deposit would require testing before being used for construction.



Airphoto No. A13138-154
Approximate Scale : 1" = 5250'

Latitude: 69° 35' N
Longitude: 141° 00' W

DEPOSIT 117C-B3

PHYSICAL SETTING

Deposit 117C-B3 is a low terrace bordering the east edge of Clarence River at the Yukon/Alaska boundary. Mile 195 of the proposed pipeline right of way crosses the southern end of the deposit. The terrace surface slopes very gently to the north and is only about 2 feet above the present level of Clarence River floodplain.

The surface of the terrace, which slopes gently to the north, is imperfectly to poorly drained. Surface seepage parallels the northward course of Clarence River. At least 1 foot of overburden consisting of peat, organic silt, and sand overlies the gravel. Ice content of the gravel is probably low to moderate.

BIOLOGICAL SETTING

Most of this deposit is covered by sedge meadow with scattered willows. Better drained parts are covered by *Dryas* with occasional small willows.

Lemmings, owls, and ptarmigan utilize small peat mounds, which are sometimes present. Arctic char spawn in the Clarence River.

MATERIALS

Although no test pit or drill hole data is available for this deposit, it is assumed that this terrace is underlain by stratified, well graded gravel. Most terraces and alluvial fans in the area show a similar stratigraphy.

VOLUME

The deposit covers 500 acres and has an estimated volume of 16,000,000 cubic yards based on a depth estimate of 20 feet.

DEVELOPMENT AND REHABILITATION

Deposit 117C-B3 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, overburden thicknesses, insitu material quality, and material requirements. The gravel would require further testing before being used in construction.

Access to the deposit with equipment could be achieved by barge to Clarence Lagoon and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul point on the right of way.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be maintained. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

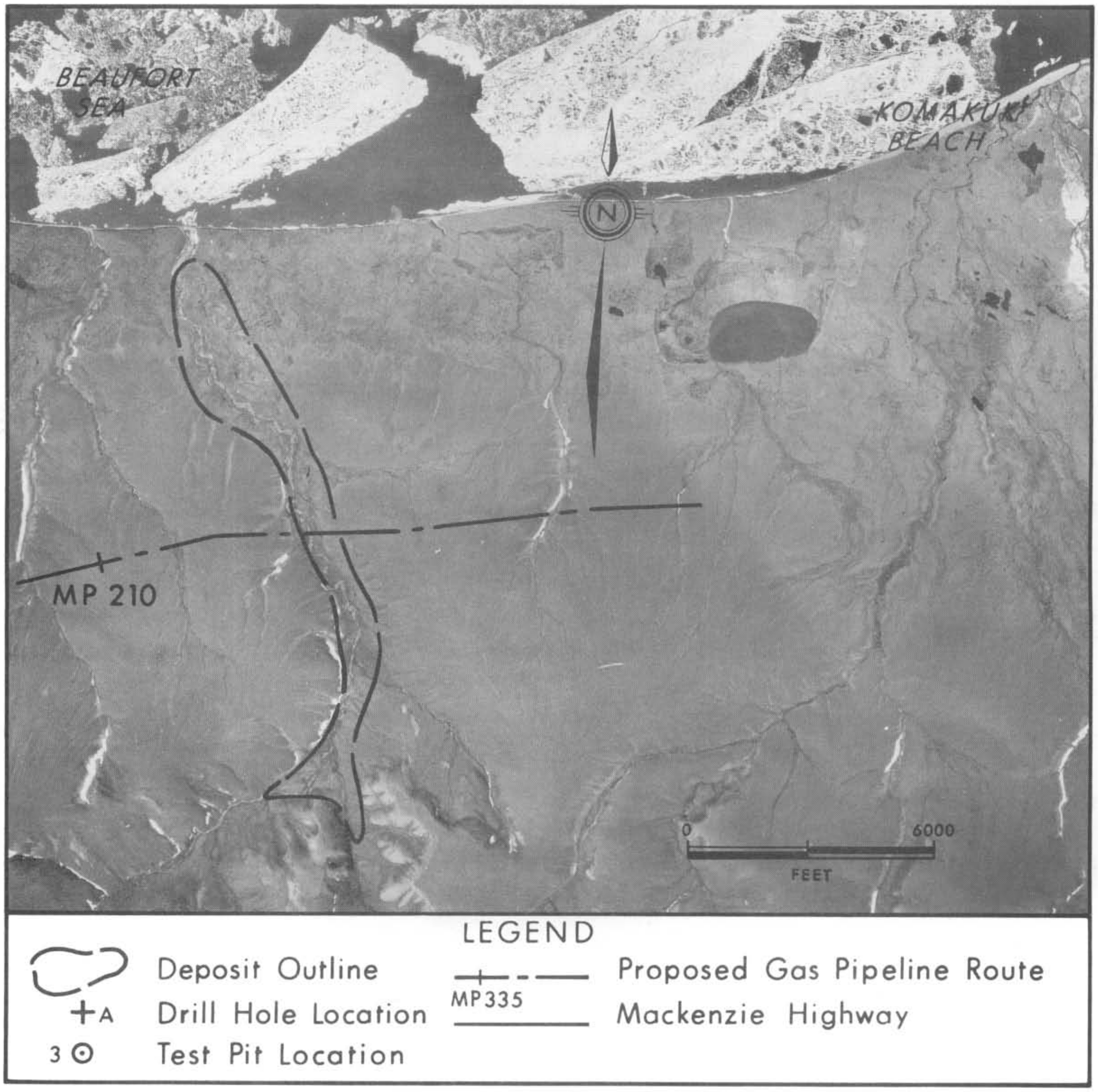
DEPOSIT 117C-B4

Physical Setting: Deposit 117C-B4 is a series of low terraces adjacent to a small stream crossing the Yukon coastal plain about 5 miles west of Komakuk Beach. It is crossed by the proposed gas pipeline route at mile 211.

Material: Well graded gravel.

Volume: 8,900,000 cubic yards.

Assessment: Deposit 117C-B4 is a good source of granular material, and the proposed gas pipeline crosses the deposit. Granular material from this deposit would require testing before being used for construction.



Airphoto No.	A13140-111	Latitude:	69° 34' N
Approximate Scale:	1" = 5250'	Longitude:	140° 20' W

DEPOSIT 117C-B4

PHYSICAL SETTING

Deposit 117C-B4 is a series of low terraces adjacent to a small stream crossing the Yukon coastal plain about 5 miles west of Komakuk Beach. The proposed pipeline right of way crosses this deposit at mile 211.

The terrace surfaces are from 2 to 10 feet above the level of a narrow floodplain. The terrace surfaces are well drained, except for the edges adjacent to the valley walls. Overburden appears to consist of sandy peat up to 3 feet in thickness. Ice content of the gravel is probably low.

BIOLOGICAL SETTING

This site was not inspected from an environmental viewpoint. However, it is covered by sedge tundra with isolated shrubs along protected slopes.

MATERIALS

The floodplain and terraces appear to be underlain by subangular, stratified, dense gravel with occasional cobbles and a few boulders. Argillite and shale chips are common in the gravel.

VOLUME

The deposit covers 550 acres and has a total estimated volume of approximately 8,900,000 cubic yards based on a depth of 10 feet.

DEVELOPMENT AND REHABILITATION

Deposit 117C-B4 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, overburden thicknesses, insitu material quality, and material requirements. Excavations would be kept away from lakes to prevent siltation. The gravel would require further testing before being used for construction.

Access to the deposit with equipment could be achieved by barge to Komakuk Beach and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so good drainage would be maintained. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

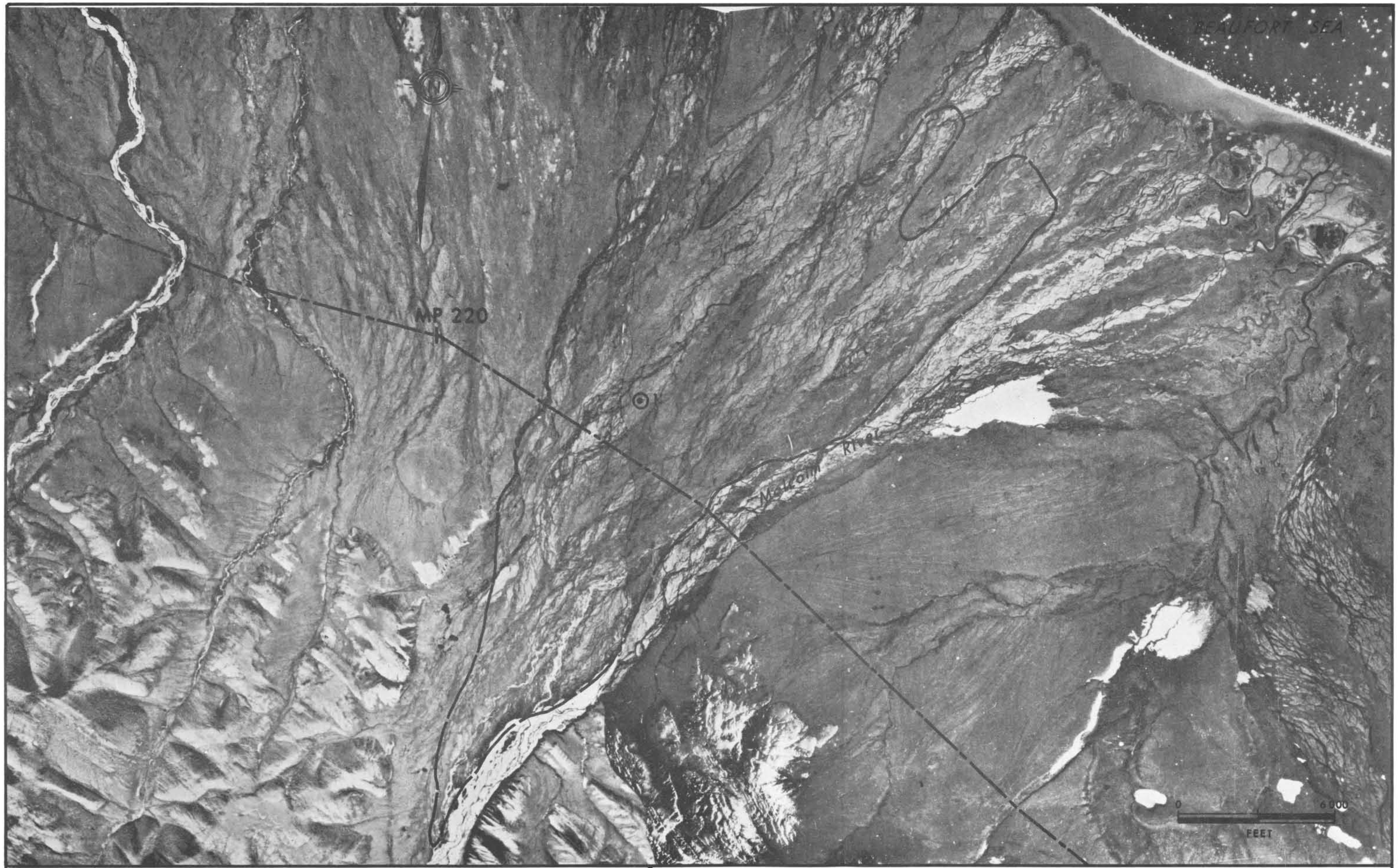
Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

DEPOSIT 117D-B1

Physical Setting :	Deposit 117D-B1 is part of a large alluvial fan of the Malcolm River on the Arctic Coast 12 miles west of Herschel Island. The proposed gas pipeline route crosses the centre of the fan at mile 222.
Material :	Gravel; well graded, coarse to fine, some sand.
Volume :	300,000,000 cubic yards.
Assessment :	Deposit 117D-B1 is an excellent source of granular material. Haul distances are short as the right of way crosses the deposit. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and concrete and asphalt.

AIRPHOTO SHOWN ON FOLLOWING PAGE



LEGEND

Deposit Outline
+A Drill Hole Location
3⊙ Test Pit Location

MP 335 Proposed Gas Pipeline Route
Mackenzie Highway

Airphoto No. A14361-85, A13140-107
Approximate Scale: 1" = 5250'

Latitude : 69° 32' N
Longitude: 139° 54' W

DEPOSIT 117D-B1

PHYSICAL SETTING

Deposit 117D-B1 is part of a large alluvial fan on the Arctic coast about 12 miles west of Herschel Island. The proposed gas pipeline crosses the centre of the fan at mile 222.

The fan slopes gently northeast from the base of the Buckland Hills to the Beaufort Sea, a distance of about 10 miles. A braided pattern of channels and bars is responsible for relief of up to 3 feet on the surface of the fan. The fan has been terraced and small 8-foot scarps are locally present. Malcolm River occupies a channel on the east side of the fan. Surface drainage over most of the deposit is good, usually following old stream channels. Some lower areas and channels are imperfectly drained. The water table is within 4 feet of the surface during summer.

Bare gravel is exposed over much of the fan surface. However, up to 2 feet of peat may exist in abandoned channels and low areas.

BIOLOGICAL SETTING

A broken vegetation cover composed mainly of moss, lichen, and dwarf birch exists on well drained areas, and tundra vegetation consisting primarily of sedge tussocks and dwarf willow is present in low imperfectly drained portions.

Moose and grizzly bear use the area adjacent to Malcolm River. Arctic ground squirrels den in the well drained parts of the fan. Malcolm River supports char and grayling populations during the summer. There is also a chance of stranding grayling and char in excavation created pools.

Snow geese have previously been sighted in the area and could be expected to use the area again.

MATERIALS

The fan is an excellent source of good quality granular material. It is composed of well graded, clean, subrounded gravel with scattered cobbles. The material quality is probably uniform across the deposit. The test pit did not reach permafrost, and no surface features are present that would indicate the presence of massive ground ice.

VOLUME

The deposit covers an area of about 8200 acres. This area, shown on the air photo, includes only the parts of the fan which are well drained and relatively free of overburden. The total fan size is about twice that of the deposit outlined.

The total volume of the deposit, based on an estimated depth of 30 feet, is about 300,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B1 is an excellent source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Excavations would be kept away from the Malcolm River stream channel to prevent siltation and to protect the natural setting. Measures should be taken to reduce the possibility of stranding grayling and char in excavation created pools following the spring floods. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production.

Access to the deposit with equipment may be achieved by barge to Komakuk Beach and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. The Malcolm River would not necessarily be crossed during development as good gravel deposits also lie immediately to the east of the river.

Initially, where a cover of peat and silt is present it would be stripped from the area to be excavated, and stockpiled around the edge of the excavation away from natural drainage channels.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be maintained. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL - coarse to fine, some sand, frequent cobbles.		UF		MA, combined samples 1 - 5 Oversize = 18.1% G = 72% S = 28% F = 2% (GW)	B1	☒				
								B2	☒				
1								B3	☒			1	
								B4	☒				
2								B5	☒			2	
3								B6	☒			3	
4			4.0 Bottom of pit ▼ Water level									4	Water level at 3.8'

LOGGED BY: D.O.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: $69^0 31'46''N$, $139^0 53'18''W$	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
DRWN. BY: G.C.B.	AIRPHOTO No.: A 15462-16	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP.: 7^0C	
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 25 M 07 Y 75 TIME: 17:00 FINISH: D 25 M 07 Y 75 TIME: 19:55

TEST HOLE No. N75-117D-B1-1

SHEET 1 OF 1

PC-9,SK373

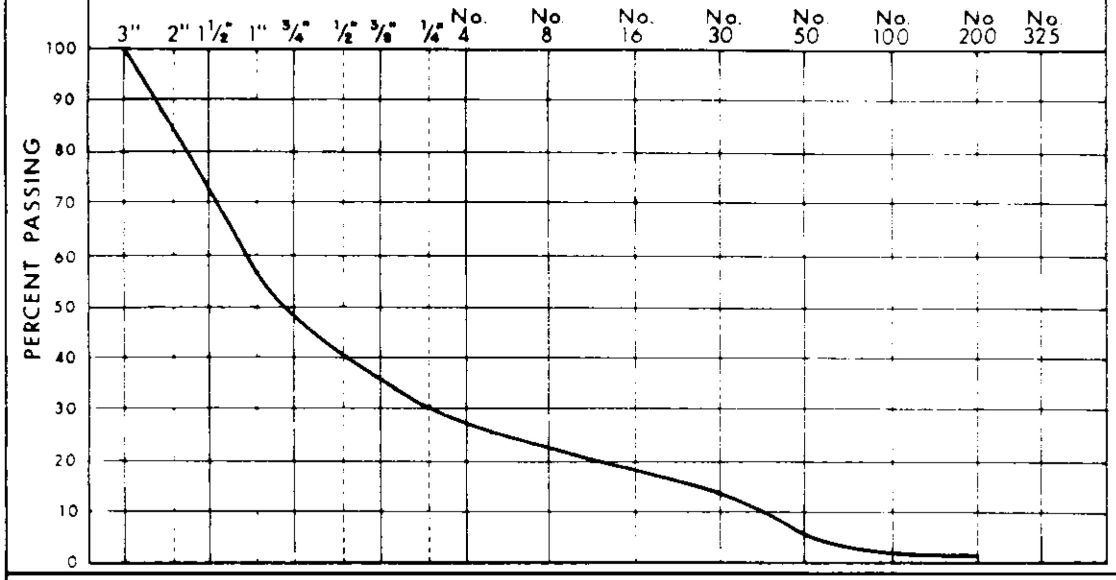
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B1-1 DEPTH 0.0 - 2.5

DATE SAMPLED July 25, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 112

GRAVEL SIZES		SAND SIZES			FINES
51 %	21 %	6 %	12 %	8 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	84.0
1½"	73.5
1"	57.8
¾"	49.1
½"	40.5
⅜"	35.4
¼"	
No. 4	27.5
No. 8	22.7
No 16	18.4
No. 30	13.1
No. 50	5.5
No.100	2.3
No. 200	1.6

COMMENTS

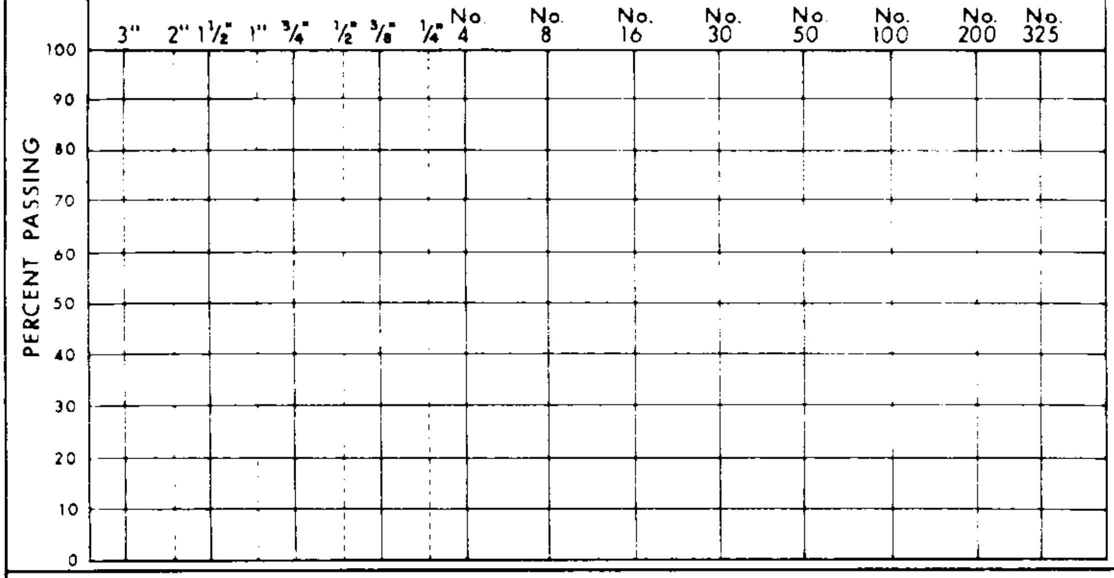
OVERSIZE (>3") = 18.1 %

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No.100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No.

N75-117D-B1

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. : N75-117D-B1-1
DATE SAMPLED : July 25, 1975
SAMPLED BY : NESCL
DEPTH (FT.) : 1 - 3.5
DATE TESTED : February, 1976
TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 0.26 %
FINE AGGREGATE : LOSS = 6.70 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 18.1 %

ORGANIC IMPURITIES TEST

NUMBER : 5
COAL REMOVED : 3
COAL & ROOTLETS REMOVED : 1
COAL CONTENT : 0.02%
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Very strong, Good	11.1
Sandstone	Medium strong to strong, Good	42.8
Siltstone		6.45
Greywacke		10.9
Limestone		4.1
Flint	Potentially reactive, Fair	0.25
Chert		1.55
Clay	Weak, Soft, Poor	0.15
Soft Siltstone		0.2
PN = 109	INTERPRETATION : Very good quality coarse aggregate.	77.5

COMMENTS :

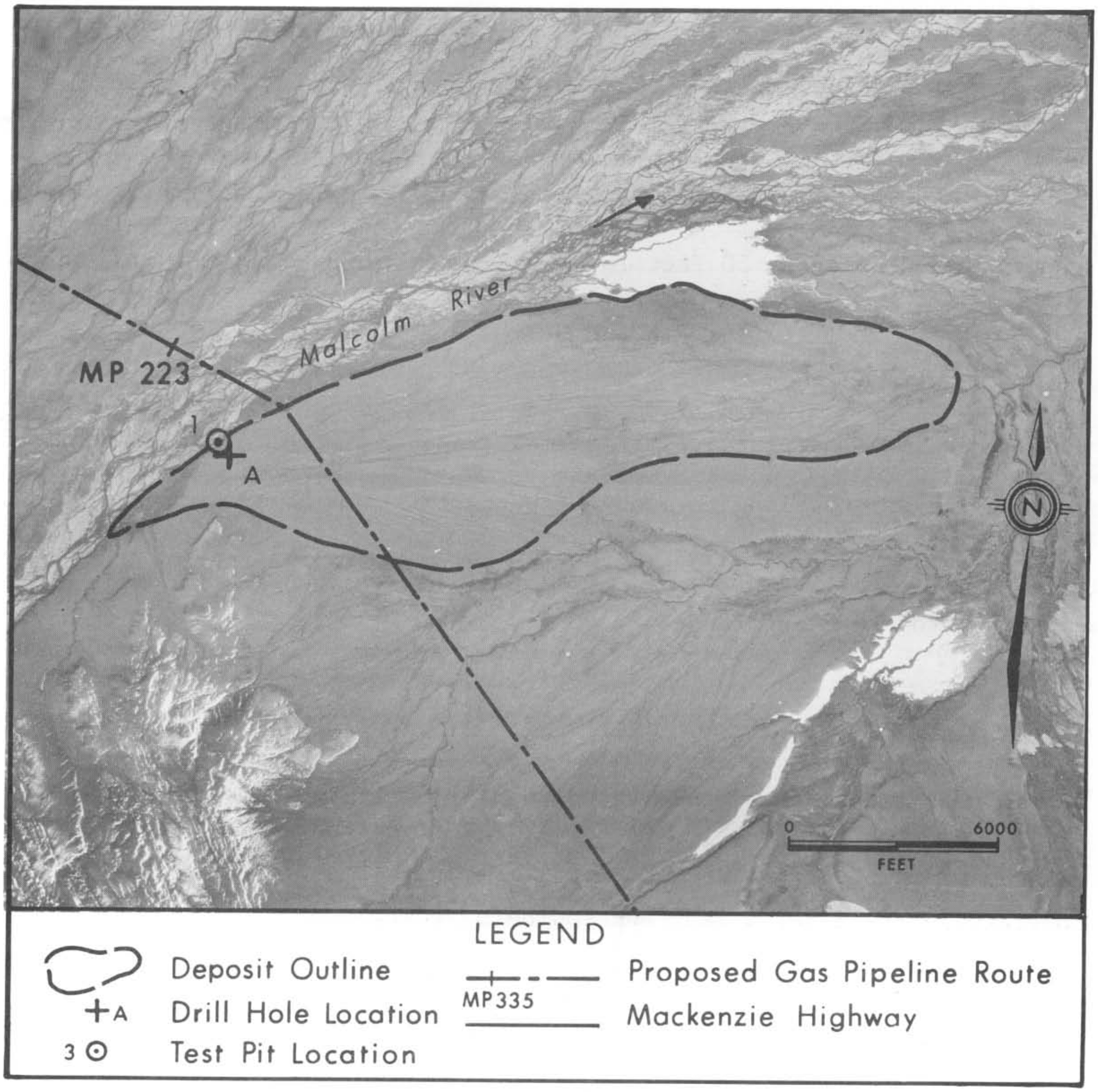
DEPOSIT 117D-B2

Physical Setting: Deposit 117D-B2 is a fluvial terrace located on the east side of the Malcolm River about 4 miles inland from the Beaufort Sea. The proposed gas pipeline route crosses the west side of the deposit at mile 224.

Material: Gravel; well graded, coarse to fine, some coarse, medium, and fine sand, trace fines.

Volume: 60,000,000 cubic yards.

Assessment: Deposit 117D-B2 is a good source of granular material, but the available volume may be limited by drainage and overburden thickness. The proposed gas pipeline crosses the western edge of the deposit. Granular material could be used for general fill, backfill in pipeline construction, building pads and concrete aggregate.



Airphoto No. A15462-16
Approximate Scale: 1" = 5250'

Latitude: 69° 30' N
Longitude: 139° 31' W

DEPOSIT 117D-B2

PHYSICAL SETTING

Deposit 117D-B2 is a fluvial terrace located on the east side of Malcolm River, about 4 miles inland from the Beaufort Sea. Mile 224 of the proposed pipeline route is located on the west side of the deposit.

The terrace is approximately 5 miles long and 1 mile wide and slopes gently to the east. It is a remnant of an alluvial fan, standing 20 feet above the present Malcolm River floodplain. The fan apex lies at the base of Buckland Hills.

On the northeast side of the deposit ice wedges have degraded, leaving high-centered polygons 50 feet in diameter and troughs between polygons up to 5 feet deep.

Surface drainage is poor, occurring mainly along shallow, poorly defined drainage ways, and along ice-wedge troughs on the northeast side of the deposit. The fan surface drains to the east into a small creek which empties into the Beaufort Sea.

Overburden, consisting of ice-rich peat and silt, is 4 to 6 feet thick on the west side of the deposit and possibly slightly thicker on the east side. The active layer is 1½ to 2 feet thick. Ice contents are moderate in the upper 4 feet and low below that.

BIOLOGICAL SETTING

Tundra, consisting primarily of sedge tussocks and moss, covers the surface of the deposit. A few dwarf willow shrubs are present in melt-out troughs.

The Malcolm River floodplain provides good summer habitat for moose and bear, and the river itself supports char and grayling populations. The terrace is a nesting area for upland bird species such as ptarmigan and longspur. Snow geese have previously been sighted in the area and could be expected to use the area again.

Siltation of the river due to borrow activities should be minimized to avoid damaging the fish population.

MATERIALS

The terrace is a source of good quality granular material. It consists of stratified, subrounded, well graded gravel and sand with scattered cobbles and a trace of silt in the upper 3 feet.

VOLUME

Drill hole data indicates that the depth of gravel is in excess of 29 feet. Based on an estimated average depth of 20 feet and medium ice contents, the total volume of the deposit is approximately 60,000,000 cubic yards.

The deposit covers about 2500 acres. This includes only the area where overburden thickness is not likely to exceed 6 feet. The size of the deposit could be extended by including areas with thicker overburden.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B2 is a good source of granular material, although overburden is thick. Location of areas to be exploited would be dictated by haul distances, insitu material quality, thickness of overburden, and material requirements. Excavations would be kept away from the Malcolm River stream channel to prevent siltation and to protect the stream environment. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Catton Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. Malcolm River would not necessarily have to be crossed during development of this deposit because another source is present west of Malcolm River.

Initially the peat cover and overburden could be stripped from the area to be excavated, and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly to a grade such that good drainage would be maintained over the area. Alternatively, dugout pit development could be established. Either type of development could be accomplished by using blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation will be adequate to obtain good gradation. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt		0.5 PEAT—fibrous, spongy,moist,dark brown.									0	19:30 new 4¼'' Walmac
	ML		1.1 SILT—trace fine to medium sand, light grey. 1.5		UF								
2	OL		SILT—(organic) some fine to coarse sand, roots, dark brown,trace coarse to fine gravel from 3 5'		F								
4			4.0 4.5									4	change to new 3 7/8'' tricone.
6			6.0										
	GP		GRAVEL - coarse large cobble										
8													
10												10	20:30
12													
			13									13	21:00
14			14 boulder ?										Slough and melt opening hole, jamming, bit stuck at 15' upon removal 23:00
			15 coarse gravel isolated cobbles to end of hole									15	
29			29 End of hole									29	

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 69°30'22''N. 139°50'44''W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 15462-16	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR CANADIAN ARCTIC GAS STUDY LIMITED
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 1°C	
	METHOD: AIR		

START: D 25 M 07 Y 75 TIME: 19:30 FINISH: D 25 M 07 Y 75 TIME: 23:00

TEST HOLE No. N75-117D-B2-A

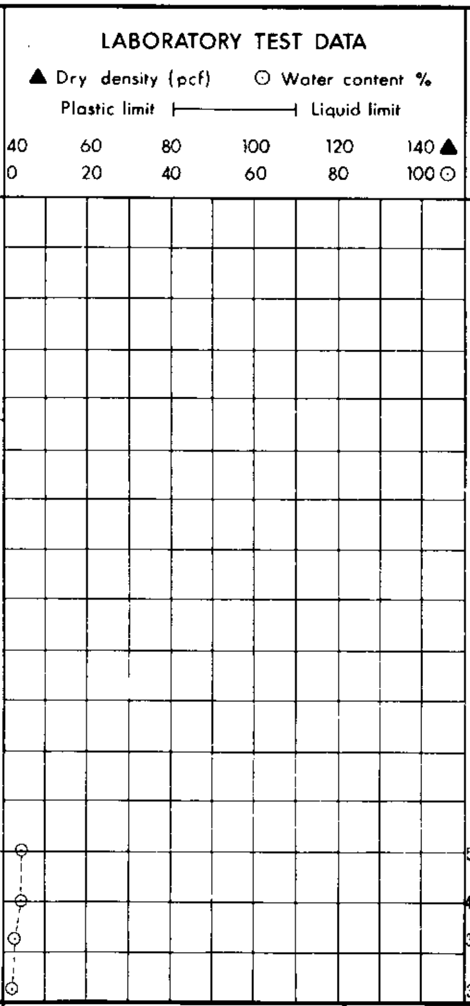
SHEET 1 OF 1

PC-9,SK273

TEST HOLE No.N75-117D-B2-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	REMARKS
0.5	Pt	PEAT - black, moist, fibrous	UF	W%			Using shovels
1.5	ML	SILT - some fine sand, little organics, non-plastic, dark brown, damp, stratified, isolated coarse gravel (< 2")					
3.8	Pt-OL	PEAT with SILT-(organic), little sand, coarse to fine, nonplastic, black, stratified, isolated coarse gravel to 2'', pockets of silt, dense	2.2 Vx 20				Using jack-hammer
6.0	GM	GRAVEL - coarse and fine, subrounded, some sànd, coarse to medium, little silt, non plastic, dark grey, stratified, isolated cobbles to 8''					
9.0	GW	GRAVEL - coarse and fine, subrounded, some sand, coarse to medium, stratified, isolated cobbles Bottom of excavation at 9.0'	6.5 Nb	5.3 MA, combined samples 1 - 6 oversize = 5.4% 4.3 G = 67% S = 28% 3.3 F = 5% 3.3	B1 B2 B3 B4		Sample B5, B6 from 8.5-9.0



LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 69°30'33''N, 139°51'04''W	ELEVATION:	
DRWN. BY: D.J.M.	AIRPHOTO No.: A 15462-16	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP: 10°C	
	METHOD: TEST PIT		

START: D 25 M 07 Y 75 **TIME:** 17:30 **FINISH:** D 25 M 07 Y 75 **TIME:** 23:25

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B2-1

SHEET 1 **OF** 1

PC-9,SK373

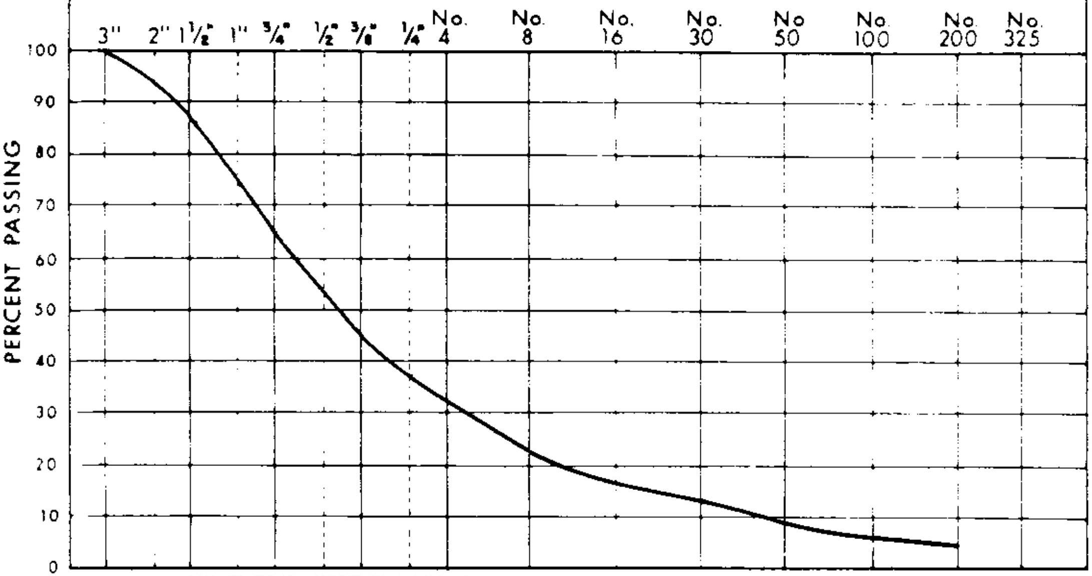
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B2-1 DEPTH 5.0 - 9.5

DATE SAMPLED July 25, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 80

GRAVEL SIZES		SAND SIZES			FINES
35 %	32 %	13 %	9 %	6 %	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.2
1½"	88.5
1"	74.3
¾"	65.3
½"	53.4
⅜"	45.0
¼"	
No. 4	32.8
No. 8	22.6
No 16	17.3
No. 30	13.4
No 50	9.8
No 100	7.0
No. 200	5.4

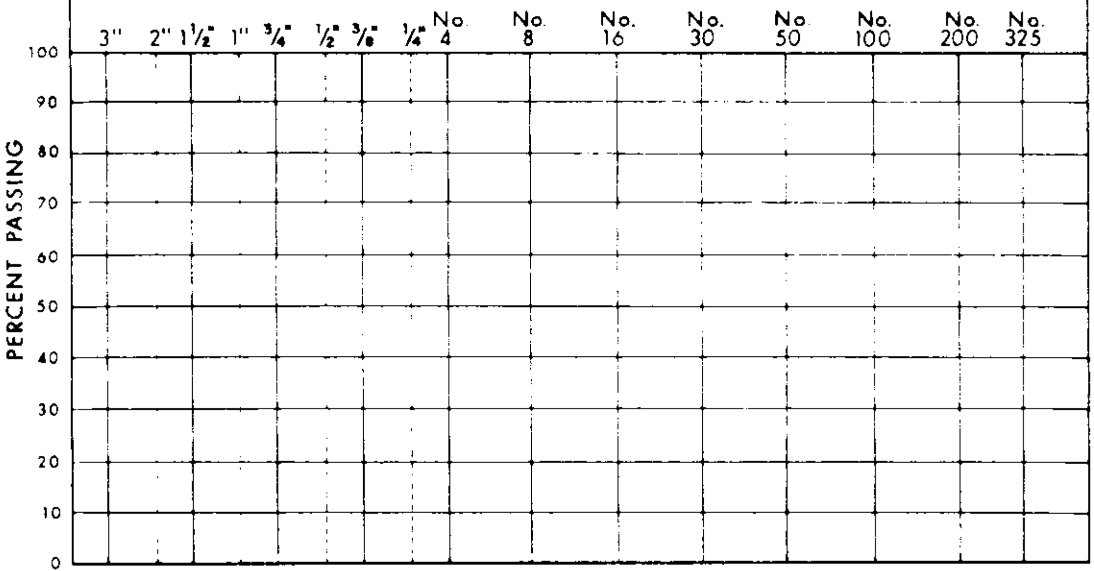
COMMENTS OVERSIZE (>3") = 6.4%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No 16	
No. 30	
No. 50	
No. 100	
No 200	

COMMENTS OVERSIZE (>3") = %

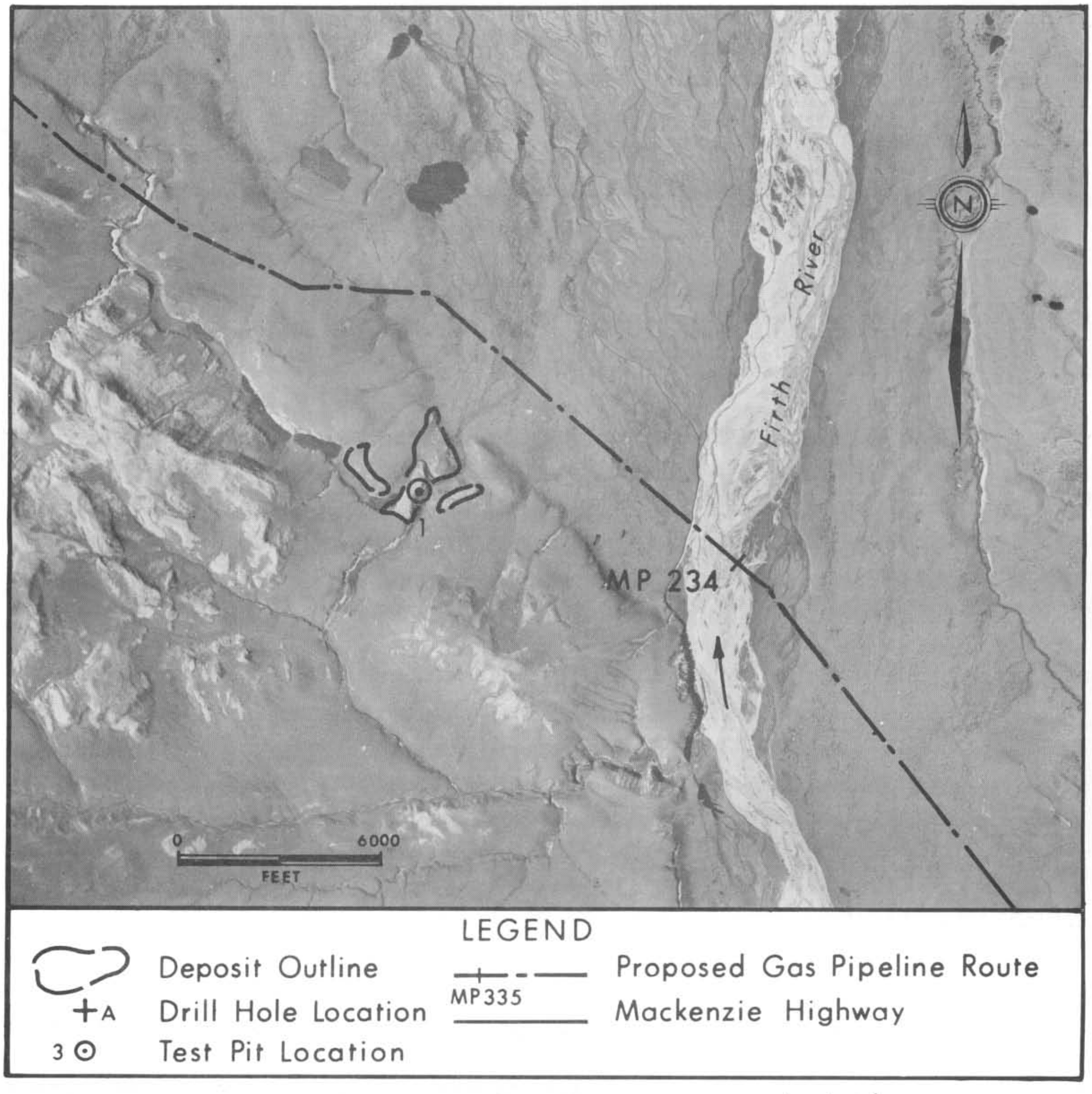
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-117D-B2

DEPOSIT 117D-B3

Physical Setting:	Deposit 117D-B3 is a kame terrace located 2 miles west of the Firth River and 10 miles south of the Beaufort Sea. The deposit is less than 1 mile south of mile 232 of the proposed gas pipeline route.
Material:	Gravel; well graded, and coarse, medium, and fine sand, trace fines.
Volume:	2,500,000 cubic yards.
Assessment:	Deposit 117D-B3 is a fair source of granular material. Haul distance from the deposit is less than 1 mile. Granular material from this deposit could be used for general fill, backfill in pipeline construction, and subgrade material for building pads.



Airphoto No.	A13751-114	Latitude:	69° 25' N
Approximate Scale:	1" = 5250'	Longitude:	139° 36' W

DEPOSIT 117D-B3

PHYSICAL SETTING

Deposit 117D-B3 is a kame terrace located 2 miles west of Firth River and about 10 miles south of the Beaufort Sea coastline. Mile 232 of the proposed pipeline route is less than a mile north of the deposit.

The terrace stands about 300 feet above the coastal plain, flanking the northern edge of Buckland Hills. The terrace surface, which slopes gently northeast, has been dissected by glacial meltwater channels and a small creek that drains northeast onto the Firth River alluvial fan. The stream-cut banks are steep. The outwash material composing the kame overlies shale bedrock at a depth of 30 to 40 feet.

A ridge extends northeast and southwest from the northern edge of the terrace. The proposed pipeline route crosses this ridge less than a mile from the deposit. The area north of the deposit is flat and marshy with extensive areas of ice-wedge polygons.

The terrace is well drained into the adjacent creek. Gravel is exposed at the surface over a large part of the deposit. Elsewhere, overburden is less than a foot deep. Ice contents are low to medium except possibly near ice-wedge polygons on the eastern part of the terrace.

BIOLOGICAL SETTING

The deposit is generally bare except for scattered patches of moss and lichen. A more continuous cover of moss, lichens and willow clump occur on some parts.

The area is occasionally visited by grizzly bear and upland bird species. Raptors utilize the hilltops in the nearby Buckland Hills. The small lakes and streams adjacent to the deposit have no suitable fish habitat.

This site falls within a proposed IBP reserve.

MATERIALS

The terrace is composed of fair quality granular material consisting of medium to coarse, stratified, angular, shaly sand with occasional fine to coarse gravel layers. Some clasts are quartzitic.

VOLUME

The terrace covers about 80 acres. The estimated depth, which has not been verified by drill hole data, is in excess of 30 feet. The total volume of the deposit, based on a depth of 30 feet, is 2,500,000 cubic yards. The designated deposit includes only the parts of the terrace with minimal overburden. The areas to the south and west of the deposit appear to be covered with silty overburden. The volume of the deposit could be increased slightly if these areas are included.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B3 is a fair source of granular materials. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Granular material from this deposit could be used for general fill, backfill in pipeline construction, and building pads.

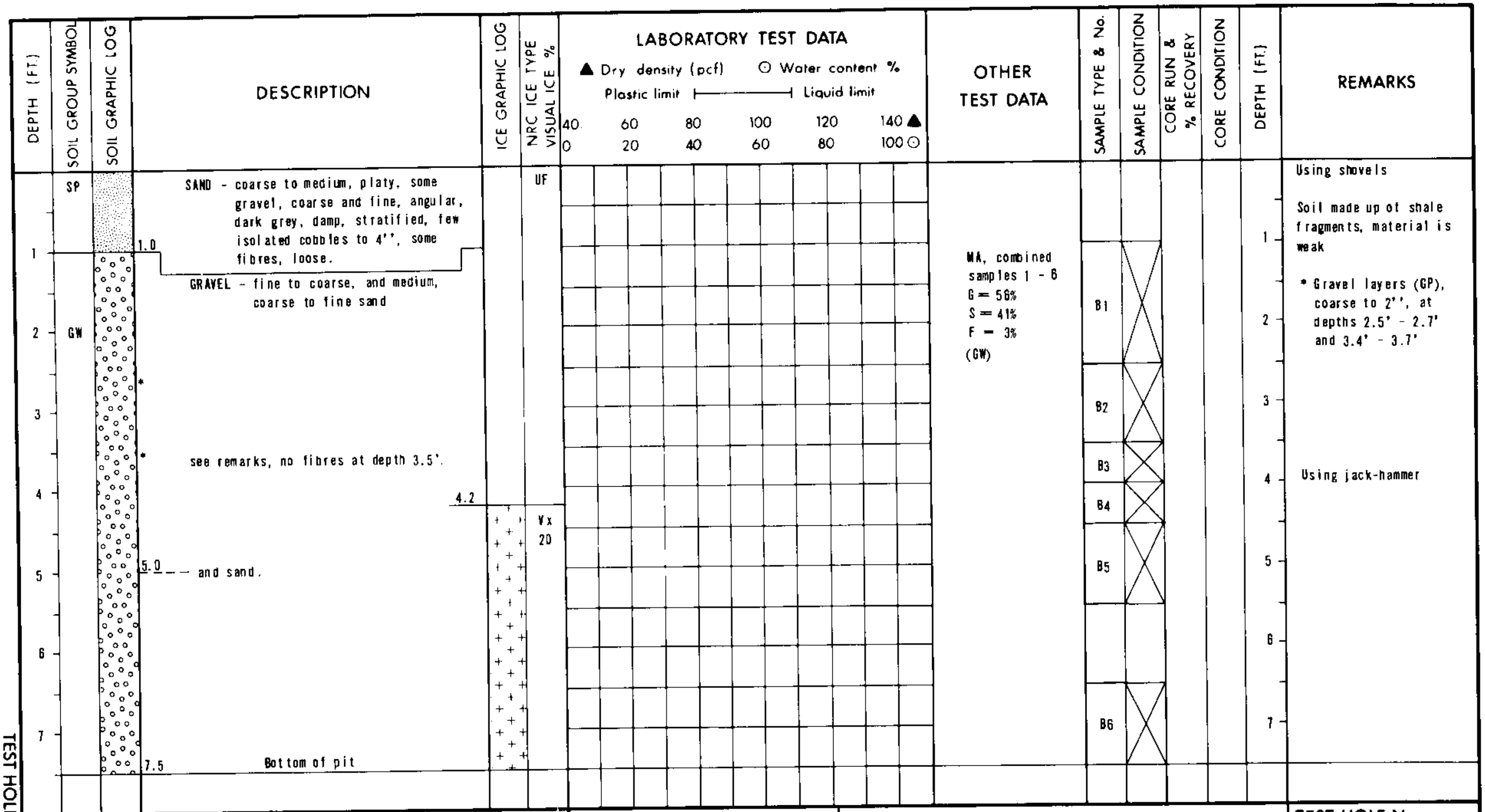
Access to the deposit with equipment could be achieved by barge to Catton Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. Snow roads would be constructed over any active stream channels in winter and removed prior to spring runoff.

Development would involve excavating borrow material evenly from well drained areas so that good drainage would be maintained over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by using blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, and crushing plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG



DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	REMARKS
0 – 1.0	SP	SAND - coarse to medium, platy, some gravel, coarse and fine, angular, dark grey, damp, stratified, few isolated cobbles to 4'', some fibres, loose.	UF			Using shovels Soil made up of shale fragments, material is weak
1.0	GW	GRAVEL - fine to coarse, and medium, coarse to fine sand		MA, combined samples 1 - 6 G = 56% S = 41% F = 3% (GW)	B1	* Gravel layers (GP), coarse to 2'', at depths 2.5' - 2.7' and 3.4' - 3.7'
		*			B2	
		* see remarks, no fibres at depth 3.5'.			B3	Using jack-hammer
4.2			Vx 20		B4	
5.0		and sand.			B5	
					B6	
7.5		Bottom of pit				

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: G.C.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°25'15''N, 139°36'02''W
AIRPHOTO No.: A 13751-114
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 4°C

START: D 25 M 07 Y 75 TIME: 12:50
FINISH: D 25 M 07 Y 75 TIME: 17:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES
COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B3-1
SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B3-1

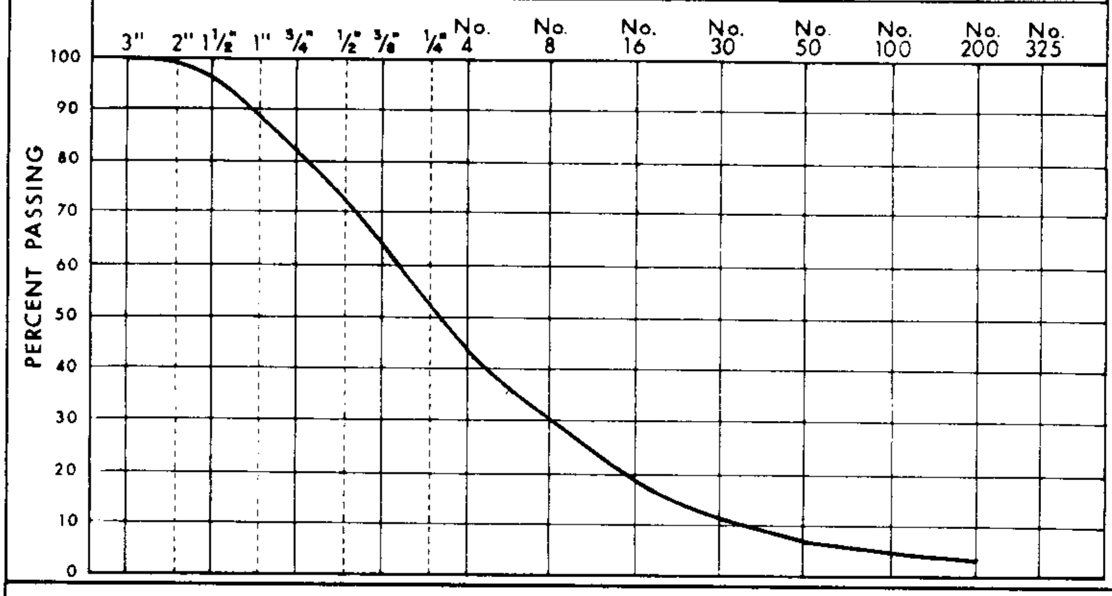
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B3-1 DEPTH 1.0 - 7.5

DATE SAMPLED July 25, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 104

GRAVEL SIZES		SAND SIZES			FINES
17 %	39 %	16%	20 %	5 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	96.3
1"	89.2
¾"	82.8
½"	73.1
⅜"	64.7
¼"	
No. 4	43.9
No. 8	30.5
No. 16	19.0
No. 30	10.8
No 50	6.5
No 100	4.4
No. 200	3.4

COMMENTS

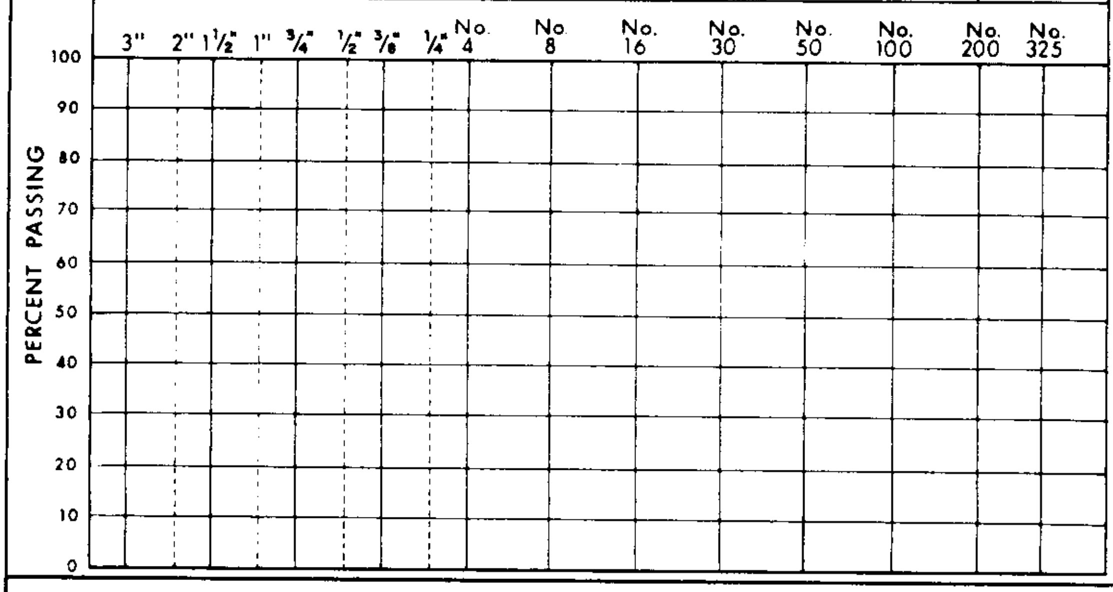
OVERSIZE (>3") = 0.0%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-117D-B3

PAGE 115

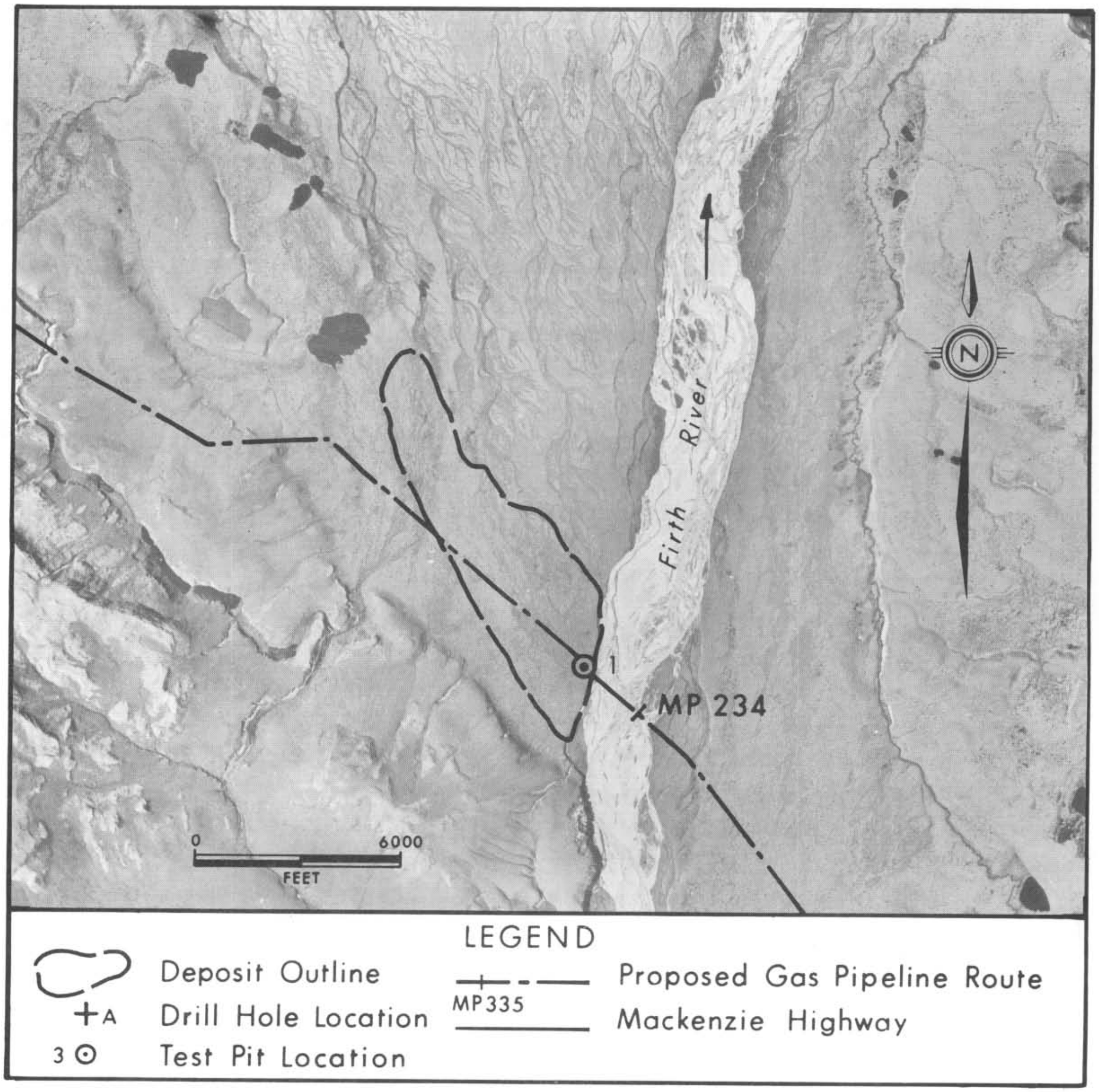
DEPOSIT 117D-B4

Physical Setting: Deposit 117D-B4 is a fluvial terrace on the west side of Firth River 10 miles south of the Arctic coast. The pipeline right of way crosses the deposit at mile 233.

Material: Gravel; well graded, coarse to fine, some sand.

Volume: 12,000,000 cubic yards.

Assessment: Deposit 117D-B4 is a good source of granular material. Haul distance along the pipeline right of way from the deposit is short. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and concrete aggregate.



Airphoto No. A13751-114

Approximate Scale: 1" = 5250'

Latitude: 69° 26' N

Longitude: 139° 32' W

DEPOSIT 117D-B4

PHYSICAL SETTING

Deposit 117D-B4 is a fluvial terrace on the west side of the Firth River, about 10 miles south of the Arctic coast. Mile 233 of the proposed pipeline route is in the southern half of the deposit.

The terrace stands 20 feet above the present Firth River floodplain, and slopes gently to the north. The west and south edges, below the scarp which is the northern limit of the Buckland Hills, are poorly drained and marshy with ice-wedge polygons 30 feet in diameter. The east and north sides are well-drained near the edges of the terrace. The terrace drains to the north onto the Firth River alluvial fan and floodplain. The water table on the terrace is probably within a few feet of the surface during summer. Ice contents in the soil are low to moderate in well drained areas.

One to 2 feet of peat, organic-rich silt and silty sand overlie most of the deposit. Overburden thickness may increase to 3 feet in poorly drained areas at the south and west edges of the deposit. To the north, about 5 feet above the Firth River floodplain, is a second terrace which is part of a large alluvial fan. This terrace has better drainage and less overburden than the higher terrace but is farther from the proposed right of way.

BIOLOGICAL SETTING

Tundra vegetation composed of sedge tussocks, moss, and a few willow shrubs cover the deposit.

Firth River provides important spawning and rearing grounds for Arctic char and grayling, and therefore, siltation of the stream should be minimized.

This site also falls within a preposed IBP reserve.

MATERIALS

The deposit is composed of good quality material consisting of stratified well graded gravel with some fine to coarse sand, a trace of silt, and scattered cobbles to 6 inches.

VOLUME

The deposit extends over 650 acres and probably exceeds 30 feet in depth. This area includes only the part of the terrace with the least overburden. It could be significantly enlarged if areas with greater overburden thickness were included.

The total volume of the deposit, based on a depth of 30 feet and moderate ice contents, is approximately 12,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B4 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses and material requirements. Excavations would be kept away from the Firth River stream channel to prevent siltation and to protect its natural setting. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete production.

Access to the deposit with equipment could be achieved by barge to Catton Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. The Firth River would not necessarily be crossed during development as gravel deposits also exist on its east side.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation away from the Firth River.

Development would involve excavating borrow material evenly down to a grade that would permit good drainage over the area. Alternatively, dugout pit development could be established. Either type of development could be accomplished by using blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.5	Pt		PEAT – dark brown, fibrous, woody, roots.		UF								
1.4	SP		SAND – fine, grey, moist, rootlets.									1	
6.0	GW		GRAVEL – coarse to fine, some sand, grey, layered, spacing 6'', frequent cobbles to 6''. Bottom of pit.				MA, combined samples 1-6 Oversize = 24.6% -3'' G = 74% S = 24% F = 2%	B 1-6	╳			2 3 4 5 6	

LOGGED BY: D.D.

CHKD: D.D.

DRWN. BY: D.J.M.

CHKD: R.H.

FACILITY:

LAT. & LONG: 69°25'23''N.139°31'51'' W

AIRPHOTO No.: A 13751-114

RIG:

METHOD: TEST PIT

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: 4° C

START: D 25 M 07 Y 75 TIME: 13:00

FINISH: D 25 M 07 Y 75 TIME: 15:25

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B4-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B4-1

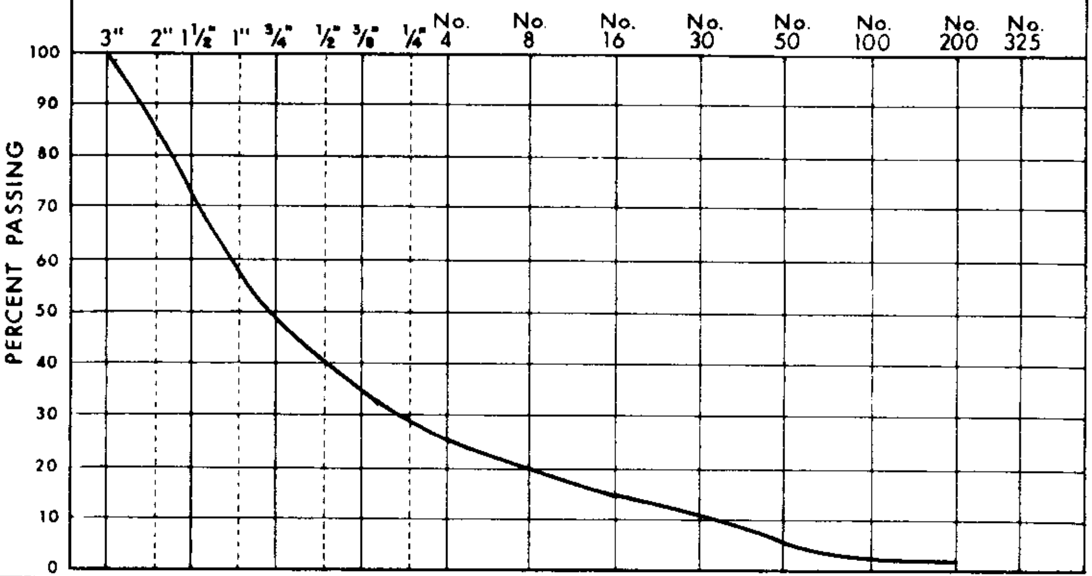
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B4-1 DEPTH 1.5 - 6.5

DATE SAMPLED July 25, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 135

GRAVEL SIZES		SAND SIZES			FINES
51 %	23 %	6 %	12 %	6 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	84.2
1½"	73.5
1"	57.2
¾"	48.9
½"	40.3
⅜"	34.9
¼"	
No. 4	25.6
No. 8	20.6
No. 16	15.8
No. 30	11.0
No. 50	6.2
No. 100	3.4
No. 200	2.4

COMMENTS

OVERSIZE (>3") = 24.6%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	

3" 2" 1½" 1" ¾" ½" ⅜" ¼" No. 4 No. 8 No. 16 No. 30 No. 50 No. 100 No. 200 No. 325

PERCENT PASSING

SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-117D-B4

PAGE 123

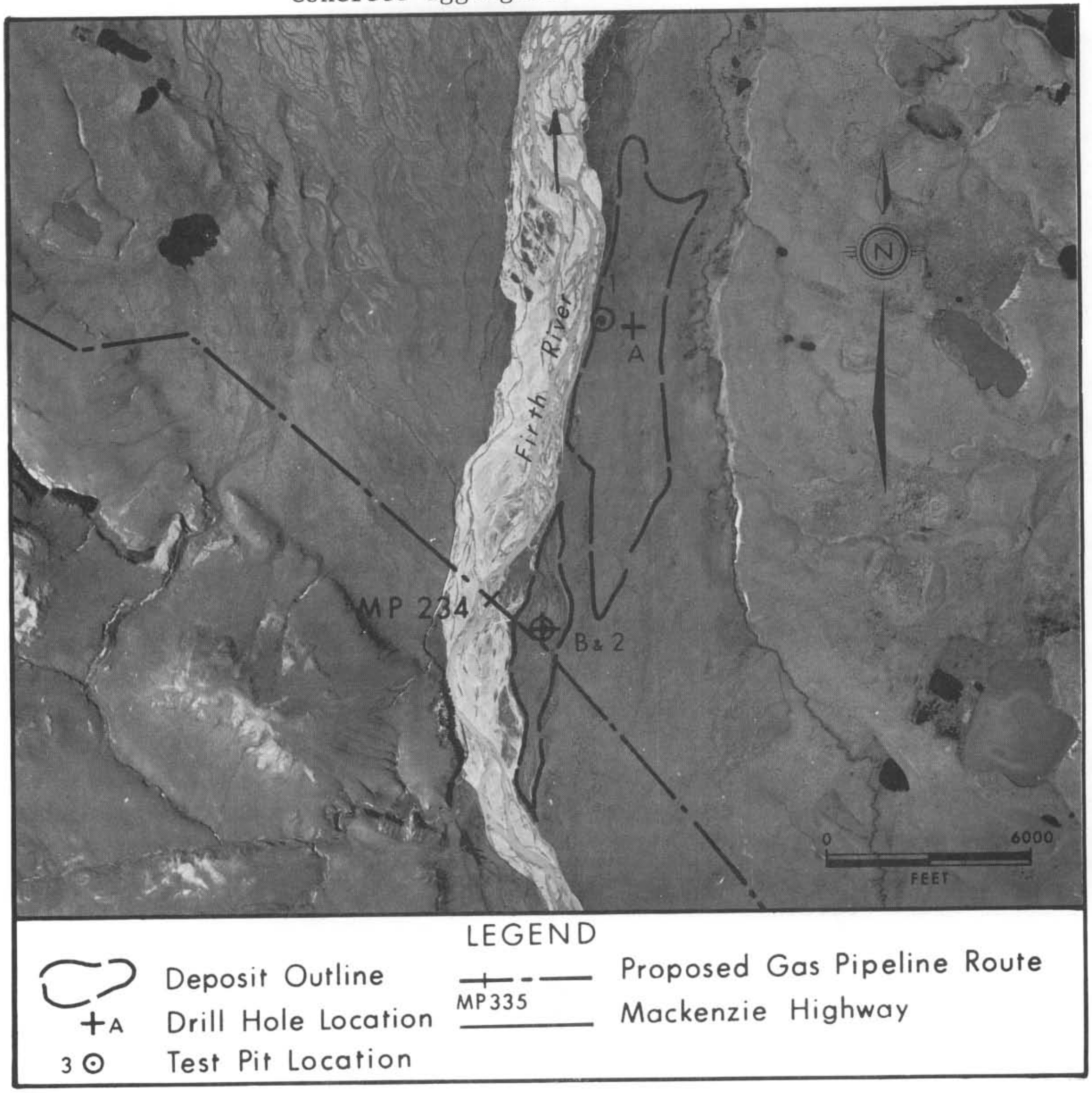
DEPOSIT 117D-B5

Physical Setting: Deposit 117D-B5 is located about 10 miles south of the Arctic coast and consists of two fluvial terraces on the east side of Firth River. The proposed gas pipeline route crosses the deposit at mile 234.5 of the route.

Material: Gravel; well graded, coarse to fine, some coarse, medium and fine sand, trace fines.

Volume: 40,000,000 cubic yards.

Assessment: Deposit 117D-B5 is a good source of granular material. Haul distances to the proposed pipeline right of way are short as the deposit is actually crossed by the pipeline. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and asphalt and concrete aggregate.



Airphoto No. A13751-114
Approximate Scale: 1" = 5250'

Latitude: 69° 25' N
Longitude: 139° 31' W

DEPOSIT 117D-B5

PHYSICAL SETTING

Deposit 117D-B5, located about 10 miles south of the Arctic coast, consists of two fluvial terraces on the east side of Firth River. Mile 234.5 of the proposed pipeline route is at the southern part of the deposit.

The southern terrace is about 5 feet above the modern floodplain, and is the equivalent of the low terrace (Deposit 117D-B4) on the west side of the river. The terrace surface, which slopes gently to the north, has a braided pattern composed of bars and 2-foot deep abandoned stream channels. This terrace is about 1½ miles long and up to ¼ mile wide. It is moderately well drained and generally has less than one foot of overburden.

The northern terrace stands about 20 feet above the Firth River floodplain, and is the east-bank equivalent of Deposit 117D-B4. This part of the deposit is about 2½ miles long and ½ mile wide. It is moderately well drained near the river, with less than 1 foot of peat and silt overlying the gravel. Away from the river the terrace is poorly drained and may have in excess of 4 feet of overburden. Ice-wedge polygons are present in some marshy areas near the north and south tips of the terrace. The active layer is 1 to 2 feet thick in areas of peat cover, and thicker where gravel is exposed. Ice contents are generally low to moderate, except beneath polygonal ground where ice wedges are present.

BIOLOGICAL SETTING

Sedge tundra characterized by tussocks, with moss between tussocks, covers both terraces. On the southern terrace, bare patches of gravel are present and willow shrubs to 3 feet high are present in scattered clumps along the eastern margin.

Grizzly bear and Arctic fox visit the area occasionally, and some upland bird species such as ptarmigan and golden plover nest in the vicinity. Snow geese have previously been sighted in the area and could be expected to use the area again.

The main channel of Firth River is a major rearing area for Arctic char and grayling. For this reason, disturbance to the aquatic environment should be minimized, particularly during summer.

This site also falls within a proposed IBP reserve.

MATERIALS

The terraces are composed of good quality granular material consisting of stratified, well graded, subrounded gravel with some layers of fine to coarse sand, scattered cobbles, and isolated boulders.

VOLUME

The part of the terrace included in the deposit is that area with the least overburden and the best drainage conditions. The deposit could be significantly enlarged if areas with thicker overburden and poorer drainage were included.

The southern terrace has an area of about 200 acres and a total volume, based on a depth of 30 feet and moderate ice contents, of 5,000,000 cubic yards. The northern terrace covers about 600 acres and has a total volume, based on a depth of 45 feet and moderate ice contents, of 35,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B5 is a good source of granular materials. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Excavations would be kept away from the Firth River stream channel to prevent siltation. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Catton Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. The Firth River would not necessarily have to be crossed during development as deposits exist on its west side.

Initially the peat cover and overburden would be stripped from the area to be excavated,and stockpiled around the edge of the excavation away from the Firth River.

Development would involve excavating borrow material evenly from well drained areas so that good drainage would be maintained over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by using blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be carried out to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % — Plastic limit ├──┤ Liquid limit — 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt		0.4 PEAT— fibrous, damp, dark brown		UF							0	12:30 3 7/8'' Walmac
	OL		SILT—(organic), sandy, moist, dark brown, 3/8'' roots, grass roots.										
			1.5										
2			2.0 light grey, roots very fine and sparse, medium sand sizes		Vx							2	small excavation revealed ice type at 2.0' as Vx
4	GM		4.0 GRAVEL— coarse, little silt, occasional cobbles.										
6													
	SP		7.0 SAND— medium, some fine to coarse gravel										
8	GP		8.0 GRAVEL— coarse, sandy, cobbles									8	13:00 hit cobble
10			cobbles at 8' and 10'										
12			sand content decreasing with depth										
14													
												15	13:20

LOGGED BY: J. J. S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: W. W.	LAT. & LONG: 69°25'26'' N, 139°29'57'' W	ELEVATION:	
DRWN. BY: A. M.	AIRPHOTO No.: A 13751-114	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D. O.	RIG: HELI-DRILL	AIR TEMP: 2°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 25 M 07 Y 75 TIME: 12:30 FINISH: D 25 M 07 Y 75 TIME: 18:30

TEST HOLE No. N75-117D-B5-A

SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117D-B5-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GP		GRAVEL (cont'd)		Vx								
18													
			20.0										
20			boulder - quartzitic, white crystals 1/32''									20	13:30 10'' into boulder with Walmac, changed to 3 7/8'' Tricone
			22.0										
22													
24			coarse gravel/cobbles trace sand										sand traces in cuttings, possibly slough
26													15:50 received fuel
28													
			4'' to 5'' cobbles									29	16:30
30													

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: W.W.	LAT. & LONG: 69°25'26'' N. 139°29'57'' W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 13751-114	PIPE MILEAGE:	
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 2°C	
	METHOD: AIR		
START: D 25 M 07 Y 75 TIME: 12:30	FINISH: D 25 M 07 Y 75 TIME: 18:30		

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B5-A
SHEET 2 OF 3

PC-9,SK373

TEST HOLE No. N75-117D-B5-A

TEST HOLE LOG

LABORATORY TEST DATA
▲ Dry density (pcf) ○ Water content %
Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	GP		GRAVEL (cont'd)		Vx								
												33	17:00
34													
36													
38													
												38	17:20
			boulder										
40													
42													
43			43.0 End of hole									43	18:00 tripping out to replace bit, difficulty retrieving stem at 20' and 5'.

LOGGED BY: J.J.S.
CHKD: W.W.
DRWN. BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°25'26''N, 138°29'57'' W
AIRPHOTO No.: A 13751-114
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 2°C

START: D 25 M 07 Y 75 TIME: 12:30
FINISH: D 25 M 07 Y 75 TIME: 18:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B5-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117D-B5-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.3 PEAT - moist, fibrous		UF							0	18:45
	GW		GRAVEL - coarse, fine to medium sand, damp, dark brown matrix, occasional cobbles to 5"										
2													
			3.5		F								
4												4	21:00 hit 5" cobble, tried pushing casing, not successful - changed to mud at 4.0'
6													
8													
			9.0 End of hole									9	22:00 hole caving in, cannot seal with mud - hole abandoned at 22:30 hrs. because no removal of cuttings.

LOGGED BY: J.J.S.
CHKD: D.O.
DRWN. BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69^{0}24'32''N, 139^{0}30'55''W
AIRPHOTO No.: A 13751-114
RIG: HELI-DRILL
METHOD: AIR and MUD

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 1^{0}C

START: D 24 M 07 Y 75 TIME: 18:45
FINISH: D 24 M 07 Y 75 TIME: 22:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B5-B

SHEET 1 OF 1

TEST HOLE No. N75-117D-B5-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
1.0	Pt		PEAT - some fine sand, little silt, non-plastic, dark grey, dry fibrous.		UF								Using shovels
3.3	SM		SAND - fine to medium, silty, non plastic brown, moist, stratified, isolated gravel to 1'', numerous fibres, medium dense.										Pit dug in a ''step'' configuration to avoid sloughing
3.8	GW		GRAVEL - coarse to fine, subrounded, some sand, med. sizes, moist, stratified, isolated cobbles to 4''.										
4.4	SP		SAND - medium, moist, frequent fibres, isolated coarse grained sand, dense										
8	GW		GRAVEL - coarse and fine (average size 2'') subrounded, some sand, coarse to medium, damp, stratified, numerous cobbles to 4.5', isolated boulders to 15''.				MA, combined samples 1 - 6 G = 65% S = 33% F = 2% (GW)	B1 B2 B3	☒ ☒ ☒				

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	
CHKD: R.H.	LAT. & LONG: 69°25'23''N, 139°30'13''W	ELEVATION:	
DRWN. BY: G.C.B.	AIRPHOTO No.: A 13751-114	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP: 4.5°C	
	METHOD: TEST PIT (EXPOSURE)		

START: D 24 M 07 Y 75 TIME: 18:55

FINISH: D 24 M 07 Y 75 TIME:

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B5-1

SHEET 1 OF 2

PC-9,SK373

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├───┤ Liquid limit; scale 40 60 80 100 120 140 ▲; 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL (cont'd)		UF			B4	☒				
			8.5 — little sand, more cobbles, dark grey.					B5	☒				
9							(MA, 1 - 6)					9	
			9.5 — boulder approximately 20''.					B6	☒				
10												10	
11			11.0 — stratification almost parallel to slope of bank, number of cobbles increasing.										
12													
13													
14			14.0 Stream level									14	Stream bed

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 69°25'23''N, 139°30'13''W	ELEVATION:	
DRWN. BY: G.C.B.	AIRPHOTO No.: A 13751-114	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP.: 4.5°C	
	METHOD: TEST PIT (EXPOSURE)		

START: D 24 M 07 Y 75 TIME: 18:55 FINISH: D 24 M 07 Y 75 TIME: 23:00

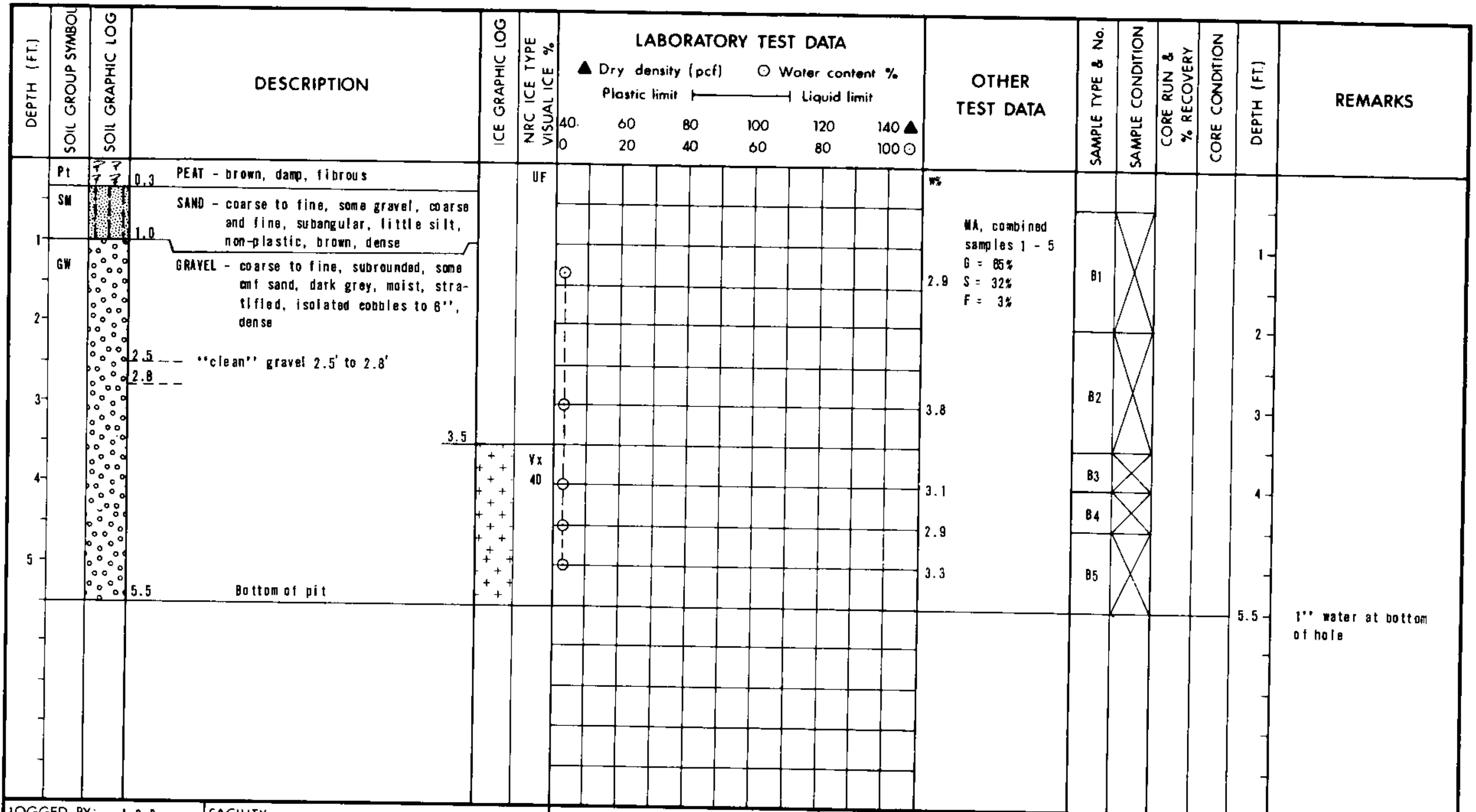
NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B5-1

SHEET 2 OF 2

PC-9,SK373

TEST HOLE LOG



DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.3	Pt	PEAT - brown, damp, fibrous	UF	w%					
1.0	SM	SAND - coarse to fine, some gravel, coarse and fine, subangular, little silt, non-plastic, brown, dense		MA, combined samples 1 - 5 G = 65% S = 32% F = 3%					
	GW	GRAVEL - coarse to fine, subrounded, some cmf sand, dark grey, moist, stratified, isolated cobbles to 6'', dense		2.9	B1			1	
2.5		''clean'' gravel 2.5' to 2.8'						2	
2.8				3.8	B2			3	
3.5			Vx 40	3.1	B3				
				2.9	B4			4	
				3.3	B5				
5.5		Bottom of pit						5.5	1'' water at bottom of hole

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 69°24'23''N, 138°31'00''W	ELEVATION:		N75-117D-B5-2
DRWN. BY: D.J.M.	AIRPHOTO No.: A 13751-114	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD: D.O.	RIG:	AIR TEMP: 4.5°C		
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

START: D 24 M 07 Y 75 TIME: 19:00 FINISH: D 24 M 07 Y 75 TIME: 23:35

PC-9,SK373

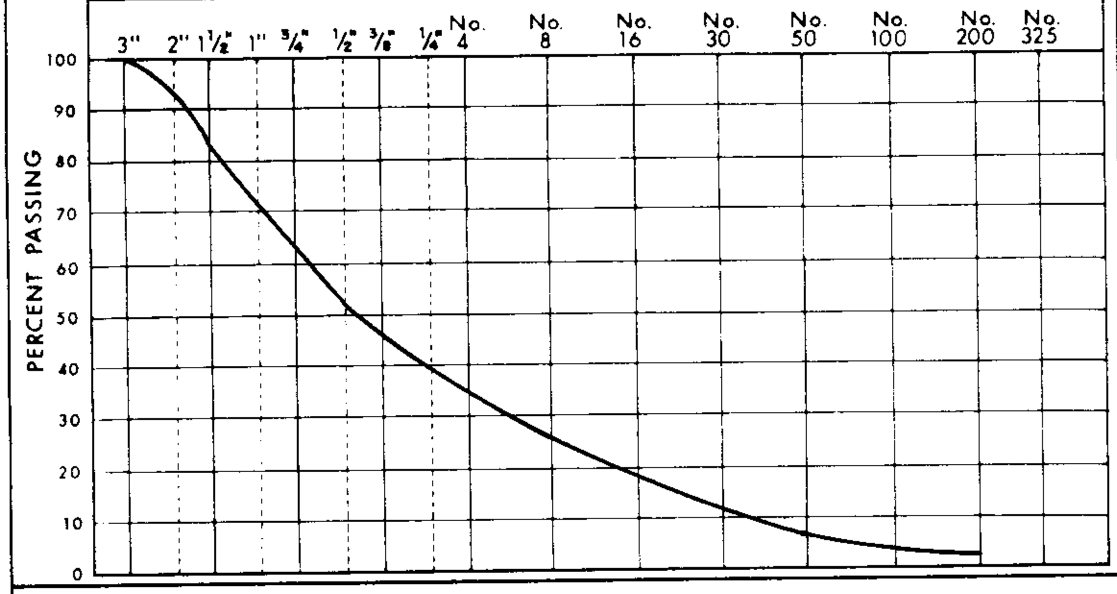
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B5-1 DEPTH 5.0 - 10.0

DATE SAMPLED July 24, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 106

GRAVEL SIZES		SAND SIZES			FINES
37%	28 %	10 %	16%	7 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	92.8
1½"	82.7
1"	71.2
¾"	63.0
½"	53.0
⅜"	46.6
¼"	
No. 4	35.3
No. 8	26.7
No. 16	18.9
No. 30	12.1
No. 50	6.4
No 100	3.3
No. 200	2.3

COMMENTS

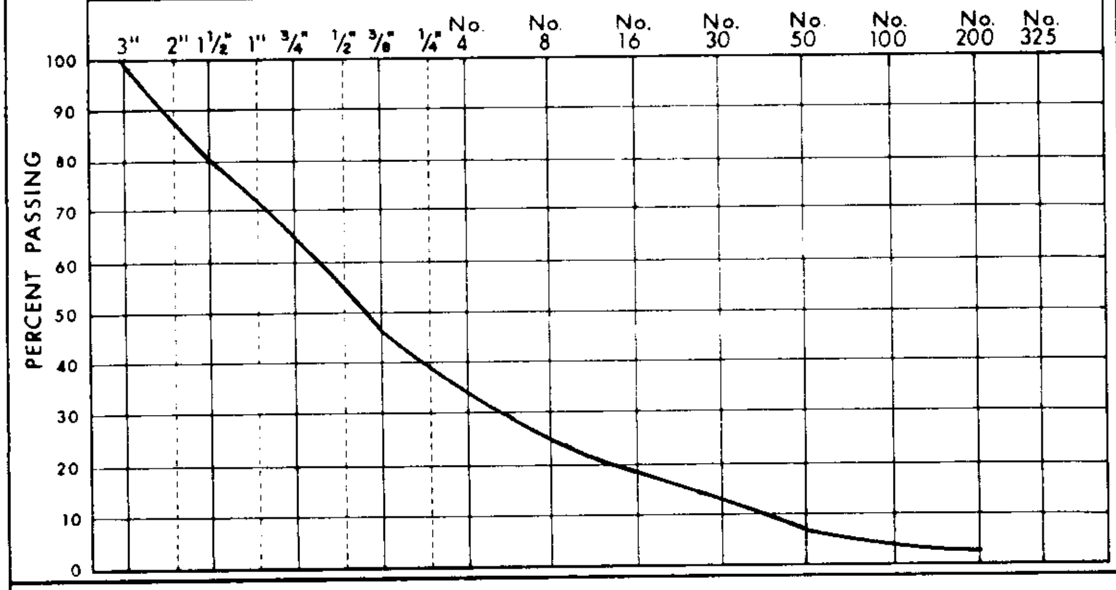
OVERSIZE (>3") = 51.3%

SAMPLE N75-117D-B5-2 DEPTH 0.5 - 5.5

DATE SAMPLED July 24, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 97

GRAVEL SIZES		SAND SIZES			FINES
35 %	30 %	10%	15%	7 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	87.8
1½"	81.7
1"	71.6
¾"	65.1
½"	54.9
⅜"	46.6
¼"	
No. 4	35.2
No. 8	25.4
No. 16	19.3
No. 30	13.4
No. 50	7.6
No. 100	4.1
No. 200	3.1

COMMENTS

OVERSIZE (>3") = 0.0%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117D-B5

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. : N75-117D-B5-1 DATE SAMPLED : July 24, 1975 SAMPLED BY : NESCL

DEPTH (FT.) : 0 - 14' DATE TESTED : February, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 0.16 %

FINE AGGREGATE : LOSS = 12.45 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 17.2 %

ORGANIC IMPURITIES TEST

NUMBER : 2

COAL REMOVED : nil

COAL & ROOTLETS REMOVED : nil

COAL CONTENT : nil

SIGNIFICANCE :

SUMMARY OF ROCK TYPES, FINE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Very strong, Good	8.05
Sandstone	Medium strong to strong, Good	1.86
Limestone		1.46
Siltstone		2.97
Chert	Potentially reactive, Fair	1.19
Flint		1.24
Ironstone	Weak, Poor	0.43
PN = 115	INTERPRETATION : Good quality aggregate	17.2

COMMENTS : See also page 139 (Coarse Aggregate)

NORTHERN Engineering Services Company Limited

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

DEPOSIT No. N75-117D-B5

PAGE 138

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. :N75-117D-B5-1 DATE SAMPLED : July 24, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 0 - 14 DATE TESTED : February, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 0.16 %
FINE AGGREGATE : LOSS = 12.45 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 17.2 %

ORGANIC IMPURITIES TEST

NUMBER : 2
COAL REMOVED : nil
COAL & ROOTLETS REMOVED : nil
COAL CONTENT : nil
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Very strong, Good	28.75
Greywacke	Medium strong to strong, Good	22.40
Siltstone		3.75
Limestone		3.80
Sandstone		22.05
Flint	Potentially reactive, Fair	0.75
Chert		0.95
Ironstone	Friable, Soft, Poor	0.35
PN = 115	INTERPRETATION : Good quality aggregate.	82.8

COMMENTS : See also page 138 (Fine Aggregate)

NORTHERN
Engineering Services Company Limited

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

DEPOSIT No.
N75-117D-B5

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-117D-B5-2 DATE SAMPLED : July 24, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1 - 5 DATE TESTED : December, 1975 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 0.36 %
FINE AGGREGATE : LOSS = 10.49 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 17.0 %

ORGANIC IMPURITIES TEST

NUMBER : 1+
COAL REMOVED : nil
COAL & ROOTLETS REMOVED : nil
COAL CONTENT : nil
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Strong and very strong, Good	13.45
Sandstone		22.55
Greywacke		1.6
Arkose		0.2
Rhyolites		5.2
Limestone	Medium strong, Good	2.9
Siltstone		13.6
Weak Siltstone	Weak, Weathered, Fair	0.6
Flint	Potentially reactive, Fair	2.0
Chert		2.0

PN = 114

INTERPRETATION : Good quality coarse aggregate. 64.3

COMMENTS :

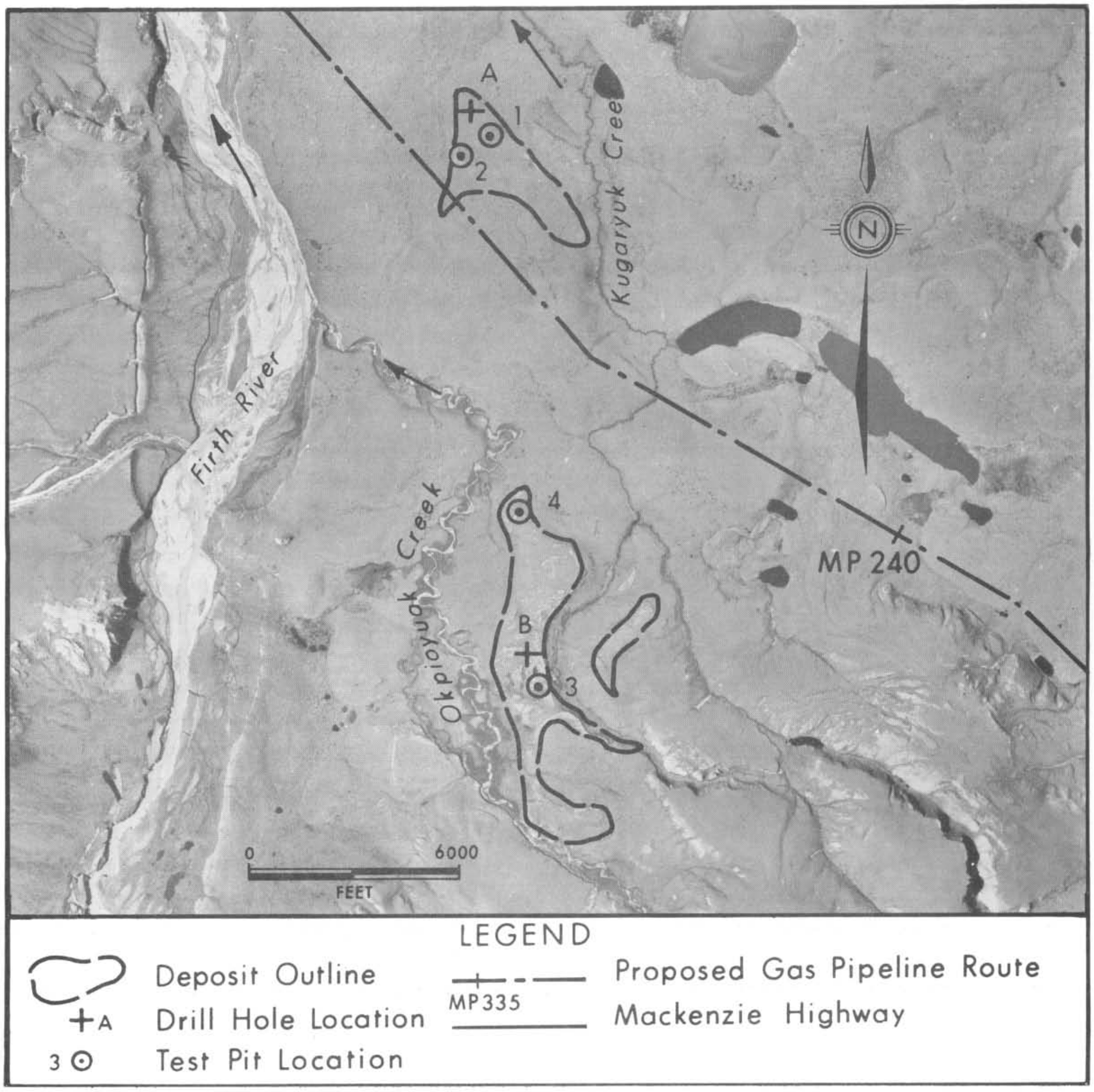
DEPOSIT 117D-B6

Physical Setting: Deposit 117D-B6 is located 12 miles south of the Arctic coast on the east side of the Firth River. It is both a kame terrace which is crossed by mile 236 of the proposed gas pipeline route and a kame delta to the south.

Material: Gravel; well graded, fine to coarse, and coarse, medium and fine sand, trace fines.

Volume: 11,000,000 cubic yards.

Assessment: Deposit 117D-B6 is a good source of granular materials. Access is short to the pipeline right of way and materials would be suitable for general fill, backfill in pipeline construction, and building pad subgrade.



Airphoto No. A13751-116
Approximate Scale: 1" = 5250'

Latitude: 69° 23' N
Longitude: 139° 27' W

DEPOSIT 117D-B6

PHYSICAL SETTING

Deposit 117D-B6 is located 12 miles south of the Arctic coast on the east side of Firth River. It consists of a kame terrace, and a kame delta. Mile 236 of the pipeline route crosses the kame terrace.

The kame delta stands 50 feet above the surrounding terrain and slopes gently to the west. Its surface is locally hummocky. Isolated trenches and steep-sided depressions are caused by melting of subsurface ice wedges and massive ice. Ice-wedge polygons up to 20 feet in diameter are present on the kame delta. Except for broad flat areas and occasional shallow depressions most of the terrace is well drained. Peat and silt are less than 1 foot deep over most of the deposit; however, overburden thickness may reach 5 feet in local depressions and on broad flat areas. Thick lenses of massive ice occur in the gravel outwash, as shown by the thermokarst features and drill hole data. Material above the massive ice generally has moderate ice contents. The active layer varies from 1 foot where peat or silt is present to more than 4 feet on bare gravel areas.

The kame terrace is 5 to 10 feet above adjacent terrain to the east and west, and merges with morainal hills to the south. The terrace surface slopes gently southwest. This terrace is well drained along its margins, but is poorly drained in the centre where low-centered ice-wedge polygons 20 to 40 feet in diameter occur. Gravel is exposed for a width of 200 feet along the terrace margin. Overburden thickness also increases towards the centre of the kame terrace where more than 5 feet of ice-rich peat and organic silt overlie gravel. The ice content of the gravel is moderate. The active layer varies according to overburden thicknesses, being in excess of 4 feet under bare gravel. The terrain surrounding the outwash is flat and marshy, with extensive areas of ice-wedge polygons. Small creeks parallel the eastern and western edges of the kame delta, and a small creek flows parallel to the northwestern edge of the kame terrace.

BIOLOGICAL SETTING

Better drained parts of the southern kame delta are bare with patches of vegetation dominated by Dryas. Poorer drained areas are covered by tundra consisting primarily of sedge and moss. Scattered clumps of willow up to 3 feet high are present on protected slopes. Sedge moss tundra covers most of the northern terrace.

Upland bird species occasionally nest in the vicinity of the borrow site, although adjacent areas are more favourable to nesting.

Grayling use Okpioyuak and Kugaryuk creeks during spring and summer. Neither creeks are spawning or overwintering areas.

This site also falls within a proposed IBP reserve.

MATERIALS

The southern delta contains good quality granular material. It consists of stratified, loose, subangular fine gravel and coarse to medium sand with little coarse gravel and isolated cobbles to 4 inches. The pebbles in the upper 3 feet are platy and aligned horizontally, and appear to be of local origin.

The northern terrace is composed of excellent quality granular material. It contains stratified, dense, well graded, subrounded gravel with little medium to coarse sand and isolated cobbles to 4 inches. The pebbles and cobbles are diverse in composition, reflecting the glacial origin of the deposit.

VOLUME

The total volume of the southern delta depends on the thickness of the gravel layer overlying massive ice, and the extent of the ice. Further drilling is required to determine the configuration of massive ice. The terrace covers about 400 acres and has a total volume, based on a depth of 15 feet and moderate ice content, of approximately 7,000,000 cubic yards.

The northern terrace covers 180 acres and has a total volume, based on a depth of 20 feet and moderate ice content, of 4,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B6 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Excavations would be kept away from Okpioyuak Creek stream channel to prevent siltation. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete production.

Access to the deposit with equipment could be achieved by barge to Catton Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation. Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established over the deposit. This type of development could be accomplished by using blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	DEPTH (FT.)	REMARKS
0	Pt	0.5 PEAT– spongy, damp, dark brown	UF		11:45 used 4¼'' Walmac
	OL	SILT– (organic), trace medium sand, low plastic, moist, light grey, occasional fine gravel size, roots up to 1/32'', at 1.5' organic content increases. 1.5			
2			F		Frozen, ice chunks present. Ice content decreases with depth (60% to 30%)
4		5.0			
6	GP	GRAVEL – fine, fine sand.			
8		9.0 gradual increase in coarse gravel size.			
10					
	GW	fine to coarse gravel			
12				13	12:15
14				15	12:30 change to 3 7/8'' Tricone.
16		cobbles			

LABORATORY TEST DATA

▲ Dry density (pcf) ⊙ Water content %

Plastic limit ├──┤ Liquid limit

40 60 80 100 120 140 ▲

0 20 40 60 80 100 ⊙

OTHER TEST DATA

SAMPLE TYPE & No. | SAMPLE CONDITION | CORE RUN & % RECOVERY | CORE CONDITION

LOGGED BY:	J.J.S.	FACILITY:		PROJECT:	13011
CHKD:	W.W.	LAT. & LONG:	69°23'34'' N, 139°27'46''W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 13751–115	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI–DRILL	AIR TEMP:	4°C
		METHOD:	AIR		

START: D 28 M 07 Y 75 TIME: 11:45 FINISH: D 28 M 07 Y 75 TIME: 12:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B6-A

SHEET 1 OF 2

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GW				F								
18			cobbles										
20			20.0 End of hole									20.0	12:45 lost circulation, not enough air pressure to remove cuttings,— pulled out to prevent jamming hole.

LOGGED BY: J.J.S.

CHKD: W.W.

DRWN. BY: A.M.

CHKD: D.O.

FACILITY:

LAT. & LONG: 69°23'34'' N, 139°27'46'' W

AIRPHOTO No.: A 13751-115

RIG: HELI-DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP.: 4°C

START: D 28 M 07 Y 75 TIME: 11:45

FINISH: D 28 M 07 Y 75 TIME: 12:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B6-A

SHEET 2 OF 2

PC-9,SK373

TEST HOLE No. N75-117D-B6-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt		0.5 PEAT—fibrous, dark brown		UF								13:40 4¼'' Walmac shovel samples used.
	OL		SILT—(organic) trace fine gravel, 1.0 low plastic, dark brown, oxidized pockets (rust brown), occasional friable medium sand pockets.		Vr to Vx								
2													
4			5.0										
6	GP		GRAVEL—coarse, sand –ice crystals with cuttings		Vx 15								
8												9	Change to 3 7/8'' Walmac
15												15	13:55 ''sleet-like'' cuttings
			16.0 15' to 16' ice content high										
16	ICE		ICE		ICE								
													continuous ICE essentially no resistance to down hole progress.
55													
56			gravel at 57.5'										
57			57.5 End of hole									57.5	14:15

LOGGED BY: J.J.S.
CHKD: W.W.
DRWN. BY: A.M.
CHKD: D.O.
START: D 28 M 07 Y 75 TIME: 13:40

FACILITY:
LAT. & LONG: 69°21'04'' N, 139°27'07''W
AIRPHOTO No.: A 13751–115
RIG: HELI-DRILL
METHOD: AIR
FINISH: D 28 M 07 Y 75 TIME: 14:15

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 1°C

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

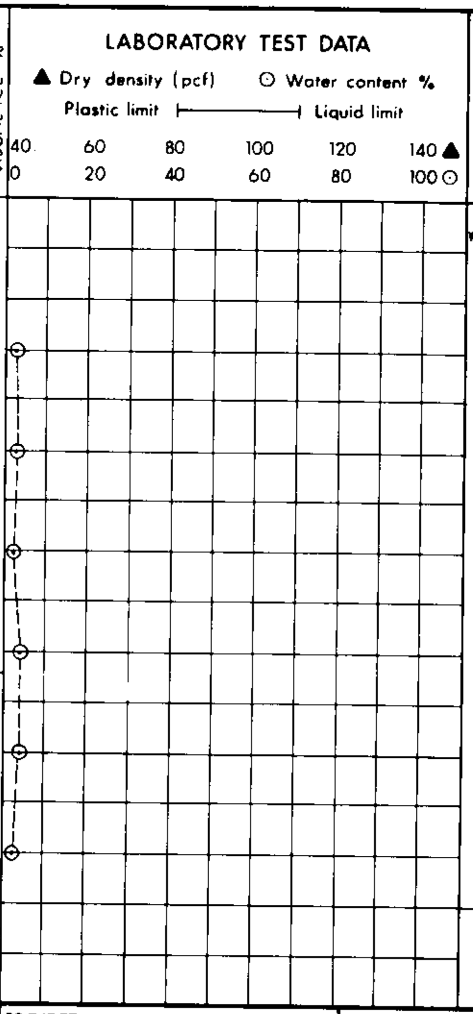
TEST HOLE No.
N75-117D-B6-B
SHEET 1 OF 1

PC-9,SK373

TEST HOLE No.N75-117D-B6-B

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GM	GRAVEL – coarse and fine, subangular; some peat (black), trace sand, fine, grey, moist, numerous fibres, dense.		UF	w%						Using shovels
1		1.0								1	
	GW	GRAVEL – fine to coarse, subrounded; some mcf sand, grey, moist, stratified, isolated cobbles to 4'', dense.			MA, combined samples 1-6 2.5	B1	☒				
2					G = 70% S = 28% F = 2% (GW)					2	
		2.5 2.7 gravel, coarse to fine, 2.5' to 2.7'			2.4	B2	☒				
3										3	
		3.5 3.8 gravel, coarse to fine, 3.5' -3.8'			2.0	B3	☒				
4										4	
		4.7			4.0	B4	☒				Using jack-hammer.
5		occasional ice-coatings	+ + +	Vx 20	4.1	B5	☒			5	
6			+ + +							6	
			+ + +		2.8	B6	☒				
7		7.0 Bottom of pit									



LOGGED BY: I.G.R.	FACILITY:	PROJECT: 13011	
CHKD: R.H.	LAT. & LONG: 69°23'19''N, 139°26'49'' W	ELEVATION:	
DRWN. BY: R.J.S.	AIRPHOTO No.: A 13751-115	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP.: 2°C	
	METHOD: TEST PIT		
START: D 27 M 07 Y 75 TIME: 12:10	FINISH: D M Y TIME:		

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B6-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.7 PEAT— some fine sand, black, moist, fibrous, isolated coarse and fine gravel.		UF								Using shovels
1	GW		GRAVEL— fine to coarse, some mcf sand, dark brown, moist, isolated cobbles to 8'', loose.				MA, sample 1 G = 77% S = 20% (GW) F = 3%	B1	☒			1	
2			2.0 fine to coarse, subrounded,. little cmf sand, dark grey, damp, stratified, isolated cobbles to 7'', loose.				MA, combined samples 2-6 G=79% S=19% F = 2% (GW)	B2	☒			2	
3								B3	☒			3	2''-4'' layers of gravel coarse and fine, at depths 3.4' and 4.2'
4			4.2 occasional ice coatings		Vx 25			B4	☒			4	
5			5.0 little sand.					B5	☒			5	
6			6.5 Bottom of pit					B6	☒			6	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 69°23'21''N, 139°28'01'' W	ELEVATION:	
DRWN. BY: R.J.S.	AIRPHOTO No.: A 13751-115	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP.: 4°C	
	METHOD: TEST PIT		

START: D 27 M 07 Y 75 TIME: 12:15 FINISH: D 27 M 07 Y 75 TIME: 16:40

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B6-2

SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt	? ? ? ?	PEAT - some fine sand, dark brown, moist, fibrous, isolated coarse and fine gravel.		UF								Using shovels
0.5	GW		GRAVEL - fine to coarse, subrounded, and cmf sand, dark grey, moist, stratified, isolated cobbles to 4", loose.										
2							MA, combined samples 1 - 6 G = 57% S = 41% F = 2% (GW)	B1	☒			2	
3								B2	☒			3	
4.0				+ +	Vx 20			B3	☒			4	Using jack-hammer
				+ +				B4	☒				
5				+ +				B5	☒			5	
6				+ +				B6	☒			6	
7.0			Bottom of pit									7	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: G.C.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°20'49''N, 139°27'00''W
AIRPHOTO No.: A 13751-115
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 4°C

START: D 27 M 07 Y 75 TIME: 18:50
FINISH: D 27 M 07 Y 75 TIME: 23:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
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CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B6-3

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B6-3

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.4	Pt		PEAT - black, moist, fibrous.		UF								Using shovels
1	GW		GRAVEL - coarse to fine, subangular, and sand, coarse to fine, platy, dark grey, damp, stratified, very few isolated cobbles to 4", loose.										
2							MA, combined, samples 1 - 7 G = 56% S = 42% F = 2% (GW)	B1	☒			2	
								B2	☒				
3.2			2" - 4" layer of gravel with no medium to fine sand.					B3	☒			3	
4												4	
4.5				4.5	Vx 20			B4	☒				Using jack-hammer
5.0			2" - 4" layer of gravel with no medium to fine sand.					B5	☒			5	
6								B6	☒			6	
7								B7	☒			7	
8.0			Bottom of pit									8	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: $69^{0}21'15''$N, $139^{0}26'34''$W	ELEVATION:	
DRWN. BY: G.C.B.	AIRPHOTO No.: A 13751-115	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP.: 4^{0}C	
	METHOD: TEST PIT		
START: D 27 M 07 Y 75 TIME: 18:45	FINISH: D 27 M 07 Y 75 TIME: 21:55		CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117D-B6-4

SHEET 1 OF 1

PC-9,SK373

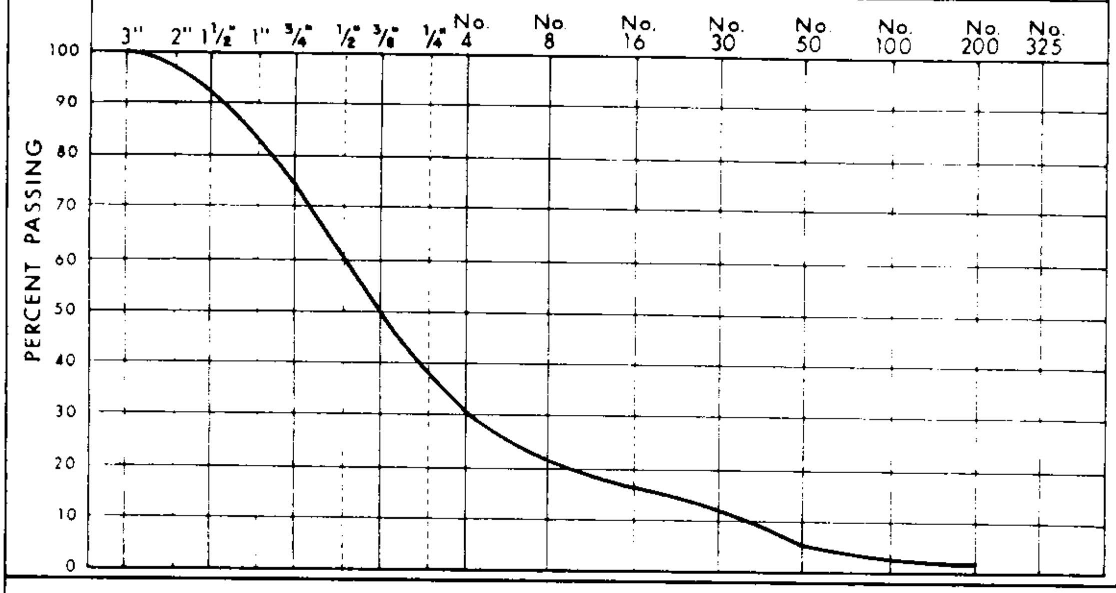
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B6-1 DEPTH 1.0 - 6.5

DATE SAMPLED July 27, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 127

GRAVEL SIZES		SAND SIZES			FINES
25 %	45 %	9 %	11 %	8 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	96.6
1½"	92.1
1"	83.7
¾"	74.9
½"	59.3
⅜"	48.6
¼"	
No. 4	30.2
No. 8	22.2
No 16	17.1
No. 30	12.2
No 50	6.2
No. 100	2.6
No. 200	1.8

COMMENTS

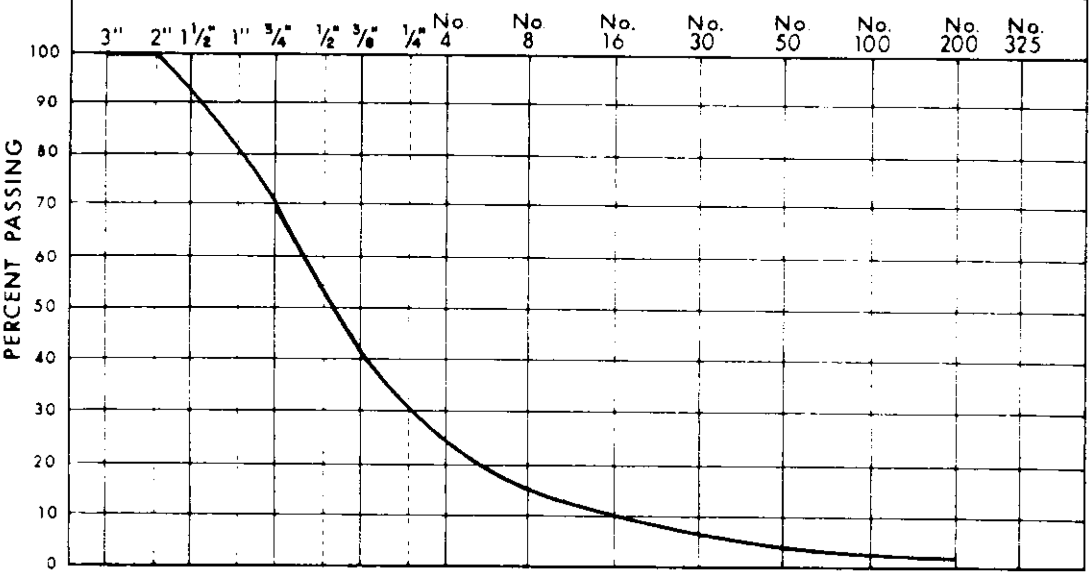
OVERSIZE (>3") = 0.0%

SAMPLE N75-117D-B6-2 DEPTH 1.0 - 2.0

DATE SAMPLED July 27, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 120

GRAVEL SIZES		SAND SIZES			FINES
30 %	47 %	7 %	9 %	4 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	90.2
1"	80.0
¾"	70.2
½"	50.6
⅜"	40.3
¼"	
No. 4	23.4
No. 8	15.9
No 16	11.1
No. 30	7.4
No. 50	5.1
No. 100	3.6
No. 200	2.8

COMMENTS

OVERSIZE (>3") = 0.0%

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services
Company Limited

DEPOSIT No.
N75-117D-B6

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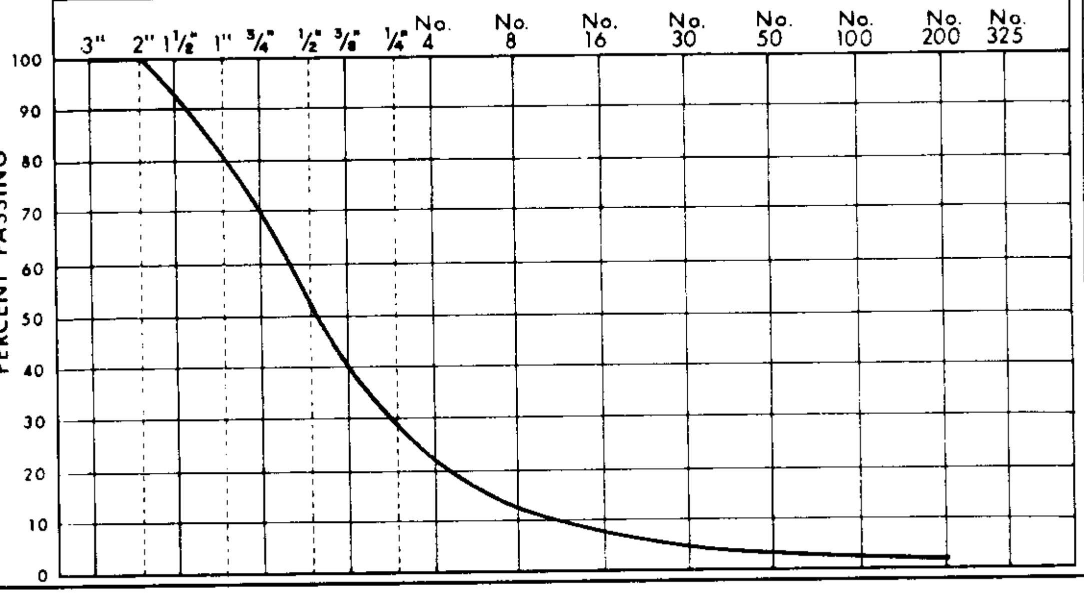
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B6-2 DEPTH 2.0 - 7.0

DATE SAMPLED July 27, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 126

GRAVEL SIZES		SAND SIZES			FINES
32 %	47 %	9 %	7 %	3 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	92.4
1"	79.9
¾"	68.4
½"	51.2
⅜"	39.5
¼"	
No. 4	21.1
No. 8	12.5
No. 16	8.1
No. 30	5.5
No. 50	3.5
No. 100	2.3
No. 200	1.7

COMMENTS

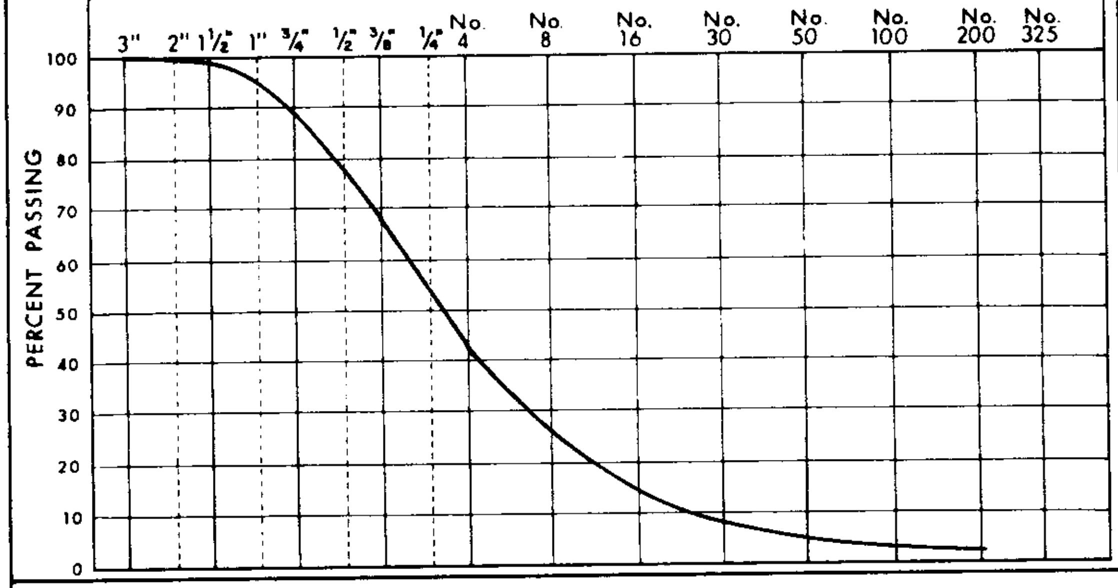
OVERSIZE (>3") = 0.0%

SAMPLE N75-117D-B6-3 DEPTH 2.0 - 7.0

DATE SAMPLED July 27, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 113

GRAVEL SIZES		SAND SIZES			FINES
12 %	45 %	21 %	17 %	3 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	99.2
1"	95.9
¾"	88.0
½"	77.8
⅜"	67.4
¼"	
No. 4	43.4
No. 8	26.0
No. 16	13.8
No. 30	7.6
No. 50	4.7
No. 100	2.7
No. 200	2.2

COMMENTS

OVERSIZE (>3") = 0.0 %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117D-B6

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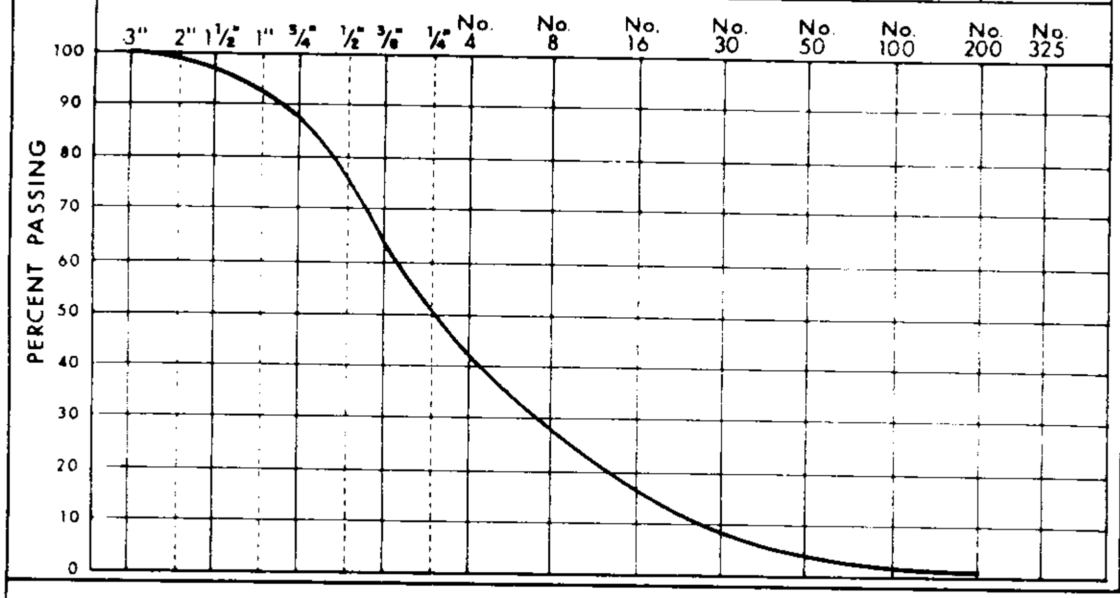
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B6-4 DEPTH 2.0 - 8.0

DATE SAMPLED July 27, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 117

GRAVEL SIZES		SAND SIZES			FINES
12 %	44 %	19 %	19 %	4 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	97.2
1"	92.7
¾"	87.7
½"	76.7
⅜"	64.5
¼"	
No. 4	44.4
No. 8	28.2
No. 16	16.5
No. 30	8.3
No. 50	4.1
No. 100	2.4
No. 200	1.8

COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	

SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

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DEPOSIT No.
N75-117D-B6

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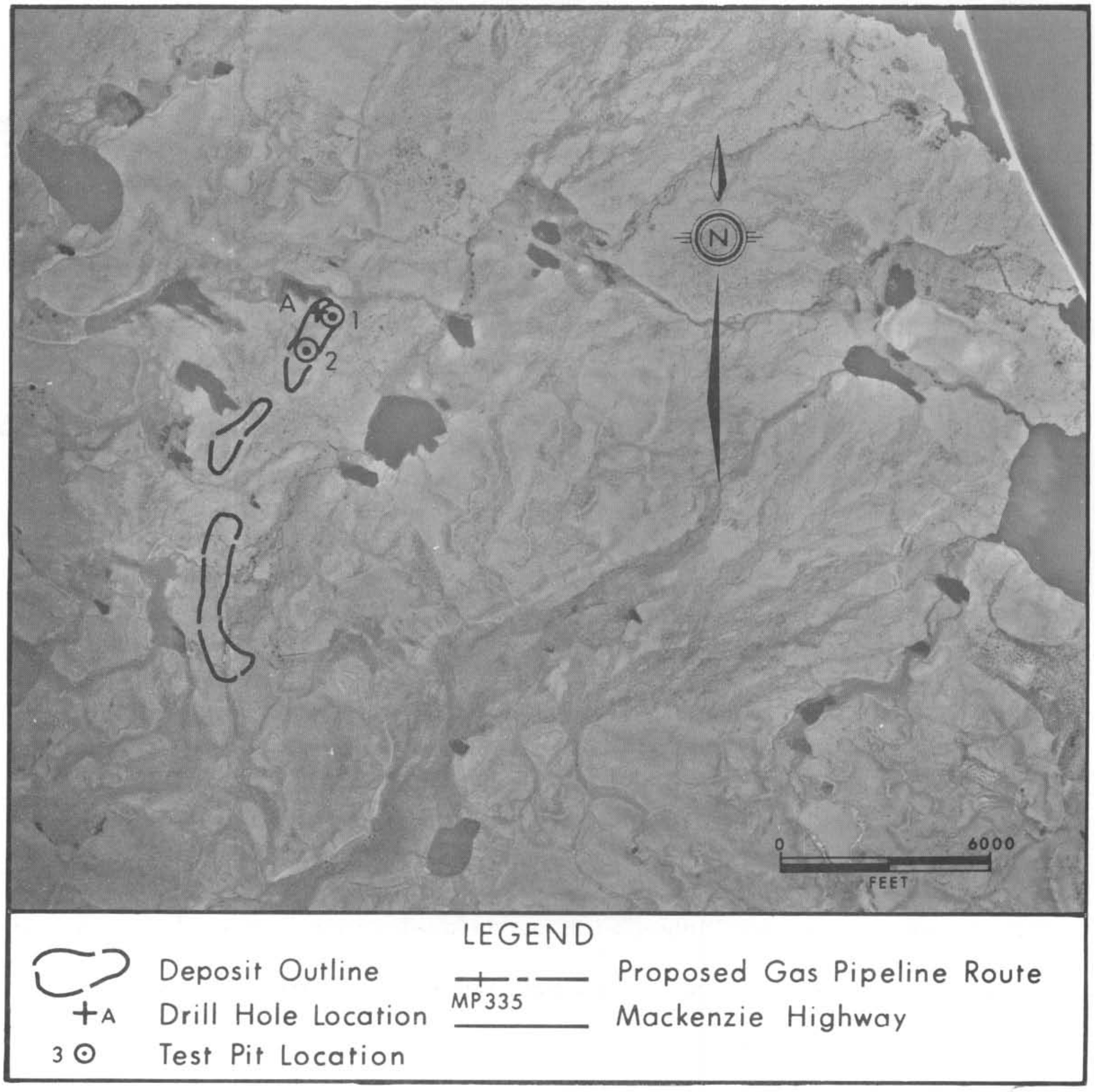
DEPOSIT 117D-B7

Physical Setting: Deposit 117D-B7 is part of an outwash plain near Catton Point. The deposit is located 6 miles northeast of mile 240 of the proposed gas pipeline route.

Material: Gravel; well graded, fine to coarse, some coarse, medium and fine sand.

Volume: 5,500,000 cubic yards.

Assessment: Deposit 117D-B7 is a good source of granular material. Haul distance would exceed 6 miles to the proposed pipeline route. Granular material from this deposit would be suitable for general fill, backfill in pipeline construction, and subgrade material for building pads.



Airphoto No. A14361-96
Approximate Scale: 1" = 5250'

Latitude: 69° 27' N
Longitude: 139° 14' W

DEPOSIT 117D-B7

PHYSICAL SETTING

Deposit 117D-B7 is part of an outwash plain, located about 5 miles south-southwest of Catton Point. Mile 240 of the proposed pipeline route is located 6 miles southwest of the deposit.

The deposit is about 800 feet wide and extends for approximately 2 miles in a north-south direction. The eastern edge is marked by a 10-foot scarp. From the scarp west for 200 feet the deposit is well drained with less than a foot of peat cover. Further west the deposit is poorly drained and overburden thickness increases to 6 feet or more. Several small lakes and low-centered ice-wedge polygons 30 feet in diameter are present on the western part of the deposit. Below the scarp to the east the terrain is poorly drained and characterized by small ponds and beaded streams.

The active layer is up to 2 feet thick under areas of thin peat cover, and thicker under bare gravel. The ice content of the gravel is low to moderate.

BIOLOGICAL SETTING

The tundra covering the well drained parts of the deposit consists primarily of mosses and lichen with occasional clumps of willow, whereas the tundra covering the poorly drained areas is composed primarily of sedges, mosses and lichens.

The area provides nesting grounds for upland bird species such as plovers and Lapland longspurs, and hunting grounds for owls. The site also is within an important staging and feeding area of snow geese.

MATERIALS

The deposit is composed of good quality granular material. It contains subrounded dense, clean, well graded sand and gravel with isolated cobbles up to 8 inches in diameter. Some chert pebbles were noted.

VOLUME

The deposit includes only that part of the outwash plain area where overburden thickness is not likely to exceed 5 feet. The available volume could be increased by including areas to the west which have thicker overburden.

The outwash plain has three sections. The northern section has an area of 35 acres and a total volume, based on an estimated depth of 40 feet and moderate ice content, of 1,500,000 cubic yards. The middle section has an area of 26 acres and a total volume of approximately 1,000,000 cubic yards, and the southern section has an area of 70 acres and a total volume of 3,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B7 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Haul distances would exceed 6 miles to the pipeline route. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Catton Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way or to potential staging areas along the coast 4 to 5 miles away.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be maintained over the deposit. This type of development could be accomplished by blasting or conventional earthmoving techniques depending on the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations.

Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be carried out to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.5	Pt		PEAT - fibrous, roots, moist, dark brown		UF							0	17:00 3 7/8" Walmac, frozen cuttings, no ice description possible
2.0	ML		SILT - clayey, low plastic, medium grey, moist, trace sand and gravel sizes in a silt to clay matrix										
6.0					F 10								
13.0	GW		GRAVEL - coarse to fine, well graded										
14.0	SP		SAND - medium, trace gravel										
16	GW		GRAVEL - coarse to fine, occasional cobbles										

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 69° 26'44"N, 139° 13'52"W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 14381-95, 96	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 1°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 23 M 07 Y 75 TIME: 17:00 FINISH: D 23 M 07 Y 75 TIME: 21:00

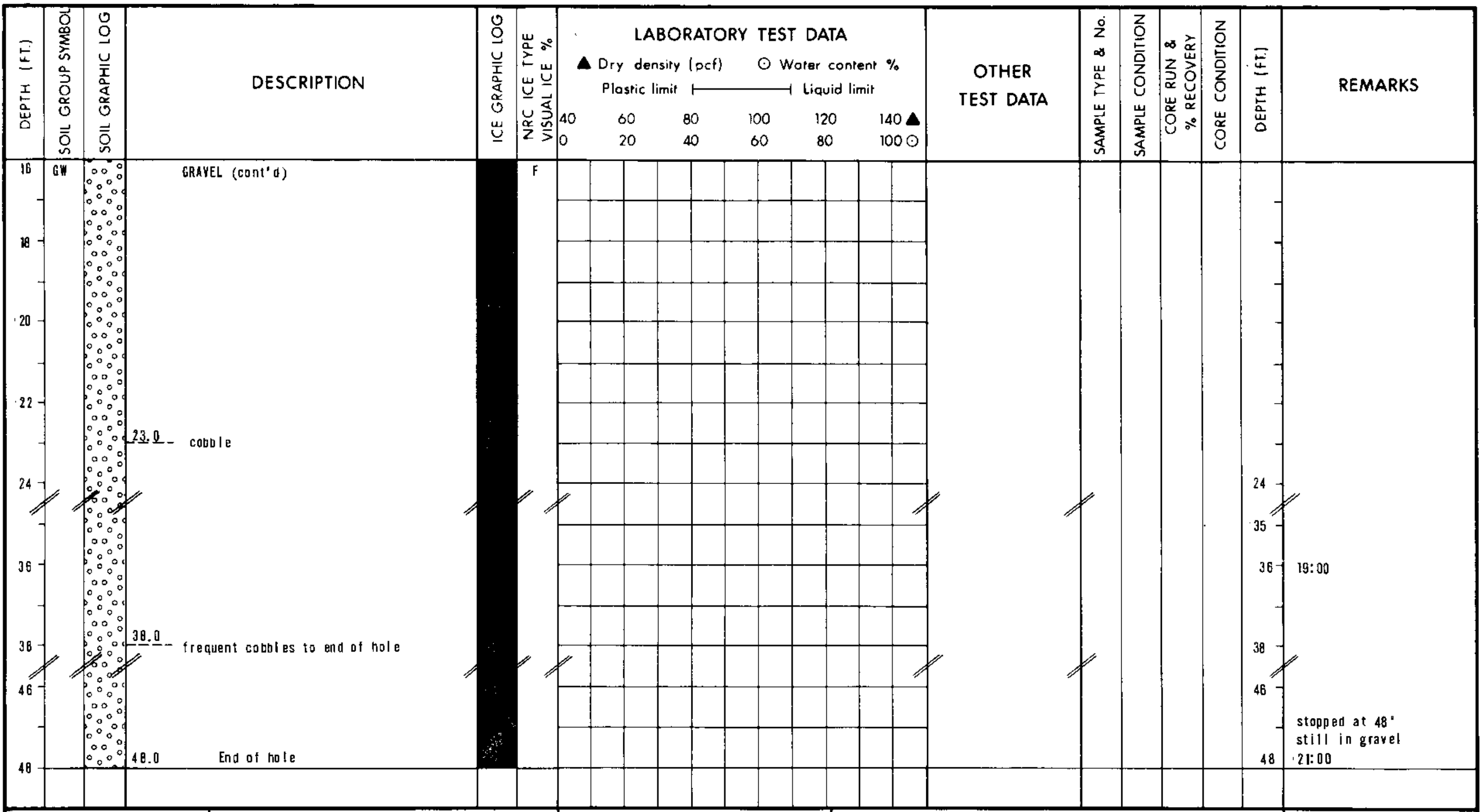
TEST HOLE No. N75-117D-B7-A

SHEET 1 OF 2

PC-9,SK373

TEST HOLE No. N75-117D-B7-A

TEST HOLE LOG



DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	DEPTH (FT.)	REMARKS
16	GW	GRAVEL (cont'd)	F		
18					
20					
22					
		23.0 cobble			
24				24	
				35	
36				36	19:00
		38.0 frequent cobbles to end of hole			
38				38	
46				46	
48		48.0 End of hole		48	stopped at 48' still in gravel 21:00

LOGGED BY:	J.J.S.	FACILITY:		PROJECT:	13011
CHKD:	D.O.	LAT. & LONG:	69°26'44''N, 139°13'52''W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 14361-95, 96	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI-DRILL	AIR TEMP.:	1°C
		METHOD:	AIR		

START: D 23 M 07 Y 75 TIME: 17:00

FINISH: D 23 M 07 Y 75 TIME: 21:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117D-B7-A

SHEET 2 OF 2

PC-9,SK373

TEST HOLE No.N75-117D-B7-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.5	Pt		PEAT - dark brown, moist, fibrous.		UF								Using shovels
1	GW		GRAVEL - coarse to fine, subrounded, some sand, stratified, isolated cobbles to 8'', dense.				MA, combined samples 1 - 4 G = 67% S = 31% F = 2% (GW)	B1	☒			1	
2								B2	☒			2	
2.7			— — cobbles sizes to 4''.										
3												3	
3.4				▒	No			B3	☒				Using jack-hammer
4								B4	☒			4	
5.0			Bottom of pit									5	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	
CHKD: R.H.	LAT. & LONG: 69°28'44''N, 139°13'43''W	ELEVATION:	1975 BORROW INVESTIGATION
DRWN. BY: G.C.B.	AIRPHOTO No.: A 14381-95	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP: Approx. 4°C	
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 23 M 07 Y 75 TIME: 14:30 FINISH: D 23 M 07 Y 75 TIME: 20:00

TEST HOLE No. N75-117D-B7-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B7-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.4 PEAT - dark brown, moist, fibrous.		UF								Using shovels
1	GW		GRAVEL - fine to coarse, some sand, pebbles, subrounded, stratified, isolated cobbles to 4.5'', dense.				MA, combined samples 1 - 4 G ═ 63% S ═ 34% F ═ 3% (GW)	B1	☒			1	
2			2.7					B2	☒			2	Using jack-hammer
3			3.0 — gravel content increases slightly with depth.		Nbn			B3	☒			3	
4			4.2 Bottom of pit					B4	☒			4	

LOGGED BY: J.G.R.	FACILITY:		PROJECT: 13011		
CHKD: R.H.	LAT. & LONG: 69⁰26'29''N, 139⁰13'55''W		ELEVATION:		
DRWN. BY: G.C.B.	AIRPHOTO No.: A 14361-95		PIPE MILEAGE:		
CHKD: D.O.	RIG:		AIR TEMP.: 4.5^0C		
	METHOD: TEST PIT				
START: D 23 M 07 Y 75 TIME: 15:30		FINISH: D 23 M 07 Y 75 TIME: 20:15			

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B7-2
SHEET 1 OF 1

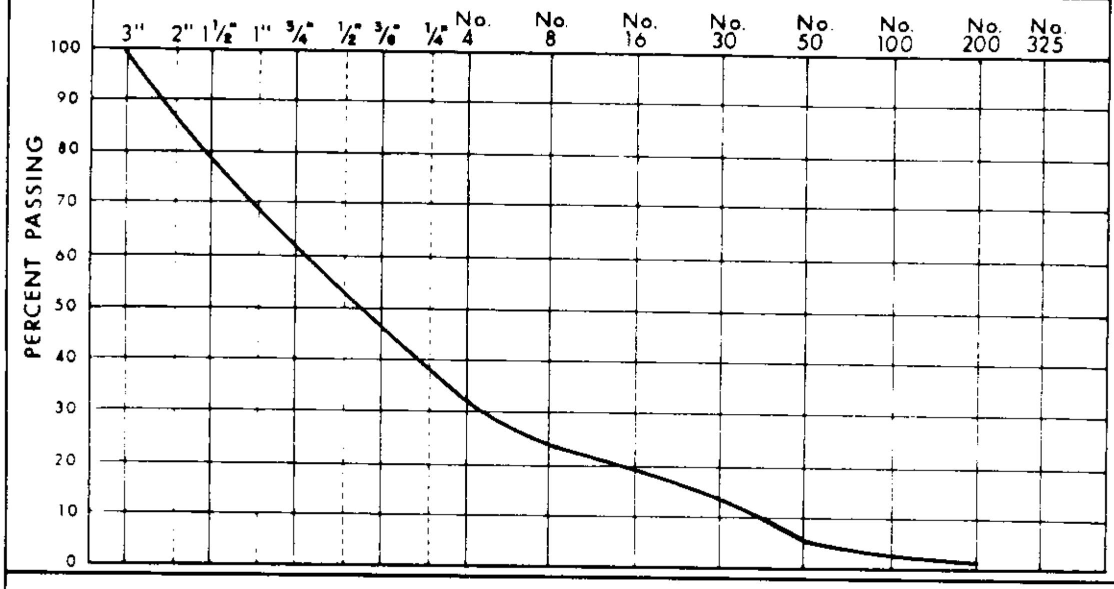
PC-9,SK373

TEST HOLE No. N75-117D-B7-2

SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B7-1
DEPTH 1.0 - 5.0
DATE SAMPLED July 23, 1975
SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 114

GRAVEL SIZES		SAND SIZES			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	
36 %	31 %	10 %	13 %	8 %	2 %



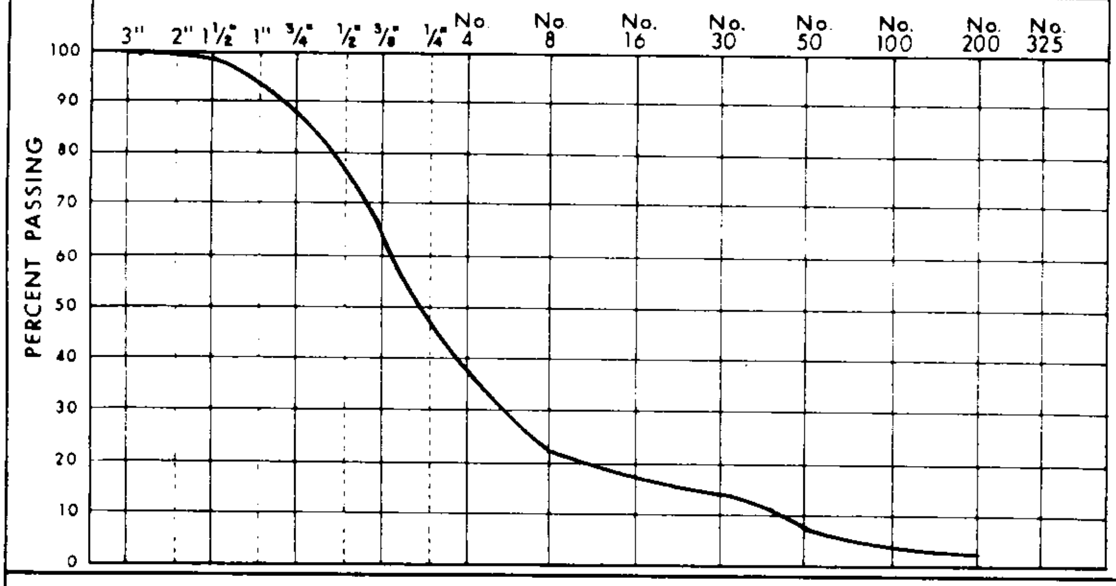
SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	87.7
1½"	81.0
1"	71.4
¾"	64.3
½"	54.3
⅜"	46.8
¼"	
No. 4	33.1
No. 8	24.7
No. 16	20.0
No. 30	13.9
No 50	5.6
No 100	2.8
No. 200	2.0

COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-117D-B7-2
DEPTH 1.0 - 4.2
DATE SAMPLED July 23, 1975
SAMPLED BY NESCL
R.M.HARDY REPORT NUMBER 115

GRAVEL SIZES		SAND SIZES			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	
11 %	52 %	15 %	10 %	9 %	3 %



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	98.5
1"	93.1
¾"	88.5
½"	78.5
⅜"	65.3
¼"	
No. 4	36.6
No. 8	23.2
No. 16	17.2
No. 30	13.9
No. 50	7.7
No. 100	3.5
No. 200	2.5

COMMENTS

OVERSIZE (>3") = 0.0%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117D-B7

PAGE
166

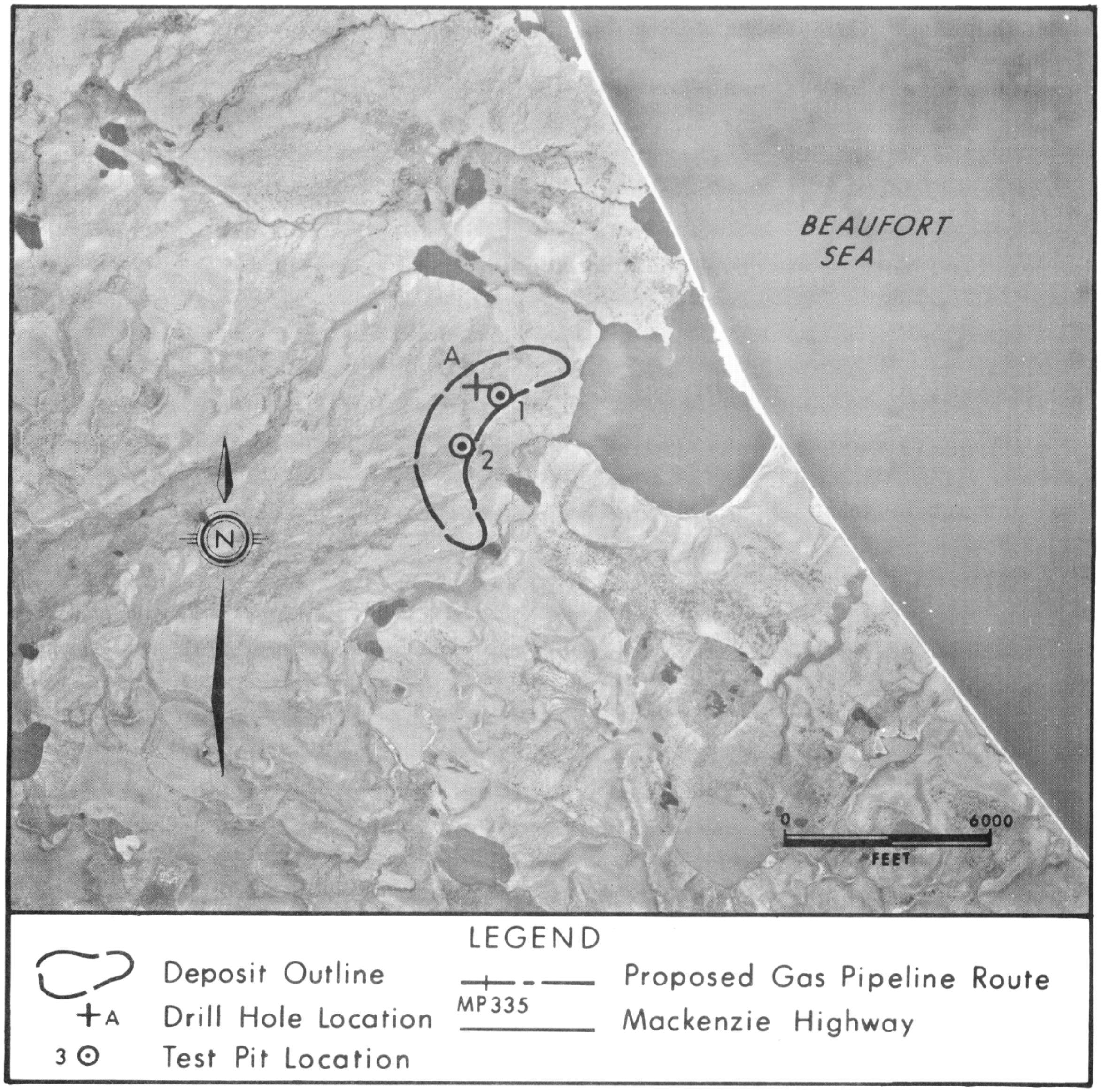
DEPOSIT 117D-B8

Physical Setting: Deposit 117D-B8 is part of an outwash plain near Catton Point 1 mile inland from the Arctic coast. The deposit is located 8 miles northeast of mile 240 of the proposed gas pipeline.

Material: Gravel; well graded, fine to coarse, little coarse, medium, and fine sand, trace to little fines.

Volume: 7,500,000 cubic yards.

Assessment: Deposit 117D-B8 is a good source of granular material. Haul distance to the proposed gas pipeline route exceeds 8 miles but the deposit is adjacent to the coast. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and concrete and asphalt aggregate.



Airphoto No. A14361-95
Approximate Scale: 1" = 5250'

Latitude: 69° 26' N
Longitude: 139° 05' W

DEPOSIT 117D-B8

PHYSICAL SETTING

Deposit 117D-B8 is part of an outwash plain located 1 mile inland from the Arctic coast near Catton Point. The pipeline route is located 8 miles southwest of the deposit.

This crescent-shaped outwash deposit is about ¼ mile wide and 1½ miles long. The eastern edge is marked by a 10-foot scarp and in several places the deposit is cut by gulleys. The western side of the deposit merges into a peat-covered plain, which has low-centered, ice-wedge polygons 30 feet in diameter. Below the scarp to the east the terrain is marshy with several small lakes and beaded streams. The latter flow into a nearby lagoon adjacent to the coastline.

The area within 200 feet of the scarp on the eastern edge of the deposit is moderately well to well drained with less than 1 foot of overburden. The deposit becomes imperfectly to poorly drained to the west and the thickness of peat and silt increases to 5 feet.

The active layer is about 1 foot thick in areas of peat cover and possibly thicker where gravel is exposed. The ice content in the outwash is low near the surface and moderate at depth. Ice wedges may be encountered beneath polygonal ground.

BIOLOGICAL SETTING

Near the eastern edge of the deposit gravel is exposed in patches, and ground cover consisting of mosses and lichens is sparse. Vegetative cover increases toward the west where the continuous vegetative cover consists primarily of sedge moss tussocks and some willow.

Waterfowl and shore birds are abundant on the nearby lagoon and along the Coast in summer. Arctic fox hunt along the beaches. Summer development activities potentially could disturb feeding birds such as the snow geese which feed on the sedges in this area.

MATERIALS

This deposit contains good quality granular material. The outwash consists of stratified, subrounded, medium-dense gravel with some medium to coarse sand, occasional cobbles up to 8 inches in diameter and isolated boulders up to 10 inches in diameter. The upper 2 feet of gravel is silty.

VOLUME

The deposit covers about 200 acres. This excludes areas of outwash where overburden is likely to exceed 5 feet in depth. The total volume is 7,500,000 cubic yards based on a depth of 40 feet and moderate ice content.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B8 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Excavations would be kept away from the coastline to protect the coastal environment. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Catton Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way or to any nearby staging areas along the coast.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation away from the natural drainage channels.

Development of this deposit would involve excavating borrow material evenly from the well drained areas so that good drainage would be maintained over the deposit. This type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to dry the gravel in heated dryers to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be carried out to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt		PEAT - fibrous, wet, dark brown to black 1.0 with depth 1.0		UF							0	13:00 3 7/8'' tricone hit cobble at 1.0'
	ML		SILT - some coarse sand, little fine gravel, low plastic, dark grey, moist		F 25								
2													
4													
	GW		GRAVEL - coarse, trace silt										
6												6	surface water running into hole creating wet cuttings
8													
10			inferred coarse gravel to small cobble sizes		10 to 15							10	water interfering with description
12												12	
			cobbles to approximately 4''										
14													
16												16	15:20 16.8' clutch slipping 15:30 continued drilling

LOGGED BY: J.J.S.
CHKD: W.W.
DRWN. BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°25'47''N, 139°05' 17''W
AIRPHOTO No.: A 14361-95, 96
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 1°C

START: D 24 M 07 Y 75 TIME: 13:00 FINISH: D 24 M 07 Y 75 TIME: 16:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES
COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B8-A
SHEET 1 OF 2

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GW		GRAVEL (cont'd)										
18													
20													
22												23	
												27	
28													
30													hole beginning to slough in, too much water for efficient removal of cuttings by air. stem became stuck at 23', lost 3 7/8'' Tricone in hole.
32													
34			34.0 End of hole									34.0	16:30

LOGGED BY:	J. J. S.	FACILITY:		PROJECT:	130 11
CHKD:	W.W.	LAT. & LONG:	69°25'47''N, 139°05'17''W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 14361-95, 96	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI-DRILL	AIR TEMP.:	1°C
		METHOD:	AIR		

START: D 24 M 07 Y 75 TIME: 13:00 FINISH: D 24 M 07 Y 75 TIME: 16:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B8-A

SHEET 2 OF 2

PC-9,SK373

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.2	PT		PEAT—dark brown, moist, fibrous.		UF								Using pick-axe and shovels
1.0	GM		GRAVEL – mostly fine; little sand, medium sizes, little silt; light brown, moist, numerous fibres.										
2.7	GW		GRAVEL – fine to coarse, subrounded; some sand, coarse to medium; dark grey, damp, isolated cobbles to 3"', numerous fibres, medium dense				MA, combined samples 1-6 G = 78% S = 19% F = 3% (GW)	B1 B2					
3.0	GP		GRAVEL – fine, rounded; some sand, coarse, brown, damp, loose.					B3					
3.8	GW		GRAVEL–as from depth 1.0' – 2.7', stratified; i.e. alternate layers of coarse and fine gravel.					B4					
5.0			occasional ice inclusions.		Nb occ Vx			B5					Using jack-hammer Soil stratification is parallel to surface of slope (25°)
7.2			Bottom of pit		Vx 40			B6					

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: R.J.S.
CHKD: D.D.

FACILITY:
LAT. & LONG: 69°25'59''N, 139°04'22'' W
AIRPHOTO No.: A 14361-95
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 7°C

START: D 24 M 07 Y 75 TIME: 11:55
FINISH: D 24 M 07 Y 75 TIME:

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B8-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B8-1

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit; 40 60 80 100 120 140 ▲; 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt - OL		PEAT - some silt; little gravel, coarse, rounded; low plastic, dark brown, damp, dense. 0.8		UF								Using shovels
1	GM- GW		GRAVEL - coarse to fine, and medium to fine sand, little silt, pebbles rounded, dark brown, damp,medium dense,isolated subrounded cobbles to 4.5''. 1.3 2.2		Nb occ Vx		MA G = 52% S = 37% F = 11%	B1	☒			1	using jack-hammer.
2	GW		GRAVEL- coarse to fine, subrounded; little medium to coarse sand, dark grey, stratified, fcequent cobbles to 8'', isolated boulders to 10''. 3.0				MA, combined samples 2-4 G = 77% S = 19% F = 4%	B2	☒			2	
3					Vx 35							3	
4			Ice content increases with depth					B3	☒			4	
								B4	☒				
5			5.1 Bottom of pit.									5	

LOGGED BY: J.G.R.

CHKD: R.H.

DRWN. BY: D.J.W.

CHKD: D.O.

FACILITY:

LAT. & LONG: 69°25'47''N,139°05'17'' W

AIRPHOTO No.: A 14361-95

RIG:

METHOD: TEST PIT

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP.: 7°C

START: D 24 M 07 Y 75 TIME: 12:20

FINISH: D 24 M 07 Y 75 TIME: 17:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B8-2

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B8-2

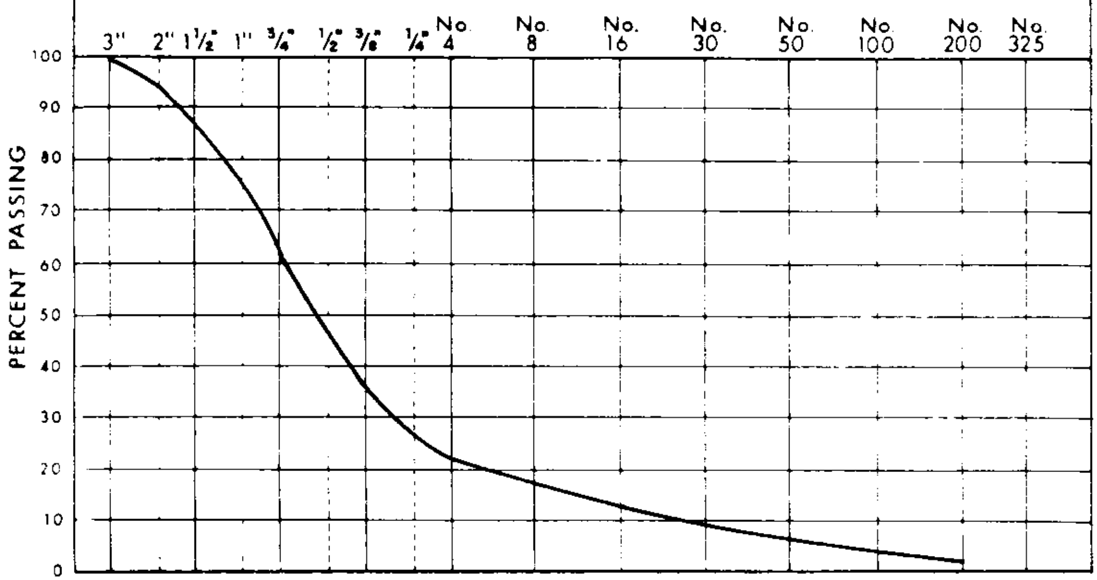
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B8-1 DEPTH 1.0 - 7.2

DATE SAMPLED July 24, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 128

GRAVEL SIZES		SAND SIZES			FINES
36 %	42 %	5 %	10 %	4 %	3%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.4
1½"	88.7
1"	75.4
¾"	63.6
½"	47.3
⅜"	36.7
¼"	
No. 4	22.4
No. 8	16.8
No. 16	13.3
No. 30	9.8
No. 50	5.0
No 100	3.2
No. 200	2.5

COMMENTS

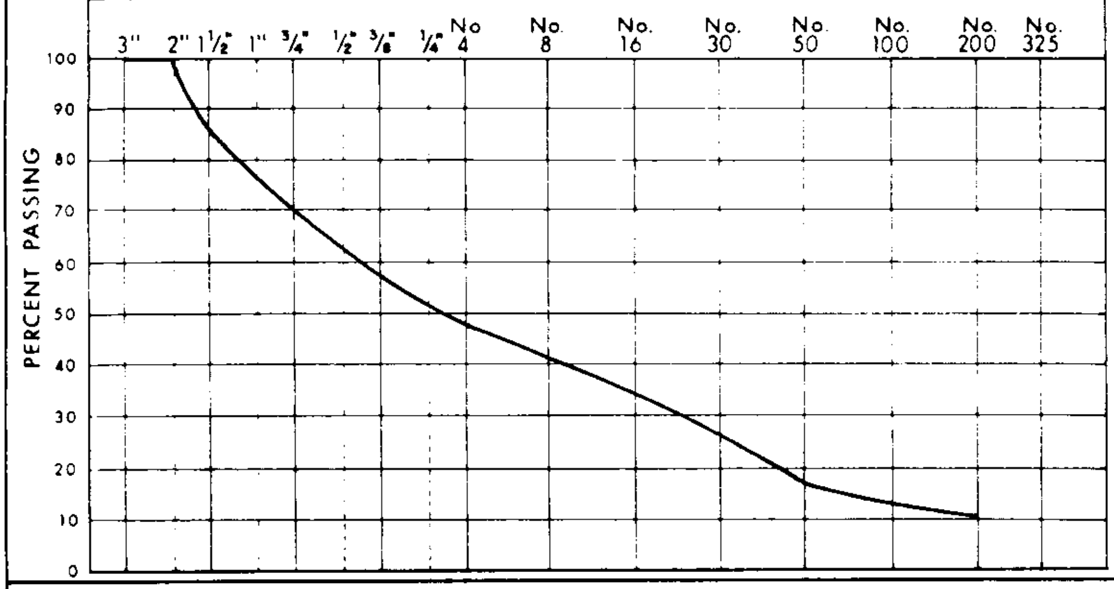
OVERSIZE (>3") = 0.0%

SAMPLE N75-117D-B8-2 DEPTH 1.0 - 2.0

DATE SAMPLED July 24, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 133

GRAVEL SIZES		SAND SIZES			FINES
28 %	24 %	8 %	18 %	11 %	11 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	87.1
1"	78.4
¾"	71.5
½"	64.1
⅜"	57.8
¼"	
No. 4	48.1
No. 8	41.5
No. 16	35.2
No. 30	27.5
No. 50	16.7
No. 100	12.6
No. 200	10.6

COMMENTS

OVERSIZE (>3") = 0.0 %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-117D-B8

PAGE 176

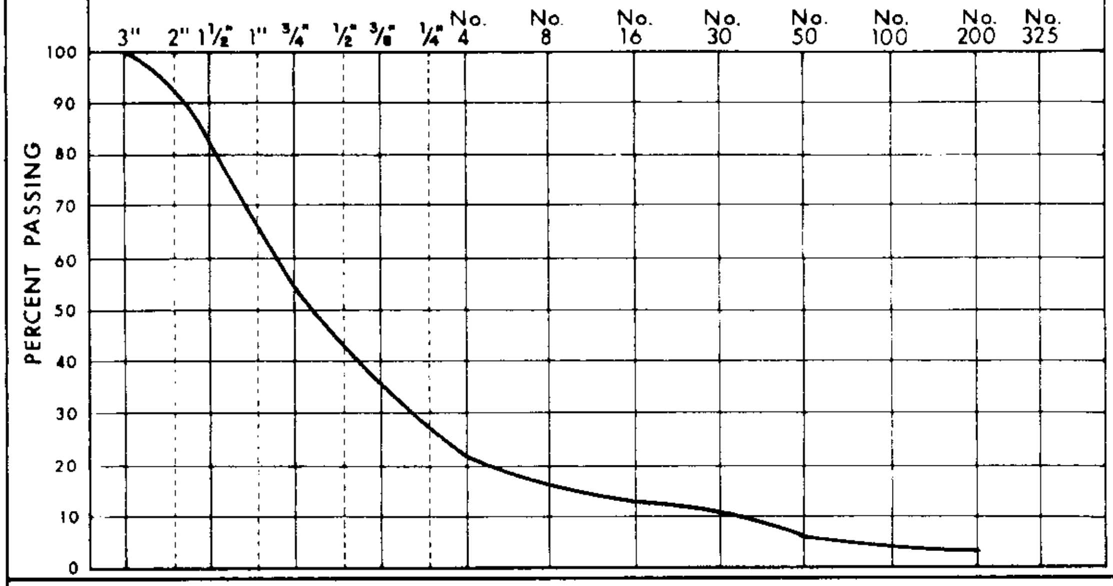
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B8-2 DEPTH 2.0 - 5.0

DATE SAMPLED July 24, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 134

GRAVEL SIZES		SAND SIZES			FINES
44 %	33%	6 %	9 %	4 %	4 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.2
1½"	81.9
1"	67.5
¾"	56.4
½"	44.0
⅜"	35.2
¼"	
No. 4	22.7
No. 8	16.7
No. 16	13.4
No. 30	10.3
No. 50	6.2
No. 100	4.9
No. 200	4.1

COMMENTS

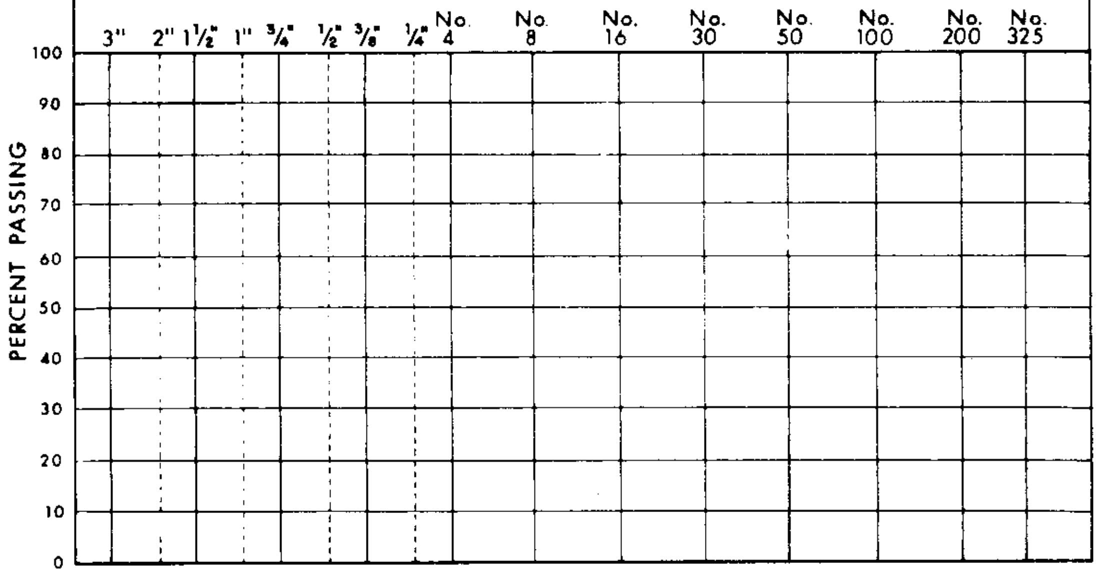
OVERSIZE (>3") = 0.0%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

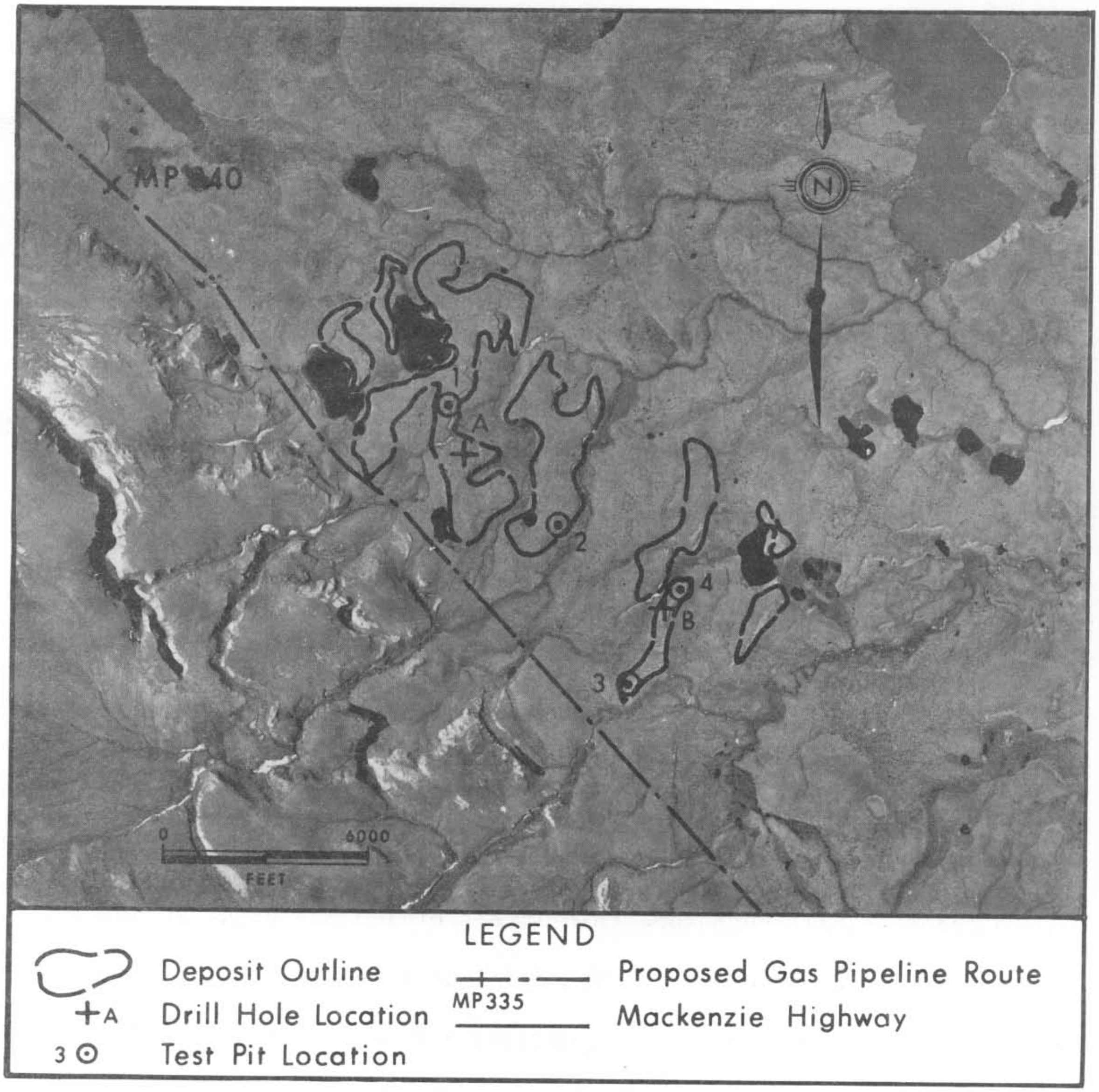
NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-117D-B8

PAGE 177

DEPOSIT 117D-B9

Physical Setting:	Deposit 117D-B9 consists of kame delta remnants located 8 miles east of the Firth River and 9 miles WSW of Roland Bay. The proposed pipeline route crosses the deposit at mile 243.
Material:	Gravel; well to poorly graded, coarse to fine, and coarse, medium and fine sand, trace fines.
Volume:	20,000,000 cubic yards.
Assessment:	Deposit 117D-B9 is a good source of granular material. Haul distance is short from the deposit to the pipeline right of way. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete aggregate.



Airphoto No. A13751-103
Approximate Scale: 1" = 5250'

Latitude: 69° 20' N
Longitude: 139° 14' W

DEPOSIT 117D-B9

PHYSICAL SETTING

Deposit 117D-B9 consists of kame delta remnants located 8 miles east of Firth River and 9 miles WSW of Roland Bay. The proposed pipeline route crosses the southern edge of the deposit.

The kames, which flank the Buckland Hills, are a group of flat-topped, steep-sided hills standing 20 to 30 feet higher than the surrounding terrain. The surfaces of the hills slope very gently northward. Local depressions have resulted from the melting out of massive ice within the kame delta sediments.

The hills are well drained except for the central parts of broad flat areas and isolated shallow depressions. The water table in the central parts of some of the hills may be close to the surface in summer. Depressions between the hills are poorly drained and swampy. The deposit has generally less than 1 foot of peat, although up to 6 feet of peat and silt are present on the central part of some broad flat areas. Gravel is often exposed at the surface.

The active layer varies slightly with overburden thickness, but is generally about 1 foot thick where peat is present and up to 5 feet where gravel is at the surface. Ice content in the gravel is usually low to moderate, although some thin layers of ice may exist at shallow depth in poorly drained areas. The drill hole at location A (see air photo on facing page) encountered massive ice at a depth of 31 feet.

BIOLOGICAL SETTING

Dry areas have a patchy cover of sedge, moss, lichen, and dwarf birch and willow. Poorly drained areas and creek channels are covered by sedge tussocks and occasional clumps of willow up to 3 feet high.

The area provides very good nesting habitat for upland bird species such as plover and ptarmigan, and den sites for Arctic ground squirrel.

The small streams adjacent to the site are part of a stream system, which provides major spawning and rearing areas for grayling. Siltation in the stream system should be minimized.

MATERIALS

The deposit consists of angular to subrounded gravel and sand. The part closest to the Buckland Hills has an abundance of angular to subangular argillite and shale in the upper 4 feet. This material is derived from nearby bedrock sources. Below the surface layer, gravel and sand is medium dense, subangular to subrounded, usually stratified into poorly graded and well graded layers, with a trace of fines, and contains numerous cobbles and isolated boulders.

VOLUME

The deposit extends over a total area of approximately 2500 acres. The thickness of the deposit is governed by the depth to massive ice. Based on an average depth of 20 feet and moderate ice content, the total volume is approximately 20,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B9 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Catton Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the pipeline right of way. No major stream crossings would be necessary.

Initially, if overburden is present it would be stripped from the area to be excavated, and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be maintained over the deposit. This type of development could be accomplished by blasting or conventional earthmoving techniques depending on the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt	0.5 PEAT—woody, fibrous, dark brown	UF							0	15:15 4¼'' Walmac (used) ice exposed by digging with shovel.
	OL	1.0 SILT—(organic), dispersed pockets of black highly organic material to ½'' diameter. Medium brown at 0.5', darker with depth, fibres up to 1/8'' diameter	Vr 10								
6	GP	6.0 GRAVEL—fine at 8', 0.5' layer yellowish brown, friable, fine sand.								6	change to 3 7/8'' Tricone (used)
		8.5	ICE								
		9.0	Vx 30								
		11.0 gradual increase in sand content									

LABORATORY TEST DATA: ▲ Dry density (pcf) ○ Water content %

Plastic limit ├──┤ Liquid limit

40 60 80 100 120 140 ▲

0 20 40 60 80 100 ○

Depth scale: 0 2 4 6 8 10 12 14 16

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: W.W.	LAT. & LONG: 69°20'04'' N, 139°15'59'' W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 13751-103	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 1°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 28 M 07 Y 75 TIME: 15:15 FINISH: D 28 M 07 Y 75 TIME: 16:30

TEST HOLE No. N75-117D-B9-A

SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117D-B9-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GP		GRAVEL (cont'd)										
			18										
18	SP		SAND – fine to medium matrix, ice coatings flat coarse sand grains, circular, 1/8'' diameter, 1/16'' thick, arranged horizontally, dark grey.		Vx 30								
20													
22													
24													
26													
28													
30													
	SP		31.0										
	ICE		ICE		ICE								

LOGGED BY: J.J.S.

CHKD: W.W.

DRWN. BY: A.M.

CHKD: D.O.

FACILITY:

LAT. & LONG: 68°20'04'' N, 139°15'59'' W

AIRPHOTO No.: A 13751-103

RIG: HELI-DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP.: 1°C

START: D 28 M 07 Y 75 TIME: 15:15

FINISH: D 28 M 07 Y 75 TIME: 16:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B9-A

SHEET 2 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	ICE		ICE, – trace silt throughout (approx. 5% silt)	■	ICE								
34				■									
36				■									
38			38.0 End of hole									38	16:30

LOGGED BY: J.J.S.
CHKD: W.W.
DRWN. BY: A.M.
CHKD: D.D.
FACILITY:
LAT. & LONG: 69°20'04'' N, 139°15'59'' W
AIRPHOTO No.: A 13751-103
RIG: HELI-DRILL
METHOD: AIR
PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 1°C
START: D 28 M 07 Y 75 TIME: 15:15
FINISH: D 28 M 07 Y 75 TIME: 16:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B9-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117D-B9-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt		0.2 PEAT		UF								17:15 4¼'' Walmac
	SW		SAND—medium to coarse, trace coarse to fine gravel, trace silt, medium brown, moist										
2													
			3.5		F								
4	GP		4.0 GRAVEL—coarse, little medium to coarse sand, occasional cobble									4	switch to 3 7/8'' Tricone
6													
8													
10													
			11.0 3'' fine sand and silt.									11	17:45
12													
14													
16													

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011
CHKD: W.W.	LAT. & LONG: 69°19'26'' N. 139°11'54'' W	ELEVATION:
DRWN. BY: A.M.	AIRPHOTO No.: A 13751-103	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 1°C
	METHOD: AIR	

START: D 28 M 07 Y 75 TIME: 17:15 FINISH: D 28 M 07 Y 75 TIME: 18:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B9-B

SHEET 1 OF 2

PC-9,SK373

TEST HOLE LOG

DEPTH (FT)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT)	REMARKS
16 18	GP		GRAVEL (cont'd)		F							17.5	17:55
19.0 20 22 24	SP		SAND – medium to coarse										
25.0 26 28	GW		GRAVEL – fine to coarse, sandy										
29.0			End of hole									29	sloughing and melt — cannot continue 18:30 without mud

LOGGED BY: J.J.S.

CHKD: W.W.

DRWN. BY: A.M.

CHKD: D.O.

FACILITY:

LAT. & LONG: 69°19'26'' N, 139°11'54''

AIRPHOTO No.: A 13751–103

RIG: HELI–DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: 1°C

START: D 28 M 07 Y 75 TIME: 17:15

FINISH: D 28 M 07 Y 75 TIME: 18:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B9-B

SHEET 2 OF 2

PC-9,SK373

TEST HOLE No. N75-117D-B9-B

TEST HOLE LOG

SOIL GROUP SYMBOL	DESCRIPTION	DEPTH (FT.)	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	REMARKS
Pt	PEAT - little fine sand, trace gravel to 2'', black, moist, fibrous	0.5	UF				Using shovels
GP	GRAVEL - fine, subangular, and sand, coarse to medium, dark grey, moist, isolated cobbles to 6''	2.0		MA, combined samples 1 - 3 oversize = 36.8% -3'' material: G = 50% S = 44% F = 6%	B1	☒	Combined samples* ''GRAVEL, coarse to fine, and cmf sand, trace fines'' (GW-GM)
SP	SAND - medium to fine, light brown, damp, isolated fine gravel, medium dense	2.5			B2	☒	
GP	GRAVEL - fine, platy, and sand, coarse to medium, damp, numerous cobbles, isolated boulders to 12'', medium dense	3.5			B3	☒	
SP	SAND - medium to fine, brown, damp, layered, isolated fine gravel, medium dense	4.0					
GW-GM	GRAVEL - coarse to fine, subangular, some cmf sand, trace fines, platy, dark grey, wet, numerous cobbles, isolated boulders to 11'', medium dense	5.1	Vx 15	MA, combined samples 4 - 7 oversize = 7.6% G = 63% S = 32% F = 5%	B4 B5	☒ ☒	Using jack hammer
	occasional Vc and ice lenses				B6 B7	☒ ☒	
	Bottom of pit	7.5					

LABORATORY TEST DATA
▲ Dry density (pcf) ⊙ Water content %
Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ⊙

CORE RUN & % RECOVERY
CORE CONDITION

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 69°20'15''N, 139°16'05''W	ELEVATION:	
DRWN. BY: D.J.M.	AIRPHOTO No.: A 13751-103	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP.: 4°C	
	METHOD: TEST PIT		

START: D 28 M 07 Y 75 TIME: 12:20 FINISH: D 28 M 07 Y 75 TIME: 15:55

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B9-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B9-1

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ○ Water content %
Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT - some sand, coarse to fine, black, moist, fibrous, medium dense		UF								Using shovels
0.7													
1	GW-GM		GRAVEL - fine to coarse, and cmf sand, trace fines, platy shale fragments dark grey, wet, stratified, medium dense				MA, combined, samples 1 - 7 G = 55% S = 40% F = 5%	B1	☒			1	
2								B2	☒			2	Sample B2 starts from depth 1.5 and B3 from 2.0
3								B3	☒			3	
3.5				+ + +	Vx 20			B4	☒				Using jack-hammer
4				+ + +								4	
4.5			some sand	+ + +				B5	☒				
5				+ + +				B6	☒			5	
6				+ + +				B7	☒			6	
6.2			Bottom of pit										

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: D.J.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°19'45''N, 139°40'00''W
AIRPHOTO No.: A 13751-103
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 4°C

START: D 28 M 07 Y 75 TIME: 12:25
FINISH: D 28 M 07 Y 75 TIME: 16:25

1975 BORROW INVESTIGATION

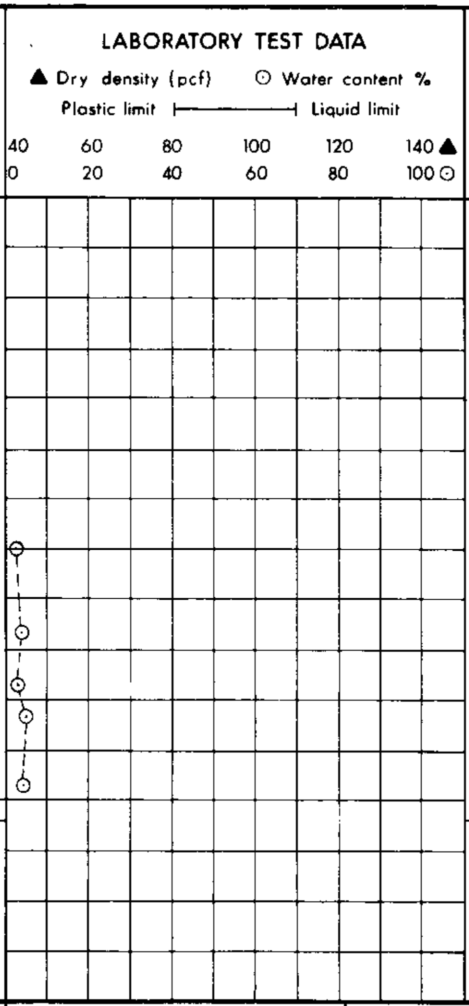
NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B9-2

SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG



DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL - coarse to fine, subangular, some sand, coarse to fine, little organics, dark brown, moist, numerous fibres, medium dense		UF	W%						Using shovels
1			1.0 — coarse to fine, little sand, light brown, moist, stratified, frequent cobbles to 8'', isolated boulders to 10'', loose									
2						MA, combined 1 - 5, & 7 Oversize = 15.8% G = 84% S = 13% F = 3% (GW)	B1	☒			2	
3						1.7	B2	☒			3	
4			4.0 — layer of coarse gravel and numerous cobbles, no sand.			3.2	B3	☒			4	
			4.8									
5	GM		GRAVEL - coarse, little silt, damp.			2.7	B4	☒			5	
						5.4	B5	☒				
							B6	☒				
			6.0			4.0	B7	☒				
6			6.2 Bottom of pit		Vx						6	Excessive sloughing

LOGGED BY:	J.G.R.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	69°18'59''N, 139°12'45''W	ELEVATION:	
DRWN. BY:	G.C.B.	AIRPHOTO No.:	A 13751-103	PIPE MILEAGE:	
CHKD:	D.O.	RIG:		AIR TEMP:	4°C
		METHOD:	TEST PIT		

START: D 28 M 07 Y 75 **TIME:** 17:05 **FINISH:** D 28 M 07 Y 75 **TIME:**

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B9-3

SHEET 1 **OF** 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.3	Pt	PEAT - some fine to medium sand, black, moist, fibrous	UF								Using shovels
1	SW-SM	SAND - coarse to fine, and fine to coarse gravel, trace fines, (high gravel content), subrounded pebbles, dark grey, moist, stratified, frequent cobbles to 5''.			MA, combined samples 1 - 8 G = 44% S = 51% F = 5% (SW-SM)	B1,	☒			1	Borderline sand/gravel for practical purposes
2						B2	☒			2	
3						B3	☒			3	Layers of gravel, coarse and fine, with no medium and fine sand at depths 3.0'-3.4' and 5.2'-5.8'
4.0		--- some sand								4	
4.5	SP	SAND - medium, rusty brown, moist, medium dense.	4.6 Vx 15								
5.0	SW-SM	SAND - coarse to fine and gravel.									
6					MA, 1 - 8	B4	☒			6	
7						B5 B6	☒ ☒			7	
8.0		Bottom of pit				B7 B8	☒ ☒			8	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: G.C.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°19'32''N, 139°11'33''W
AIRPHOTO No.: A 13751-103
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 4°C

START: D 28 M 07 Y 75 TIME: 16:55
FINISH: D 28 M 07 Y 75 TIME: 21:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B9-4

SHEET 1 OF 1

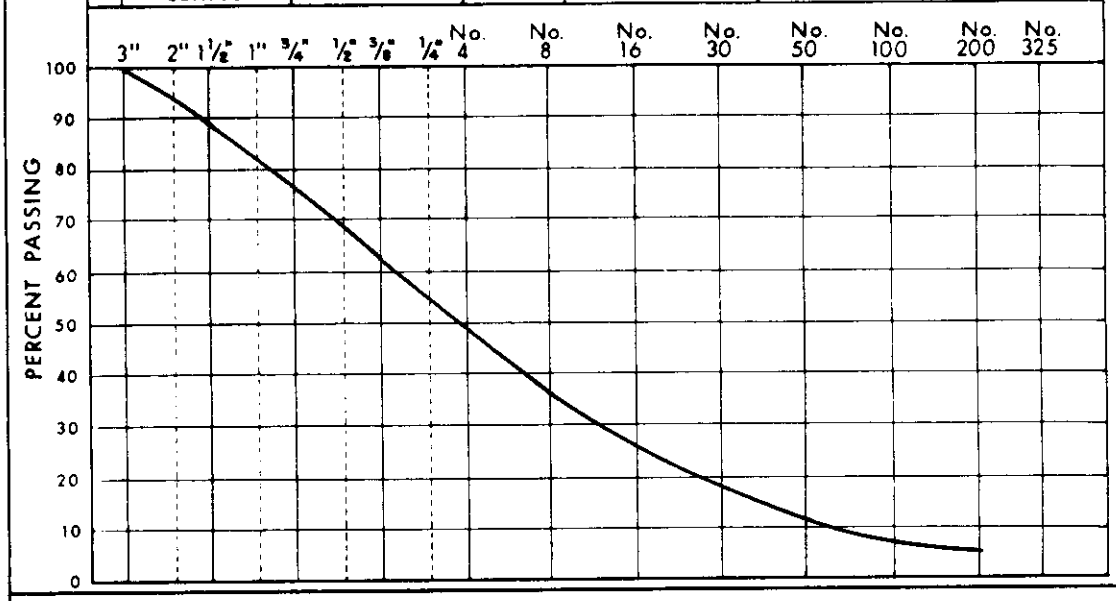
PC-9,SK373

SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B9-1 DEPTH 1.0 - 4.0
DATE SAMPLED July 28, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 92

GRAVEL SIZES		SAND SIZES			FINES
22 %	28 %	15%	20 %	9 %	6 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.8
1½"	88.6
1"	81.5
¾"	77.8
½"	69.6
⅜"	63.0
¼"	
No. 4	50.1
No. 8	36.9
No 16	27.2
No. 30	20.4
No 50	13.8
No 100	7.9
No. 200	6.3

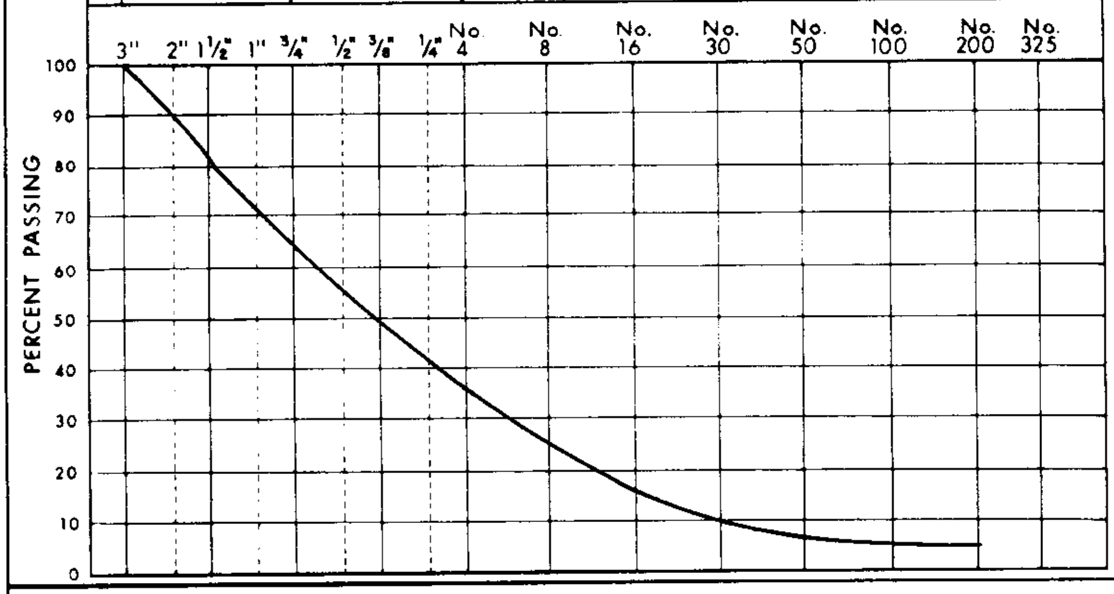
COMMENTS

OVERSIZE (>3") = 36.8%

SAMPLE N75-117D-B9-1 DEPTH 4.0 - 7.0
DATE SAMPLED July 28, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 93

GRAVEL SIZES		SAND SIZES			FINES
35 %	28 %	14 %	14 %	4 %	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	90.3
1½"	82.7
1"	72.2
¾"	65.1
½"	55.6
⅜"	48.9
¼"	
No. 4	37.0
No. 8	26.1
No. 16	15.8
No. 30	10.1
No. 50	7.5
No. 100	6.1
No. 200	5.4

COMMENTS

OVERSIZE (>3") = 7.6 %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

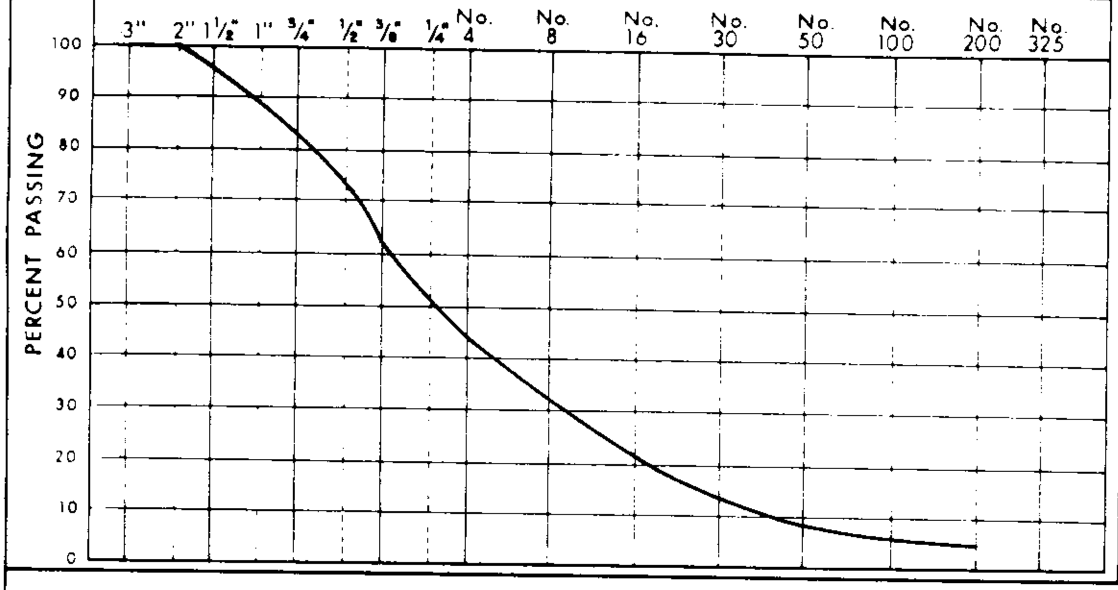
DEPOSIT No.
N75-117D-B9

SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B9-2 DEPTH 1.0 - 6.2
DATE SAMPLED July 28, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER
82

GRAVEL SIZES		SAND SIZES			FINES
17 %	38 %	15 %	20 %	5 %	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	93.1
1"	88.4
¾"	83.0
½"	72.0
⅜"	62.6
¼"	
No. 4	44.7
No. 8	32.4
No 16	22.2
No. 30	13.9
No 50	8.3
No 100	5.9
No. 200	5.0

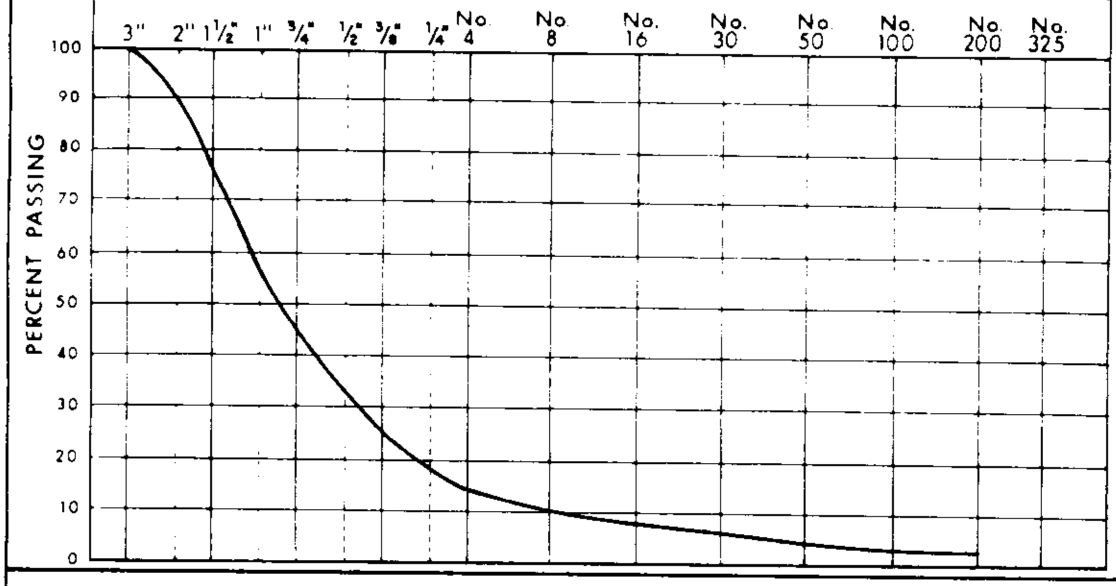
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-117D-B9-3 DEPTH 2.0 - 6.0
DATE SAMPLED July 28, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER
101

GRAVEL SIZES		SAND SIZES			FINES
53 %	31 %	6 %	4 %	3 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	90.5
1½"	76.9
1"	56.8
¾"	47.3
½"	33.3
⅜"	25.1
¼"	
No. 4	15.7
No. 8	10.9
No 16	8.8
No. 30	6.8
No. 50	4.8
No 100	3.4
No. 200	2.9

COMMENTS

OVERSIZE (>3") = 15.8%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117D-B9

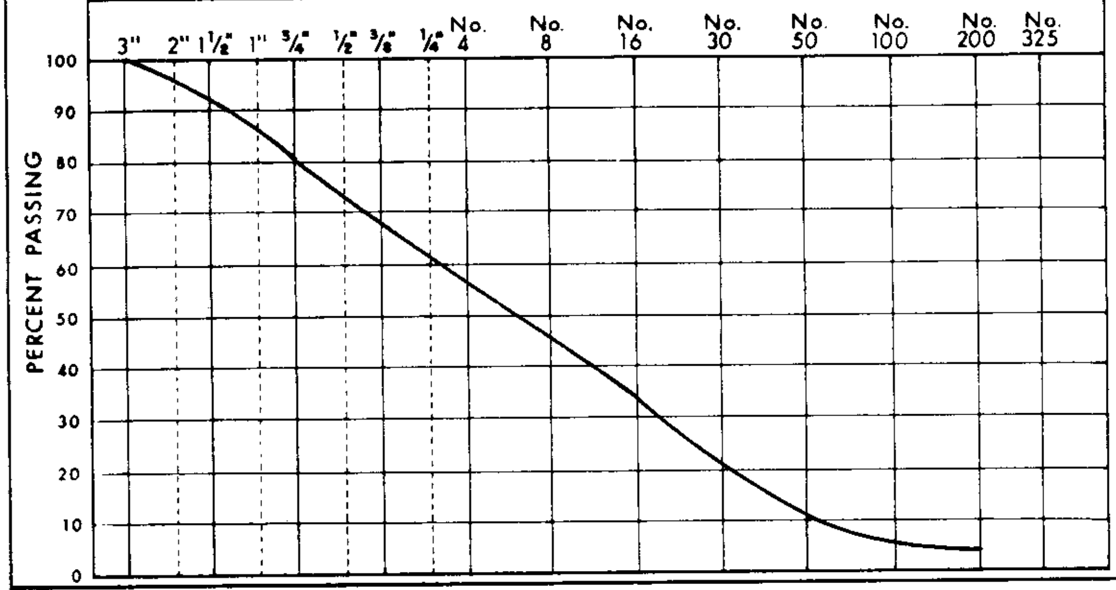
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B9-4 DEPTH 1.0 - 8.0

DATE SAMPLED July 28, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 108

GRAVEL SIZES		SAND SIZES			FINES
19 %	25 %	13 %	28 %	10 %	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	97.5
1½"	93.0
1"	85.5
¾"	80.5
½"	73.3
⅜"	67.8
¼"	
No. 4	55.8
No. 8	46.5
No. 16	34.5
No. 30	20.2
No. 50	9.9
No. 100	5.7
No. 200	4.6

COMMENTS

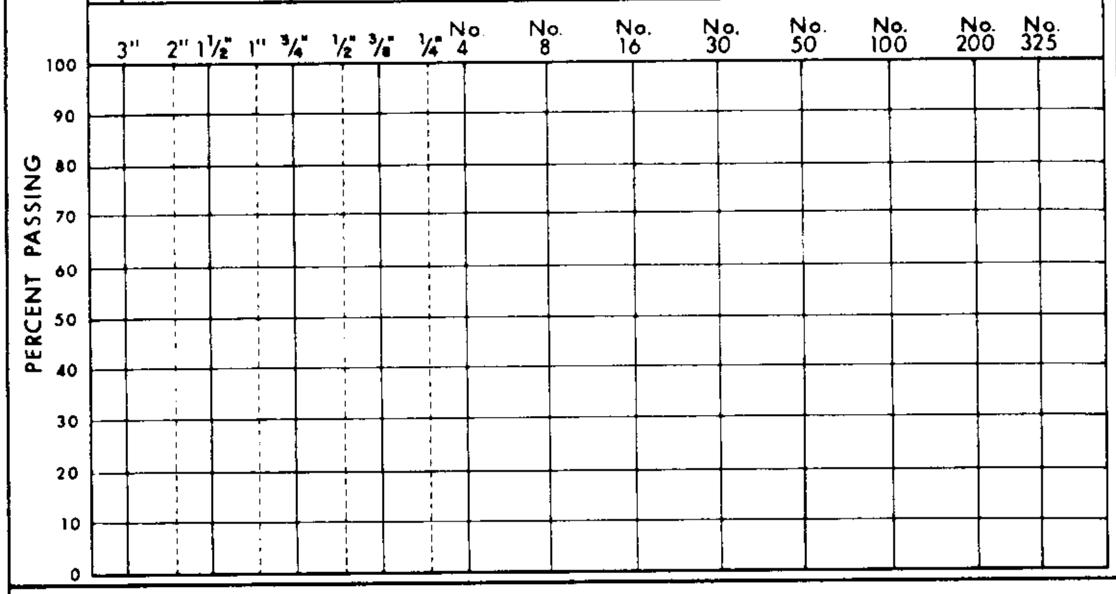
OVERSIZE (>3") = 0.0 %

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services
Company Limited

DEPOSIT No.

N75-117D-B9

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-117D-B9-2 DATE SAMPLED : July 28, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1.0 - 6.2 DATE TESTED : March, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 32.65 %
FINE AGGREGATE : LOSS = 48.58 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 28.0 %

ORGANIC IMPURITIES TEST

NUMBER : 3
COAL REMOVED : nil
COAL & ROOTLETS REMOVED : nil
COAL CONTENT : nil
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Very strong, Good.	14.85
Sandstone	Strong, Good.	1.10
Limestone		0.45
Siltstone	Strong, Flat, Good.	17.20
Chert	Potentially reactive, Fair.	3.05
Flint		1.70
Soft Siltstone	Soft, Weak, Poor	0.05
Ironstone	Soft, Friable, Deleterious	0.05
PN = 127	INTERPRETATION : Fair to good quality aggregate for concrete.	38.45

COMMENTS :

NORTHERN Engineering Services Company Limited

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

DEPOSIT No. N75-117D-B9

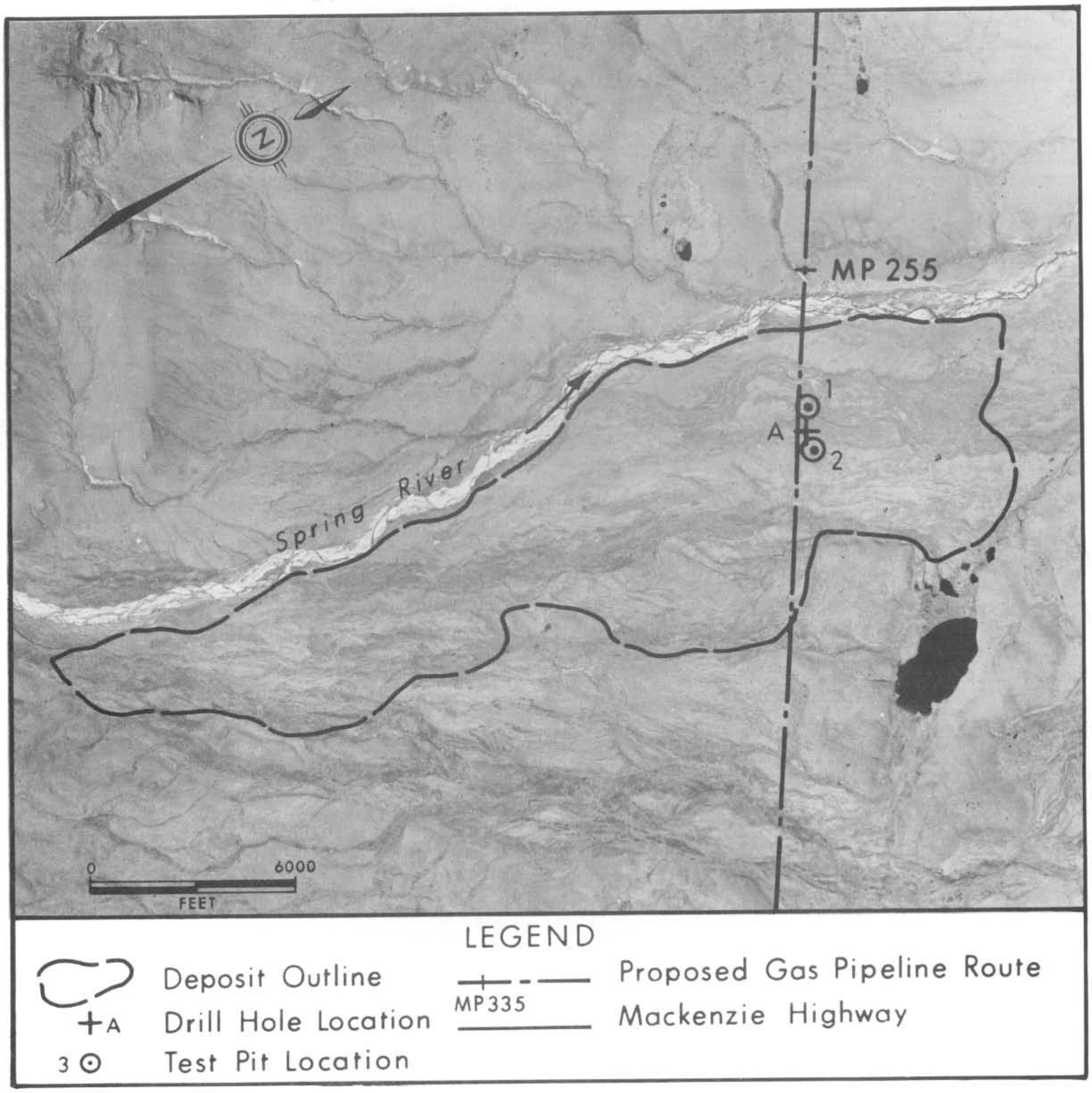
DEPOSIT 117D-B10

Physical Setting: Deposit 117D-B10 is a series of fluvial terraces on the east side of Spring River, about 11 miles SSW of Stokes Point. Mile 256 of the proposed gas pipeline crosses the north end of the deposit.

Material: Gravel; well graded, coarse to fine, little to some coarse, medium, and fine sand.

Volume: 125,000,000 cubic yards.

Assessment: Deposit 117D-B10 is a good source of granular material. The proposed gas pipeline crosses the northern end of the deposit thus reducing haul distances. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and concrete and asphalt aggregate.



Airphoto No.	A13470-132	Latitude:	69° 12' N
Approximate Scale:	1" = 5250'	Longitude:	138° 53' W

DEPOSIT 117D-B10

PHYSICAL SETTING

Deposit 117D-B10 is a series of fluvial terraces on the east side of Spring River about 11 miles SSW of Stokes Point. Mile 256 of the proposed pipeline route crosses the north end of the deposit.

The terraces stand 5 to 15 feet above the present level of the Spring River floodplain. Different terraces are separated by abandoned stream channels 20 to 30 yards wide and 5 to 10 feet deep. The terraces and channels extend for 6 miles parallel to Spring River, and for 2 miles to the east. The deposit as outlined on the airphoto includes only the area where overburden is least likely to exceed 5 feet. The western boundary of the terraces is formed by the present channel of Spring River.

Drainage on the deposit varies from moderately good to imperfect. Surface drainage is localized along abandoned stream channels which drain northward. Channel bottoms and occasional depressions are imperfectly to poorly drained. The water table in summer is probably within 2 feet of the surface over most of the deposit. The active layer is 3 feet thick, and the ice content of the gravel is low to moderate.

Peat and silt cover varies in thickness. Gravel is exposed over approximately one-third of the deposit. Elsewhere, depth of overburden ranges from 1 to 5 feet.

BIOLOGICAL SETTING

The better drained areas support shrub tundra vegetation composed primarily of dwarf willow, dwarf birch, sedge and moss. Imperfectly drained areas are covered by sedge tussocks and moss.

The area provides good nesting habitat for ptarmigan, plovers, Lapland longspurs, whimbrels, and other upland bird species. Snow geese feed in the area but it is not a major concentration area.

Spring River is a spawning and rearing area for grayling, and rarely, Arctic char.

MATERIALS

The terraces contain good quality granular materials consisting of clean, well graded, subrounded, medium dense, stratified gravel with little coarse to medium sand, frequent cobbles up to 8 inches in diameter and isolated boulders up to 10 inches in diameter.

VOLUME

The area of the deposit is about 3500 acres. The total volume, based on a depth of 30 feet and moderate ice content, is about 125,000,000 cubic yards.

This volume could be doubled by extending the deposit to include a large area of terraces to the north and east where overburden thicknesses generally exceed 5 feet.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B10 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Excavations would be kept away from the Spring River stream channel to prevent siltation. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Stokes Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. Any snow roads crossing the stream channels would be breached before spring runoff begins.

Initially the peat cover and overburden would be stripped from the excavated area and stockpiled around the edge of the excavation away from the drainage channels.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be maintained over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt	0.5 PEAT—fibrous moist, dark brown	UF								20:00 4¼'' Walmac (new) 3 foot pit dug to prevent sloughing.
2	GP	GRAVEL - coarse, trace silt, frequent cobbles to 10'' 3.0 3.0									
4	OL	SILT—(organic), sandy, oxidized pockets dark grey and brown. Organics (wood fibres to 1/8'' diameter) 4.3	Vr								
	GW	GRAVEL—fine to coarse, cobble at 4.3' (6''), occasional cobble to 19.0'								5	4¼'' Tricone (used)
6										6	20:40
8										9	21:00 melting lining of hole – change to 3 7/8'' Tricone at 10.0'
14											Hole wet up – wait until dry
16										17	21:45 Experienced jamming upon tripping out,
18										18	22:30 Tricone worn
19		19.0 End of hole								19	out.

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: W.W.	LAT. & LONG: 69°12'01''N, 138°52'50'' W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 13470-132	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 2°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 28 M 07 Y 75 TIME: 20:00	FINISH: D 28 M 07 Y 75 TIME: 22:30		

TEST HOLE No.

N75-117D-B10-A

SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
1 2	GW		GRAVEL - coarse to fine, subrounded, little sand, coarse to medium, dark grey, wet, stratified, frequent cobbles to 7'', medium dense ▼ water level		UF		MA, combined G = 80% S = 19% F = 1%	B1 B2 B3 B4	☒ ☒ ☒ ☒			1 2	1"- 2'' peat cover, black using shovels
			2.5 Bottom of pit										

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: $69^0 12' 10''N$, $138^0 52' 50''W$	ELEVATION:	
DRWN. BY: D.M.	AIRPHOTO No.: A 13470-132	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP.: Approx. 7^0C	
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 29 M 07 Y 75 TIME: 12:00 **FINISH:** D 29 M 07 Y 75 TIME: 12:50

TEST HOLE No.

N75-117D-B10-1

SHEET 1 OF 1

PC-9,SK373

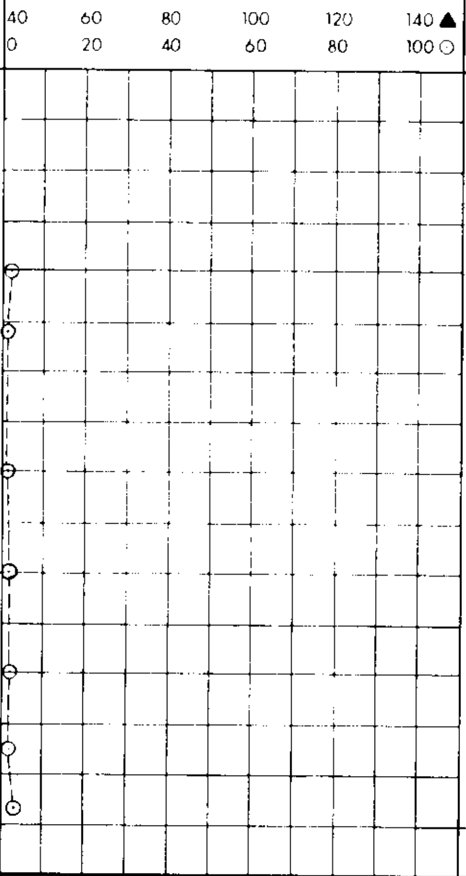
TEST HOLE No. N75-117D-B10-1

TEST HOLE LOG

LABORATORY TEST DATA

▲ Dry density (pcf) ⊙ Water content %

Plastic limit ├──┤ Liquid limit



DEPTH (FT)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	DEPTH (FT.)	REMARKS
	GW	GRAVEL - coarse to fine, subrounded, some cmf sand, dark grey, moist, stratified, numerous cobbles to 8'', isolated boulders to 10'', subrounded, medium dense.	UF	w%			1'' peat cover, dark brown, fibres to depth 2.7'
1						1	
2				2.9 MA, combined samples 1 - 7 oversize = 33.8% - 3'' material	B1	2	
				1.8 G = 72% S = 27% F = 1% (GW)			
3					B2	3	Thin layer (2''-3'') of gravel, with trace coarse sand at depth 3.0'
4				2.0	B3	4	
							Excessive sloughing
5		5.0 occasional ice coatings	Vx 15	2.8	B4	5	Using jack-hammer
6				2.6	B5	6	
7				2.2	B6	7	
		7.5 Bottom of pit		3.2	B7		

LOGGED BY: J.G.R.	FACILITY	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG 69°11'51''N, 138°52'16''W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA
DRWN. BY: G.C.B.	AIRPHOTO No. A 13470-132	PIPE MILEAGE:	ENGINEERS FOR
CHKD: D.D.	RIG:	AIR TEMP: 10°C	CANADIAN ARCTIC GAS STUDY LIMITED
	METHOD: TEST PIT		

START: D 28 M 07 Y 75 TIME:

FINISH: D 29 M 08 Y 75 TIME: 16:00

TEST HOLE No. N75-117D-B10-2

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B10-2

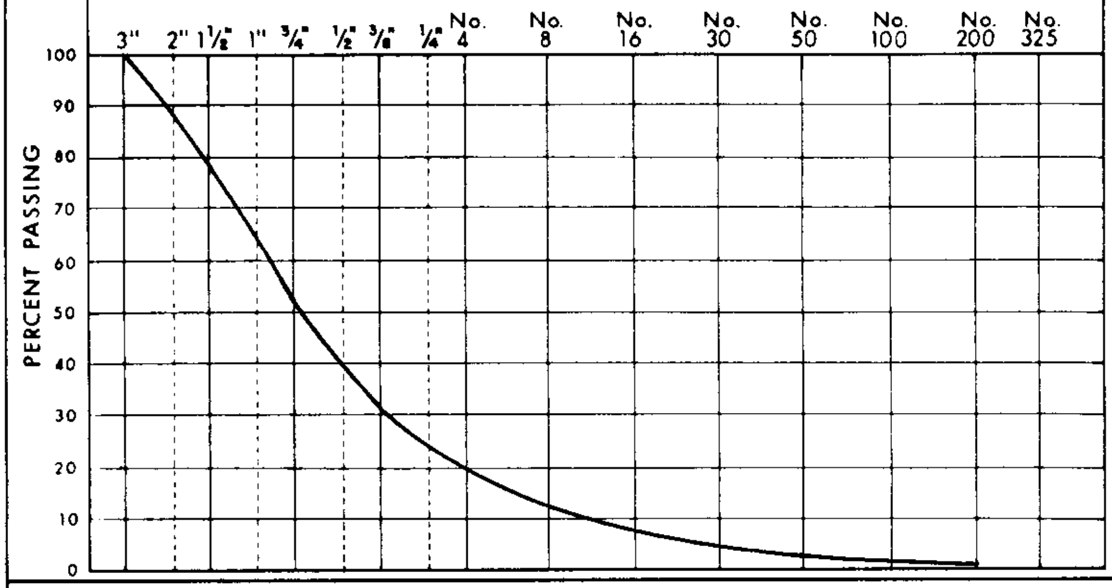
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B10-1 DEPTH 0.0 - 2.0

DATE SAMPLED July 29, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 48

GRAVEL SIZES		SAND SIZES			FINES
48 %	32 %	8 %	3 %	1 %	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	89.2
1½"	79.7
1"	62.0
¾"	52.0
½"	39.7
⅜"	31.0
¼"	
No. 4	19.7
No. 8	12.9
No. 16	8.7
No. 30	5.2
No. 50	2.5
No 100	1.4
No. 200	1.0

COMMENTS

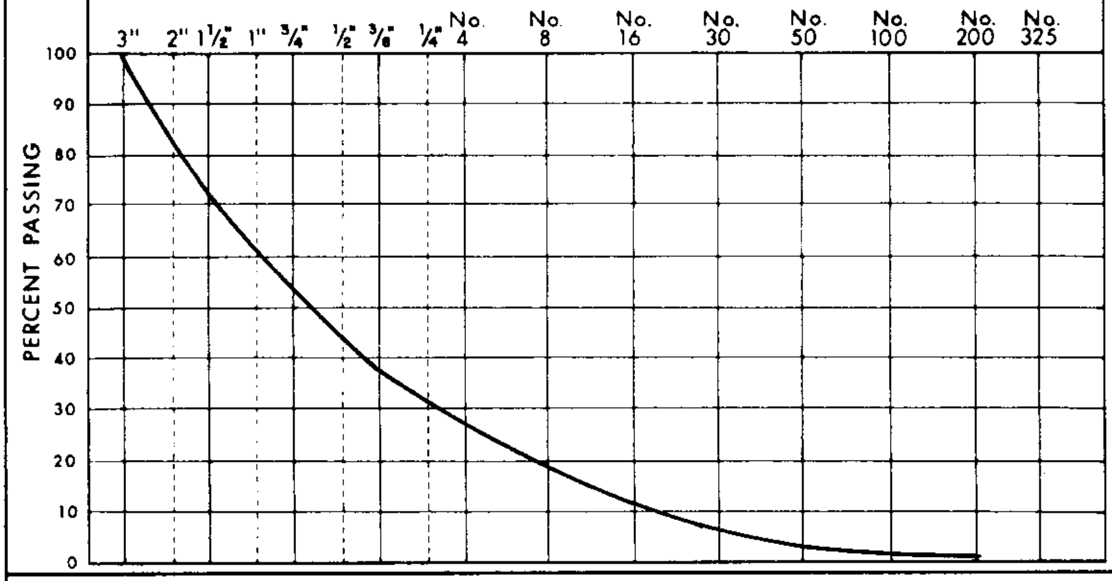
OVERSIZE (>3") = 0.0%

SAMPLE N75-117D-B10-2 DEPTH 1.5 - 7.5

DATE SAMPLED July 28, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 102

GRAVEL SIZES		SAND SIZES			FINES
45 %	27 %	10 %	13 %	4 %	1 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	85.7
1½"	73.6
1"	63.3
¾"	55.2
½"	45.0
⅜"	38.4
¼"	
No. 4	28.4
No. 8	19.3
No. 16	12.2
No. 30	6.8
No. 50	3.5
No. 100	2.0
No. 200	1.4

COMMENTS

OVERSIZE (>3") = 33.8%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117D-B10

PAGE
205

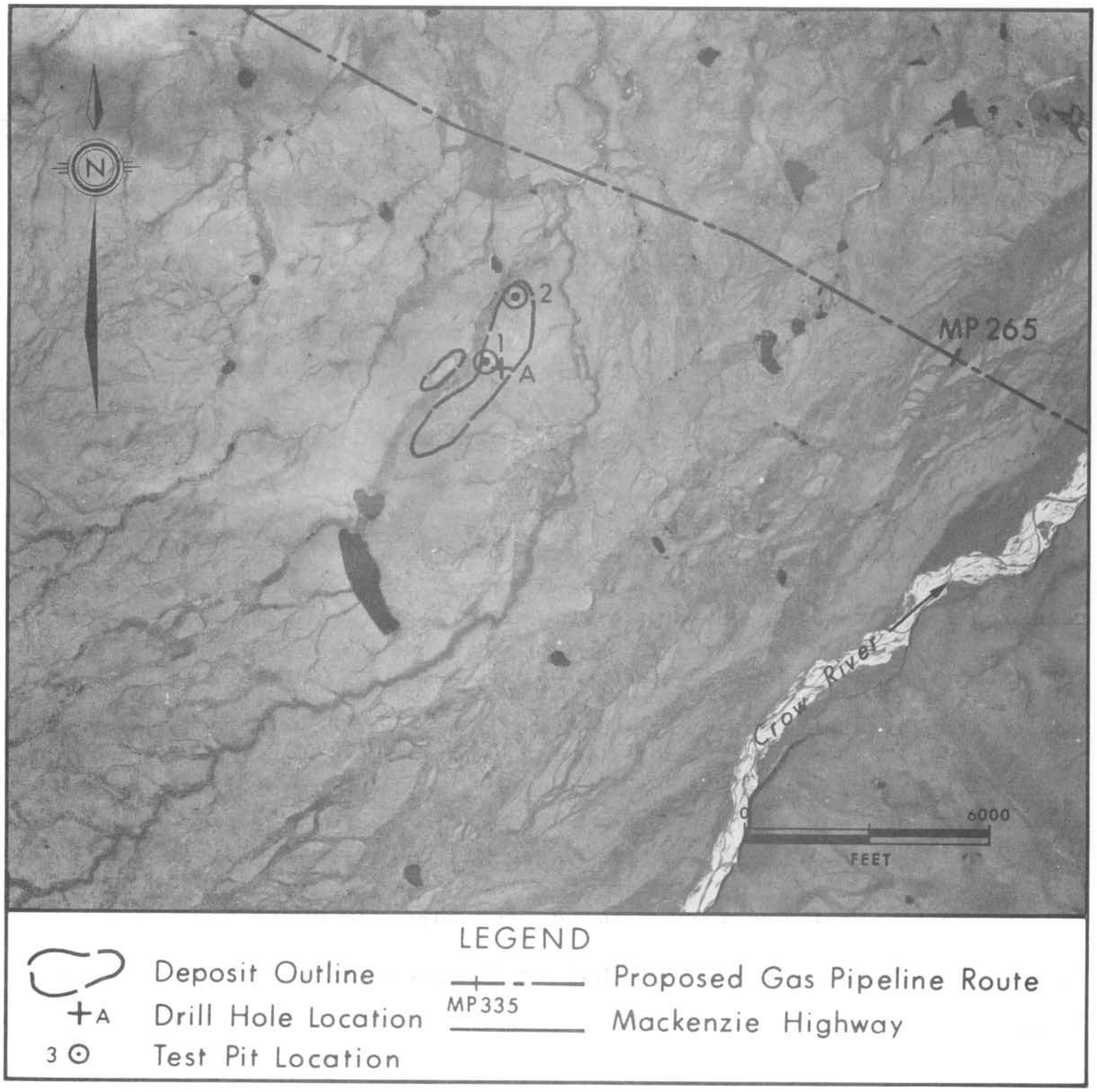
DEPOSIT 117D-B11

Physical Setting: Deposit 117D-B11 is a small kame delta located 4 miles south of Bloomfield Lake and 3 miles west of Crow River. It is situated 1 mile south of mile 265 of the proposed gas pipeline.

Material: Gravel; well graded, coarse to fine, little to some coarse, medium, and fine sand.

Volume: 2,500,000 cubic yards.

Assessment: Deposit 117D-B11 is a good source of granular material. Access to the pipeline is good. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and concrete and asphalt aggregate.



Airphoto No. A13383-159

Approximate Scale: 1" = 5250'

Latitude: 69° 06' N

Longitude: 138° 43' W

DEPOSIT 117D-B11

PHYSICAL SETTING

Deposit 117D-B11 is a small kame delta located 4 miles south of Bloomfield Lake and about 3 miles west of Crow River. Mile 265 of the proposed pipeline right of way is less than a mile north of the deposit.

The kame is a northeast-southwest trending ridge which rises 15 feet above the surrounding terrain. It has moderate to steep-sided slopes and a gently undulating surface. The ridge is approximately 1 mile long and 1000 feet wide and has been incised by meltwater streams.

The surface of the deposit is generally well drained. Gravel is exposed over a large part of the deposit; however, some depressions and flat-lying areas have up to 5 feet of peat and ice-rich silt overlying the gravel.

The terrain surrounding the deposit is imperfectly to poorly drained, and is characterized by small lakes and ponds, beaded streams, and occasional patches of ice-wedge polygons. Several small creeks cross terrain between the deposit and the pipeline.

The outwash material in the kame delta has massive ice layers within the gravel, as indicated by drill hole 117D-B11-A. Close to the surface ice contents are low to moderate. The active layer is approximately 1 foot thick over much of the deposit, but is in excess of 4 feet under bare gravel.

BIOLOGICAL SETTING

A patchy cover of mosses, sedge and dwarf willow is present in well drained areas. Tundra vegetation, consisting mainly of sedge tussocks and moss, covers poorly drained areas. The site is within an area occasionally used by snow geese for feeding.

MATERIALS

The deposit contains good quality material consisting of stratified, subangular to subrounded, dense gravel, with some coarse to fine sand, frequent cobbles, and a trace of silt in some strata.

VOLUME

The deposit has an area of 140 acres. The recoverable volume, based on a depth to massive ice of approximately 20 feet and moderate ice contents, is 2,500,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B11 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Excavations would be kept away from any nearby streams to prevent siltation. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Phillips Bay and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. Care would have to be taken during construction as small stream crossings would be involved.

Initially, where overburden is present, it would be stripped from the area to be excavated, and stockpiled around the edge of the excavation away from the natural drainage channels.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established. This type of development could be accomplished by blasting or conventional earthmoving techniques depending on the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural conditions. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	DEPTH (FT.)	REMARKS
0	Pt	PEAT- spongy, damp, dark brown, roots and fibres, finer with depth. 1.0	UF	0	12:45 4¼'' Walmac (used) ½'' ice lense
		1.0			
	OL	SILT- (organic), little fine to medium sand, high organic content (odour) dark brown, rusty (oxidized) pockets at 1.0'	F		
2			40		
		4.0			
4	GP	GRAVEL- coarse, sandy, trace silt. ICE	40		
6				6.5	change to 3 7/8'' Tricone (used)
		7.0 5'' cobble			
8					
		9.5		9	13:10 new 3 7/8'' Tricone
10		10.3 boulder			
		10.5 boulder			
		11.3			
12		cobbles frequent to 19.0'		12	melt down hole
14					
		15.5			
16		sandy silt lense		16	13:40

LABORATORY TEST DATA
▲ Dry density (pcf) ○ Water content %
Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ○

OTHER TEST DATA

SAMPLE TYPE & No. | SAMPLE CONDITION | CORE RUN & % RECOVERY | CORE CONDITION

ICE GRAPHIC LOG | SOIL GRAPHIC LOG

LOGGED BY:	J.J.S.	FACILITY		PROJECT:	13011
CHKD:	W.W.	LAT. & LONG:	69°06' 19'' N, 136°42'52'' W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 13383-158	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI-DRILL	AIR TEMP:	
		METHOD:	AIR		

START: D 29 M 07 Y 75 TIME: 12:45
FINISH: D 29 M 07 Y 75 TIME: 16:40

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B11-A

SHEET 1 OF 3

PC-9,SK273

TEST HOLE No. N75-117D-B11-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GP		16.5		F							16	13:40
18			19.0									19	13:50
20	ICE + SM		ICE - trace sand and silt throughout		ICE +								
22												22	change 3 7/8'' Walmac (new)
24													
26			26.5										
	GW		GRAVEL - fine to coarse, trace silt, fine sand		F								
28			29.5 cobbles to 5''										
30	GW											30	14:15 change to used 3 7/8''Tricone, Walmac used completely
32													

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: W.W.	LAT. & LONG: 69°06'19''N, 138°42'52'' W	ELEVATION:		
DRWN. BY: A.M.	AIRPHOTO No.: A 13383-158	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-117D-B11-A
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.:		
	METHOD: AIR			
START: D 29 M 07 Y 75 TIME: 12:45	FINISH: D 29 M 07 Y 75 TIME: 16:40		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	GW				F								
34			34.0									34	15:00
			34.6 cobble occasional cobbles to 41.0'										
36													
38												39	15:40
40													
42													
44													
			45.0 End of hole									45	16:40 cuttings not coming up hole, danger of jamming bit.
46													

LOGGED BY: J.J.S.
CHKD: W.W.
DRWN. BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°06'19'' N, 138°42'52'' W
AIRPHOTO No.: A 13383-158
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP:

START: D 29 M 07 Y 75 TIME: 12:45
FINISH: D 29 M 07 Y 75 TIME: 16:40

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B11-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW	GRAVEL - coarse to fine, average size 1.5'' - 2.0'', subrounded, some sand, coarse to fine, trace silt and fibres to depth 1.8', light brown, damp, stratified, frequent subangular cobbles to 7'', dense		UF								Using shovels Some peat to depth 0.5'
1												
2						MA, combined Samples 1 - 7 G = 74% S = 24% F = 2% GW	B1	☒			2	
3							B2	☒			3	
4		4.2 — some sand, coarse and medium, dark grey, moist									4	
5							B3	☒			5	sloughing begins
			5.8				B4	☒				
6				Vx 5			B5	☒			6	using jack-hammer
							B6	☒				
7							B7	☒			7	
8.4		Bottom of pit	8.4									

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011
CHKD: R.H.	LAT. & LONG: 69°06'17''N, 138°43'05''W	ELEVATION:
DRWN. BY: D.M.	AIRPHOTO No.: A 13383-158	PIPE MILEAGE:
CHKD: D.O.	RIG:	AIR TEMP.: Approx. 10°C
	METHOD: TEST PIT	

START: D 30 M 07 Y 75 **TIME:** 12:15 **FINISH:** D 30 M 07 Y 75 **TIME:**

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B11-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B11-1

TEST HOLE LOG

DEPTH (FT)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT)	REMARKS
	GW		GRAVEL - fine to coarse, subrounded, little sand, fine to coarse to 3.3', some peat (organic) to depth 1.0', fibres to depth 3.0', light brown, moist, stratified, isolated subangular cobbles to 6'', medium dense		UF								Using shovels
1							MA, combined samples 1 - 7 G = 84% S = 14% F = 2% (GW)	B1	☒			1	
2			2.7 trace silt to depth 3.3'					B2	☒			2	
3			3.3 no silt, no medium to fine sand, average particle size 1''					B3	☒			3	
4			4.0 trace silt to depth 4.6'					B4	☒			4	
5			4.8 no silt, little fine to coarse sand					B5	☒			5	
6			6.0					B6	☒			6	
			6.2 no fine to medium sand	+ + +	Vx 5			B7	☒				
			6.5 Bottom of pit										

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN BY: F.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°06'37''N, 138°41'49''W
AIRPHOTO No.: A 13383-158
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: Approx. 10°C

START: D 30 M 07 Y 75 TIME: 12:15
FINISH: D 30 M 07 Y 75 TIME: 16:50

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B11-2

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117D-B11-2

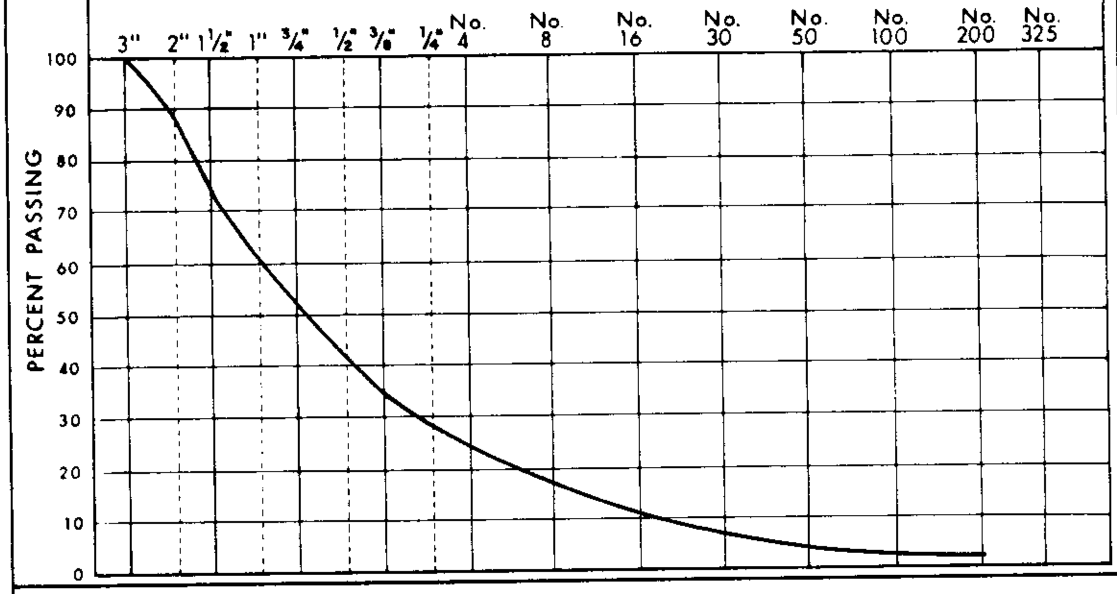
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B11-1 DEPTH 0.0 - 8.0

DATE SAMPLED July 30, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 5

GRAVEL SIZES		SAND SIZES			FINES
48 %	26 %	9 %	12 %	3 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	88.4
1½"	76.0
1"	60.9
¾"	51.9
½"	41.9
⅜"	34.7
¼"	
No. 4	25.9
No. 8	17.5
No. 16	12.2
No. 30	6.5
No. 50	3.3
No 100	2.5
No. 200	2.2

COMMENTS

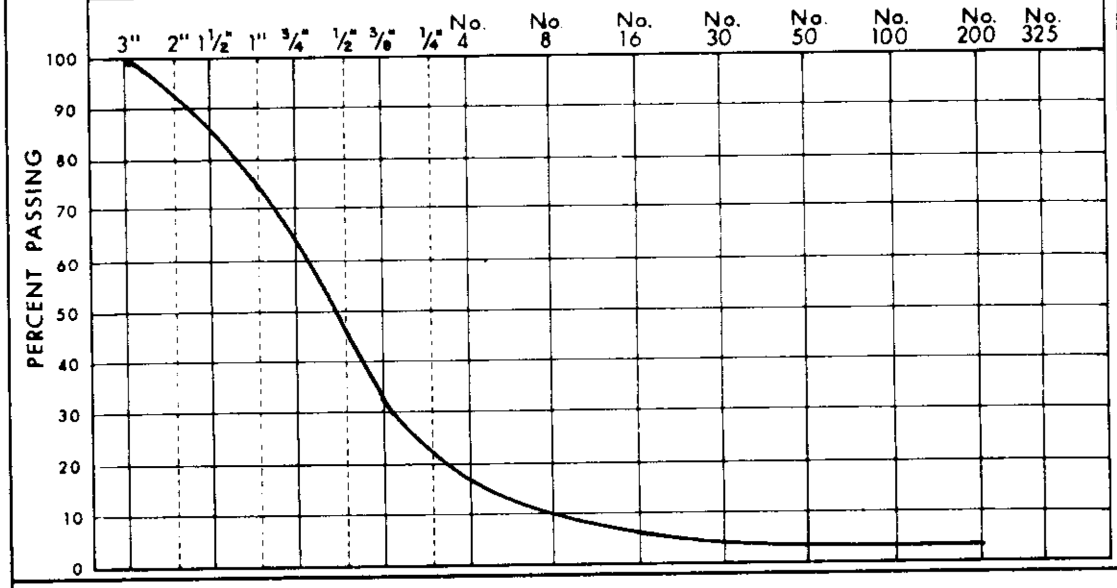
OVERSIZE (>3") = 0.0%

SAMPLE N75-117D-B11-2 DEPTH 1.0 - 7.0

DATE SAMPLED July 30, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 52

GRAVEL SIZES		SAND SIZES			FINES
38 %	46 %	7 %	5 %	2 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.8
1½"	85.2
1"	73.4
¾"	62.0
½"	45.3
⅜"	33.4
¼"	
No. 4	16.4
No. 8	9.7
No. 16	6.7
No. 30	4.7
No. 50	3.3
No 100	2.6
No. 200	2.3

COMMENTS

OVERSIZE (>3") = 5.1 %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117D-B11

PAGE
217

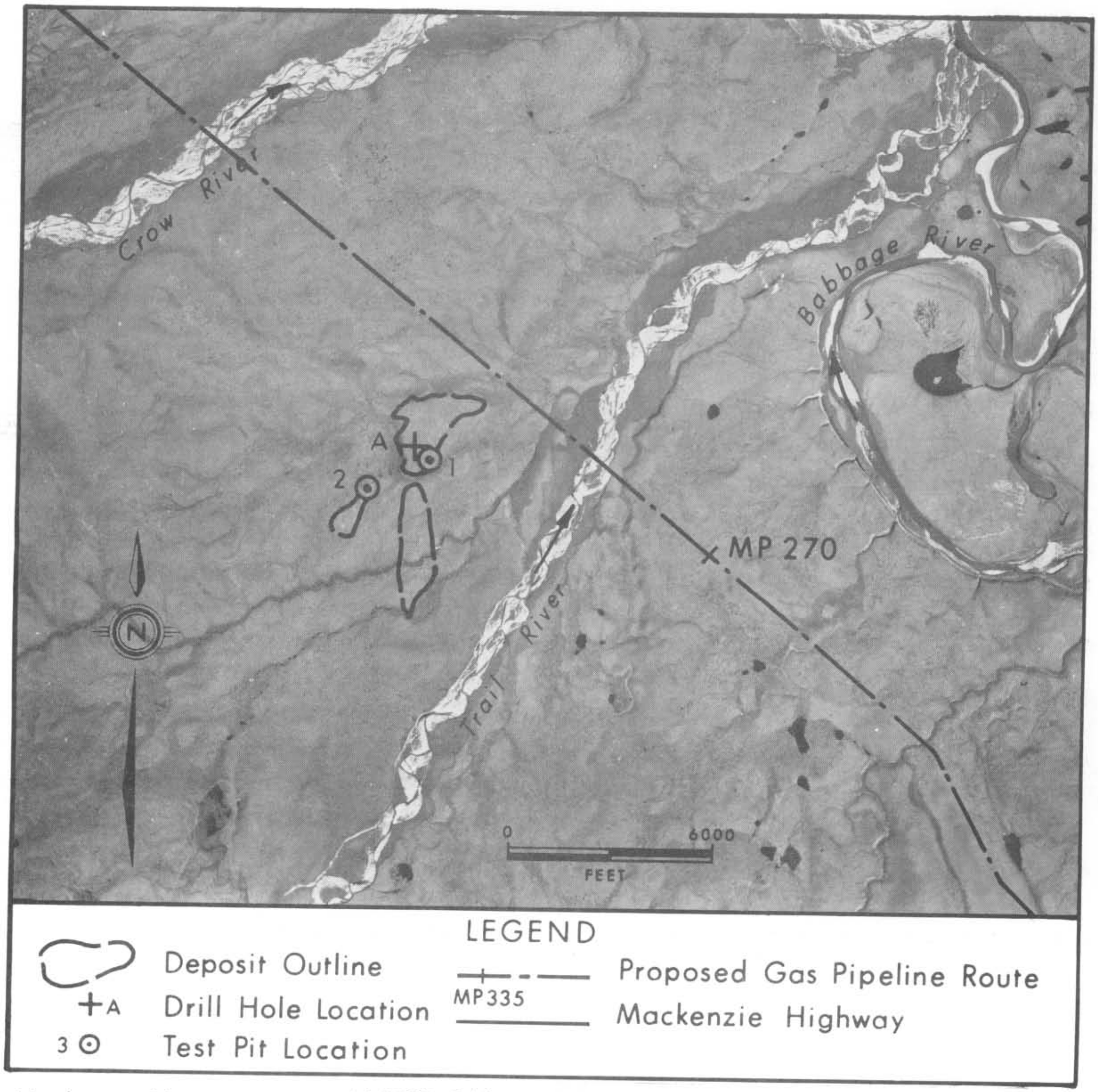
DEPOSIT 117D-B12

Physical Setting: Deposit 117D-B12 consists of three flat remnants of a glacial outwash plain and is located 4 miles southwest of the confluence of the Crow, Trail, and Babbage Rivers. Mile 268 of the proposed gas pipeline is less than ½ mile north of the deposit.

Material: Gravel; well graded, coarse to fine, some coarse, medium and fine sand, trace fines.

Volume: 6,500,000 cubic yards.

Assessment: Deposit 117D-B12 is a good source of granular material with good access to the pipeline. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and concrete and asphalt aggregate.



Airphoto No. A13383-148

Approximate Scale: 1" = 5250'

Latitude: 69° 05' N

Longitude: 138° 29' W

DEPOSIT 117D-B12

PHYSICAL SETTING

Deposit 117D-B12, located approximately 4 miles southwest of the confluence of the Crow, Trail, and Babbage Rivers, consists of three flat remnants of a glacial outwash plain. Mile 268 of the pipeline right of way is less than ½ mile north of the deposit.

These outwash remnants stand 5 to 20 feet above the surrounding terrain. They have broad flat surfaces and steep-sided slopes. A small creek, tributary to Trail River, flows through the southern section of the deposit. Drill hole data indicates that the outwash layer is more than 40 feet thick.

The deposit is well drained near its edges where there is negligable peat cover. The remainder of the deposit is moderately well to poorly drained and has from 2 to 8 feet of peat and ice-rich silt overlying the gravel. Ice-wedge polygons 10 to 30 feet in diameter are present in these areas. Ice contents in the soil are generally moderate, although some thin layers of ice are present. The active layer varies from 1 foot where overburden is present to more than 4 feet where gravel is exposed.

The terrain surrounding the deposit is marshy and poorly drained with small streams and extensive areas of ice-wedge polygons.

BIOLOGICAL SETTING

A patchy cover of sedge, moss, lichen and scrub willow exists on the edges of the deposit. The poorly drained central areas are covered by tundra dominated by sedge tussocks.

Some upland bird species nest in the area, snow geese occasionally feed in this area during staging, and Arctic ground squirrels den in dry slopes. The small stream crossing the southern part of the deposit has no suitable fish habitat.

MATERIALS

The outwash plain contains good quality granular material comprising stratified, medium dense, subrounded to rounded gravel with some fine to coarse sand, a few cobbles to 6 inches, and some silty sand layers up to 2 feet thick.

VOLUME

The deposit includes only parts of the outwash plain remnants with little overburden. Therefore, size and volume could be increased by including areas of outwash with thicker overburden.

The total area covered by the outwash remnants is approximately 160 acres, and the total volume, based on a depth of 40 feet and moderate ice contents, is 6,500,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B12 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Excavations would be kept away from stream channels that flow into the Trail River to prevent siltation. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate. The gravel would require further testing before being used in concrete production.

Access to the deposit with equipment could be achieved by barge to Phillips Bay and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

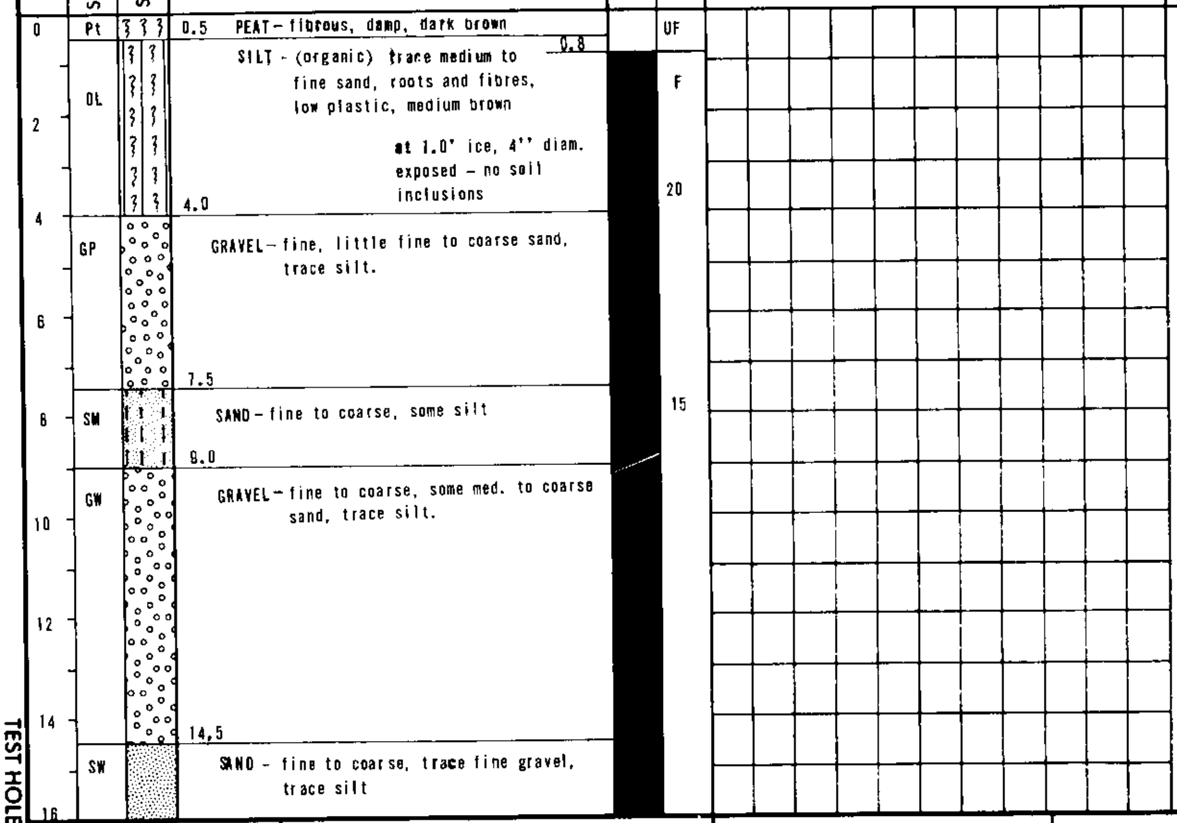
Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation. Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established over the area. This type of development could be accomplished by using blasting or conventional earthmoving techniques depending on the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations.

Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be carried out to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG



DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	DEPTH (FT.)	REMARKS
0	Pt	0.5 PEAT – fibrous, damp, dark brown	UF	0	14:00 4¼'' WALMAC (used)
		0.8			
2	OL	SILT – (organic) trace medium to fine sand, roots and fibres, low plastic, medium brown at 1.0' ice, 4'' diam. exposed – no soil inclusions	F 20		
4		4.0			
	GP	GRAVEL – fine, little fine to coarse sand, trace silt.			
6		7.5			
8	SM	SAND – fine to coarse, some silt	15		
		9.0		9	change 3 7/8'' Walmac
10	GW	GRAVEL – fine to coarse, some med. to coarse sand, trace silt.			
12					
14		14,5			
	SW	SAND – fine to coarse, trace fine gravel, trace silt			
16					

LABORATORY TEST DATA

▲ Dry density (pcf) ⊙ Water content %

Plastic limit ├──┤ Liquid limit

40	60	80	100	120	140 ▲
0	20	40	60	80	100 ⊙

OTHER TEST DATA

SAMPLE TYPE & No.

SAMPLE CONDITION

CORE RUN & % RECOVERY

CORE CONDITION

LOGGED BY: J.I.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: W.W.	LAT. & LONG: 69°05'01''N, 138°29'29'' W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 13383-147	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.:	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 30 M 07 Y 75 TIME: 14:00 FINISH: D 30 M 07 Y 75 TIME: 16:00

TEST HOLE No. N75-117D-B12-A

SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117D-B12-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	SW		**SAND** - fine to coarse, trace fine gravel, trace silt. 17.0 17.0		F								
	ICE		ICE - trace silt 18.0		ICE								
18	GP		**GRAVEL** - fine, trace silt -Vc around sand particles		Vx 30								
20													
			(21.0) coarse gravel content increasing										
22	GW												
24													
			25.0 little sand										
26					20								
			sand content decreasing										
28													
30			at 30', trace fine sand										Gradual increase in drilling resistance, decrease in sand content.
32													

LOGGED BY: J.J.S	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: W.W.	LAT. & LONG: $69^0 05'01''$N, $138^0 29'29''$ W	ELEVATION:		N75-117D-B12-A
DRWN. BY: A.N.	AIRPHOTO No.: A 13383-147	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP:		
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 3

START: D 30 M 07 Y 75 TIME: 14:00 FINISH: D 30 M 07 Y 75 TIME: 16:00

PC-9,SK373

TEST HOLE No. N75-117D-B12-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	GW		GRAVEL (cont'd)		Vx								
			(33.0)										
	GP		GRAVEL- clean, no sand.										
34			Ice inclusions-34 ice crystals 1/8'' diameter		30							34	15:00
36													
			37									37	Change to new 3 7/8'' Tricone,3 7/8'' Walmac worn out.
			37.6 boulder										
38			boulder										
			38.6										
40													
			41.0 End of hole									41	16:00 Bit jamming, cutting not returned.

LOGGED BY: J.I.S
CHKD: W.W.
DRWN BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°05'01''N, 138°29'29'' W
AIRPHOTO No.: A 13383-147
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP:

START: D 30 M 07 Y 75 TIME: 14:00
FINISH: D 30 M 07 Y 75 TIME: 16:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117D-B12-A

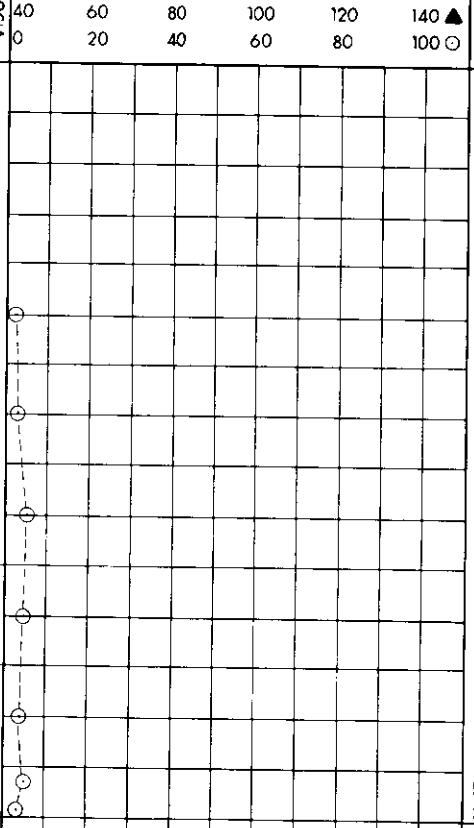
SHEET 3 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	REMARKS
0.5	Pt	PEAT - black, moist, fibrous		UF		Using shovels
2.6	GP	GRAVEL - fine, average size ½'', rounded to subrounded, some sand, coarse to fine, trace organics, brown, moist, numerous fibres, loose			MA, combined Samples 1 - 7 G = 60% S = 36% F = 4% (GW)	
3.4	GW	GRAVEL - coarse and fine, subrounded, some sand, coarse to medium, light brown, damp, dense				
4.0	GP	GRAVEL - fine, rounded, trace coarse sand, brown, moist, loose				
4.3		same as from 0.5' - 2.6'				
4.5		same as from 3.4' - 4.0'				
5.0	GW	GRAVEL - as 2.6' - 3.4'	5.0			Using jack-hammer
6.2	SM	SAND - fine, little silt, dark grey, moist	6.0	Nb		
7.5	GW	GRAVEL - fine, subrounded, and sand, coarse to fine, dark grey, very few isolated cobbles to 5''		Vx 5		
		Bottom of pit				

LABORATORY TEST DATA



SAMPLE TYPE & No.	w%
B1	2
B2	3
B3	5
B4	4
B5	3
B6	5
B7	3

SAMPLE CONDITION | CORE RUN & % RECOVERY | CORE CONDITION | DEPTH (FT.)

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 69°05'02''N, 138°29'10''W	ELEVATION:	
DRWN. BY: F.B.	AIRPHOTO No.: A 13383-147	PIPE MILEAGE:	
CHKD: D.D.	RIG:	AIR TEMP: 7°C	
	METHOD: TEST PIT		

START: D 30 M 07 Y 75 TIME: 17:50 FINISH: D 30 M 07 Y 75 TIME:

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B12-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.7	Pt		PEAT - dark brown, damp, fibrous		UF								Using shovels
1	GW		GRAVEL - coarse and fine, subrounded, some sand, coarse to fine, dark grey, damp, stratified, isolated cobbles to 6'', dense									1	Layers of gravel, coarse to fine, with trace coarse sand occur at: 1.2' - 1.7'; 2.0' - 2.3'; 3.2' - 3.9'; 4.6' - 4.9'; 5.6' - 6.0'
2							MA, combined samples 1 - 6 G = 72% S = 26% F = 2% GW oversize = 2.6%	B1	☒			2	
3								B2	☒			3	
4												4	
5			5.2					B3	☒			5	Using jack hammer
					Vx 5								
6								B4	☒			6	
								B5 B6	☒ ☒				
7.0			Bottom of pit									7	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: G.B.
CHKD: D.D.

FACILITY:
LAT. & LONG: 69°04'51''N, 138°30'18''W
AIRPHOTO No.: A 13383-147
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: Approx. 7°C

START: D 30 M 07 Y 75 **TIME:** 17:00 **FINISH:** D 30 M 07 Y 75 **TIME:** 21:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B12-2

SHEET 1 **OF** 1

PC-9,SK373

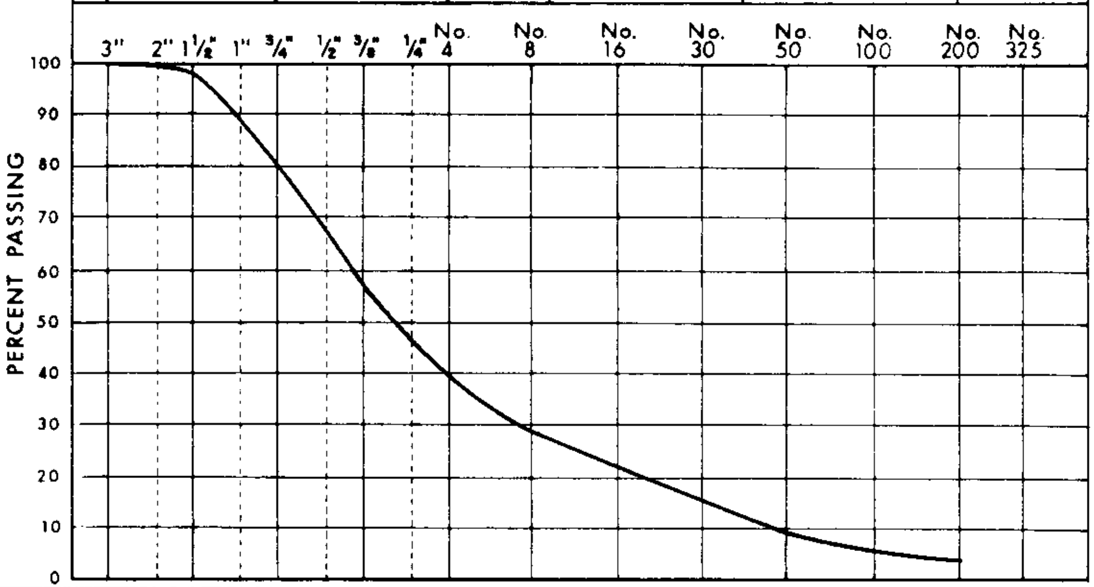
TEST HOLE No. N75-117D-B12-2

SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B12-1 DEPTH 2.0-7.5
DATE SAMPLED July 30, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 66

GRAVEL SIZES		SAND SIZES			FINES
19 %	41 %	12 %	14 %	10 %	4 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	98.8
1"	89.0
¾"	81.0
½"	67.6
⅜"	56.3
¼"	
No. 4	39.5
No. 8	28.8
No. 16	22.5
No. 30	17.0
No. 50	9.1
No. 100	5.5
No. 200	3.9

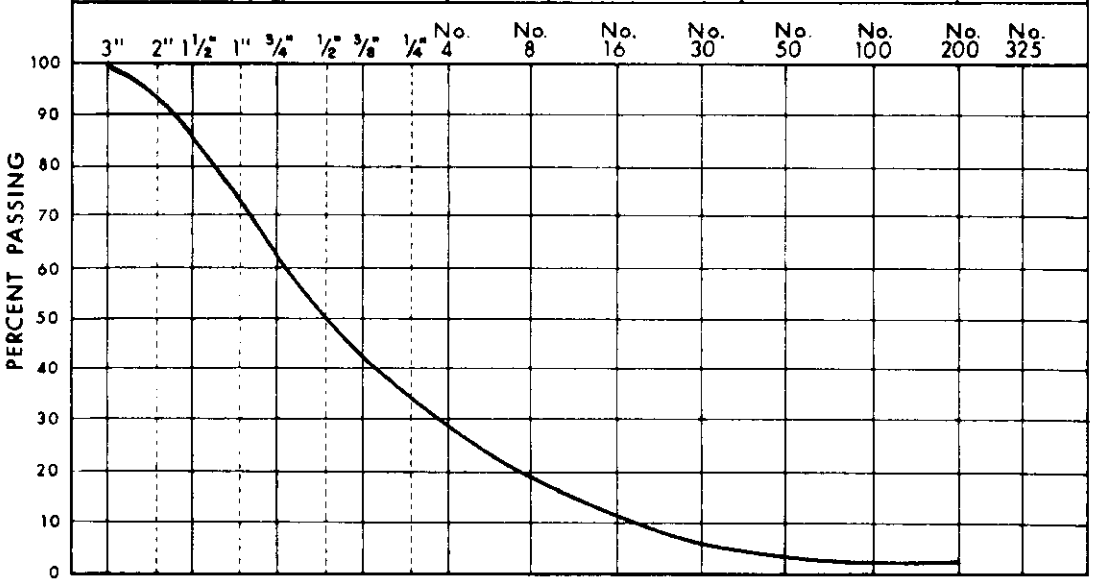
COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE N75-117D-B12-2 DEPTH 0.0 - 7.0
DATE SAMPLED July 30, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 3

GRAVEL SIZES		SAND SIZES			FINES
36 %	36 %	10 %	13 %	3 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	94.7
1½"	86.1
1"	73.2
¾"	63.6
½"	51.2
⅜"	41.4
¼"	
No. 4	27.7
No. 8	19.1
No. 16	12.5
No. 30	6.3
No. 50	3.0
No. 100	2.4
No. 200	2.1

COMMENTS

OVERSIZE (>3") = 2.6%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services
Company Limited

DEPOSIT No.
N75-117D-B12

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-117D-B12-2
DATE SAMPLED : July 30, 1975
SAMPLED BY : NESCL
DEPTH (FT.) : 1 - 7
DATE TESTED : December, 1975
TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 1.23 %
FINE AGGREGATE : LOSS = 8.72 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 22.8 %

ORGANIC IMPURITIES TEST

NUMBER : 2
COAL REMOVED : nil
COAL & ROOTLETS REMOVED : nil
COAL CONTENT : nil
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Strong to very strong, Good	30.0
Sandstone		15.6
Gneiss		0.4
Granite		2.4
Siltstone	Medium strong, Good	7.5
Carbonates	Weak, Porous, Fair	10.5
Sandstone	Weak, Friable, Fair	1.2
Flint	Potentially reactive, Fair	2.7
Chert		2.6
Sand Clusters	Very weak, Soft, Poor	0.1
PN = 147	INTERPRETATION : Poor to very poor	73.0

COMMENTS :

NORTHERN Engineering Services Company Limited

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

DEPOSIT No. N75-117D-B12

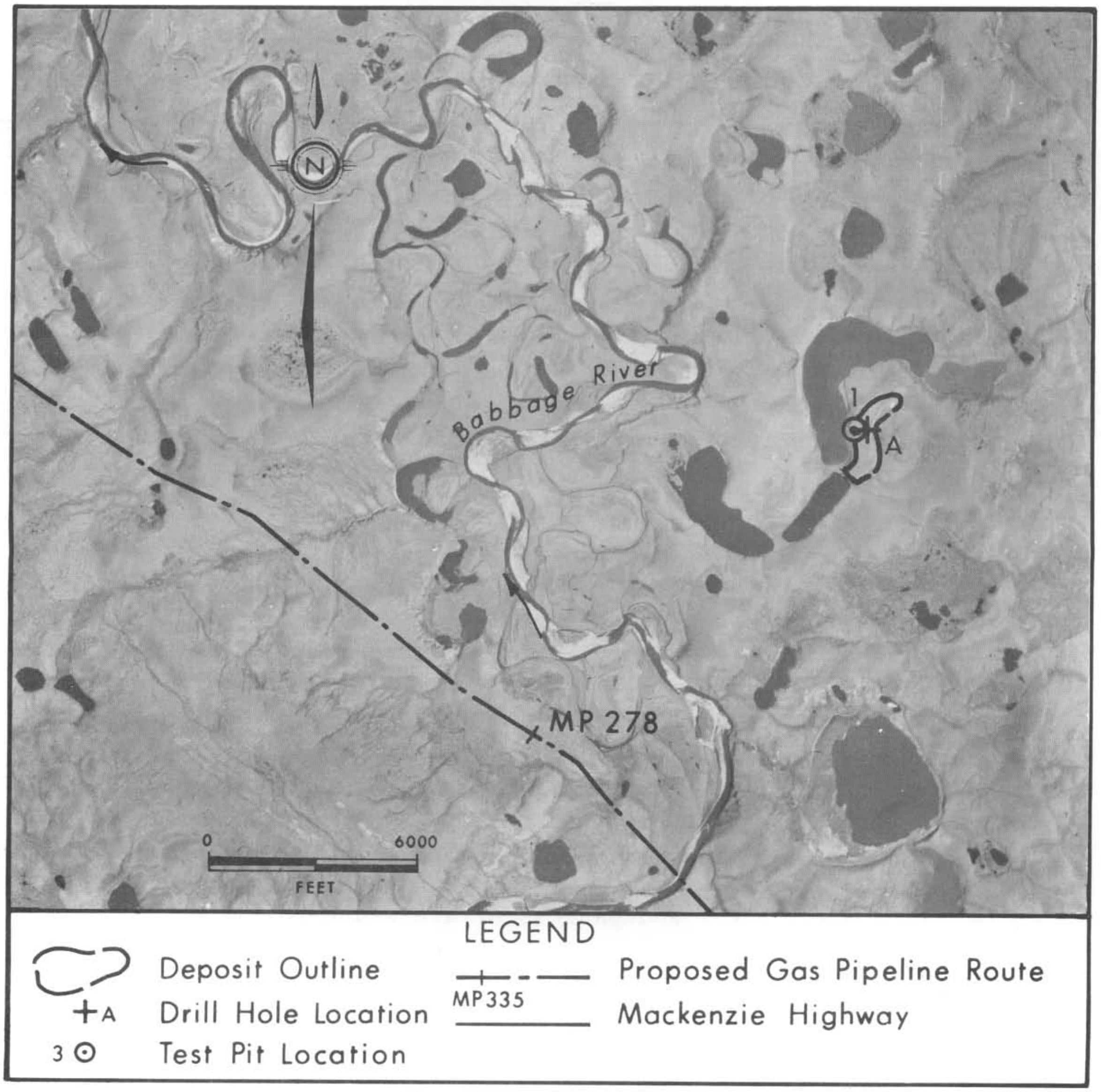
DEPOSIT 117D-B13

Physical Setting: Deposit 117D-B13 is a glaciofluvial terrace 2 miles east of the Babbage River and 6 miles south of King Point. The deposit is located 3 miles north of mile 280 of the proposed gas pipeline.

Material: Gravel; well graded, coarse to fine, some coarse, medium, and fine sand.

Volume: 1,100,000 cubic yards.

Assessment: Deposit 117D-B13 is a good source of granular material but the available volume may be limited by drainage and overburden thickness. Haul distances exceed 3 miles to the proposed pipeline right of way. Material is suitable for general fill, backfill in pipeline construction, and subgrade material for building pads.



Airphoto No. A14406-45
Approximate Scale: 1" = 5250'

Latitude: 69° 02' N
Longitude: 138° 06' W

DEPOSIT 117D-B13

PHYSICAL SETTING

Deposit 117D-B13 is a glaciofluvial terrace 2 miles east of Babbage River, and about 6 miles south of King Point. Mile 280 of the proposed pipeline is 3 miles south of the deposit.

The terrace, which is approximately 2500 feet long and 1000 feet wide, stands 70 feet above a glacial meltwater channel to the west. This channel was formed subsequent to the deposition of outwash in the terrace. On the east, the deposit is bounded by a drained lake basin.

The outwash (gravel) is about 10 feet thick and overlies 15 to 20 feet of sand. Silt underlies the sand. The ice content in the gravel is low, but massive ice layers are present in the sand and silt.

The edges of the terrace are well drained, and gravel is exposed in patches. Peat cover is sparse within 20 yards of the banks, but may reach depths of 4 feet on imperfectly drained parts of the terrace.

The Babbage River floodplain lies between the deposit and the pipeline route. This floodplain zone is a mile or more in width and contains many oxbow lakes, meander scars, abandoned stream channels and terraces as well as the present river channel. Beyond the floodplain, the terrain is dotted with small lakes and patches of ice-wedge polygons.

BIOLOGICAL SETTING

Tundra vegetation composed primarily of sedge tussocks and mosses, with some dwarf birch and willow, covers most of the terrace. Some patches of vegetation consisting mainly of mosses and lichens are present along the well drained edge of the terrace.

The meltwater lake and adjacent terrace provide good summer habitat for waterfowl and some upland bird species. The lake does not provide suitable habitat for fish.

MATERIALS

The outwash consists of subrounded, stratified, well graded gravel and sand with isolated cobbles and a trace of silt in some strata. This overlies well graded, fine to coarse sand with some fine gravel. The gravel is good quality granular material suitable for most construction purposes, and the sand is fair quality material suitable for general fill.

VOLUME

The area of the terrace is about 45 acres. The volume of the gravel, based on an average depth of 10 feet and moderate ice contents, is about 500,000 cubic yards. The total volume of sand, based on a stratum thickness of 15 feet and moderate ice content, is about 600,000 cubic yards.

Only one hole was drilled at this site. Further drilling is required to verify the depth of gravel, and to locate massive ice layers in the sand.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B13 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Excavations would be kept away from the nearby lake to prevent siltation. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to King Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. Access to the pipeline right of way is only fair because rolling terrain and the Babbage River would have to be crossed. Also haul distances in excess of 3 miles would be required.

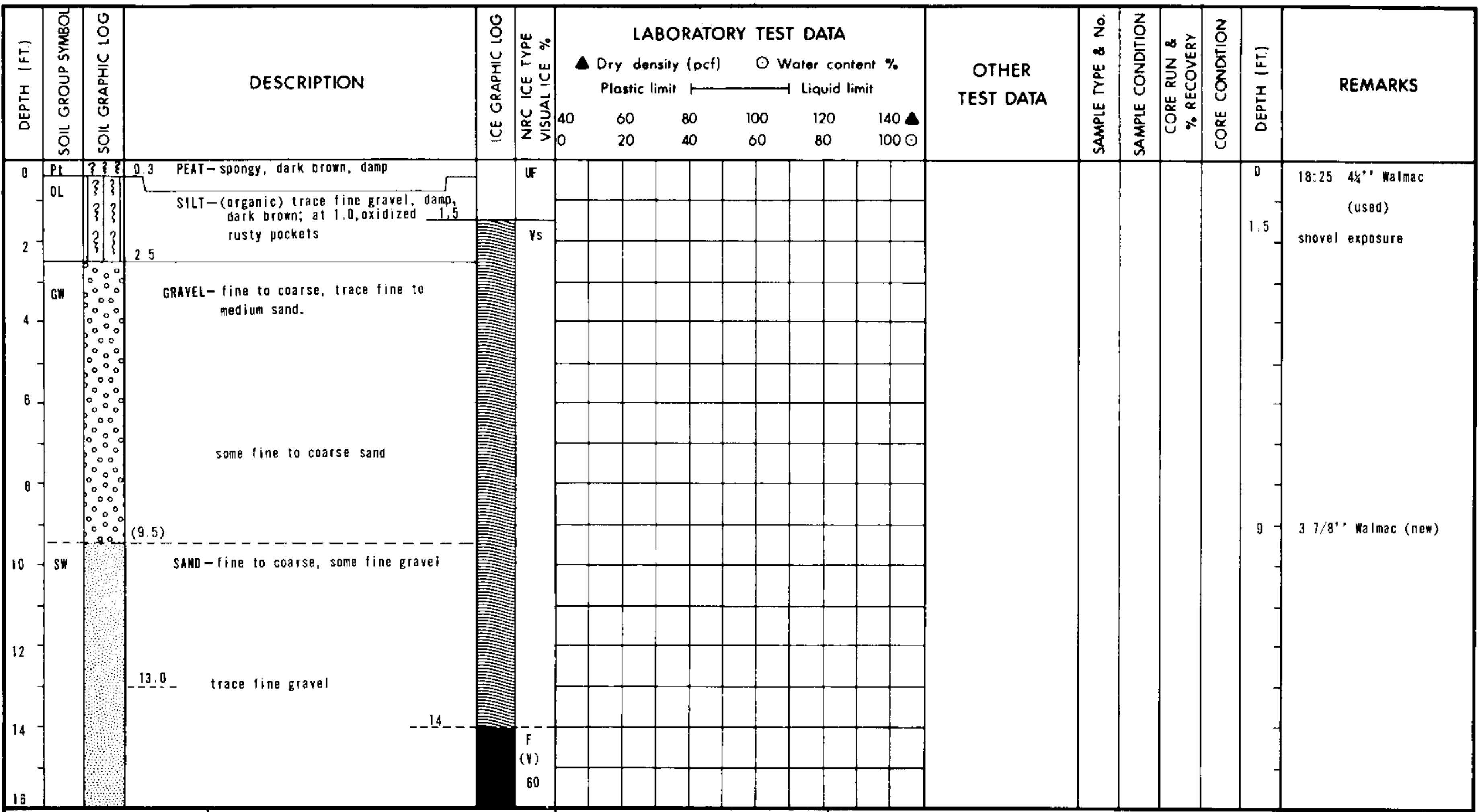
Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation away from the terrace edge adjacent to the lake.

Development would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by using blasting or conventional earthmoving techniques depending on the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be carried out to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG



0.3 PEAT—spongy, dark brown, damp

SILT—(organic) trace fine gravel, damp, dark brown; at 1.0, oxidized rusty pockets 1.5

2.5

GRAVEL—fine to coarse, trace fine to medium sand.

some fine to coarse sand

(9.5)

SAND—fine to coarse, some fine gravel

13.0 trace fine gravel

14

18:25 4¼'' Walmac (used)

shovel exposure

3 7/8'' Walmac (new)

LOGGED BY: J.J.S
CHKD: W.W.
DRWN. BY: J.B
CHKD: D.D.

FACILITY:
LAT. & LONG: 69°02'08''N, 138°05'57'' W
AIRPHOTO No.: A 14406-46
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 6°C

START: D 30 M 07 Y 75 TIME: 18:25
FINISH: D 30 M 07 Y 75 TIME: 19:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B13-A
SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117D-B13-A

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % — Plastic limit ├──┤ Liquid limit — 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	SW				F								
18			18.0 some coarse gravel										
20													
22			22.0 trace silt with fine sand										
24													
26													
			27.0 27.0										
28	ICE		ICE, clear		ICE								
			29.0 29.0										
30	CH		CLAY – silty, trace fine sand, high plastic, dark grey		F 60								
32													

LOGGED BY:	J.J.S	FACILITY:		PROJECT:	13011
CHKD:	W.W.	LAT. & LONG:	69°02'00''N, 138°05'57'' W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A 14406-46	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI-DRILL	AIR TEMP.:	6°C
		METHOD:	AIR		

START: D 30 M 07 Y 75 TIME: 18:25 FINISH: D 30 M 07 Y 75 TIME: 19:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117D-B13-A

SHEET 2 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	CH	▨	CLAY (cont'd)	■	F								
34		▨		■	60								
36		▨		■									
38		▨		■								38	18:55
40		▨		■									
42		▨		■									
44		▨		■									
46		▨	46.0 46.0	■									
	ICE		ICE, clear 47.0 47.0	■	ICE								
48	CH	▨	CLAY 48.0 End of hole	■	F							48	19:00

LOGGED BY: J.J.S
CHKD: W.W.
DRWN. BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 69°02'00"N, 138°05'57" W
AIRPHOTO No.: A 14406-46
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 6°C

START: D 30 M 07 Y 75 TIME: 18:25
FINISH: D 30 M 07 Y 75 TIME: 19:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117D-B13-A

SHEET 3 OF 3

PC-9,5K373

TEST HOLE No. N75-117D-B13-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL - fine to coarse, subrounded, and sand, coarse to medium, trace organics to depth 2.5', moist, stratified, very few isolated cobbles to 4'', numerous fibres to depth 3.0'.		UF								Using shovels
1							MA, combined samples 1 - 7 G = 53% S = 42% F = 5% Oversize = 4.7% (GW)					1	
2													
3													
4			3.9 — — layer of fine to medium sand, with 4.2 — — trace silt to depth 4.2'.					B 1 - 7					
5													
			5.5		Vx 10								Using jack-hammer
6													
7												7	
8			8.0 Bottom of pit									8	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 130 11	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 69°02' 01" N, 138°06' 10"W	ELEVATION:		
DRWN. BY: G.C.B.	AIRPHOTO No.: A 14406-45	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-117D-B13-1
CHKD: D.O.	RIG:	AIR TEMP.: 4°C		
	METHOD: TEST PIT			
START: D 30 M 07 Y 75 TIME: 23:00	FINISH: D 31 M 07 Y 75 TIME: 02:55		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

PC-9,SK373

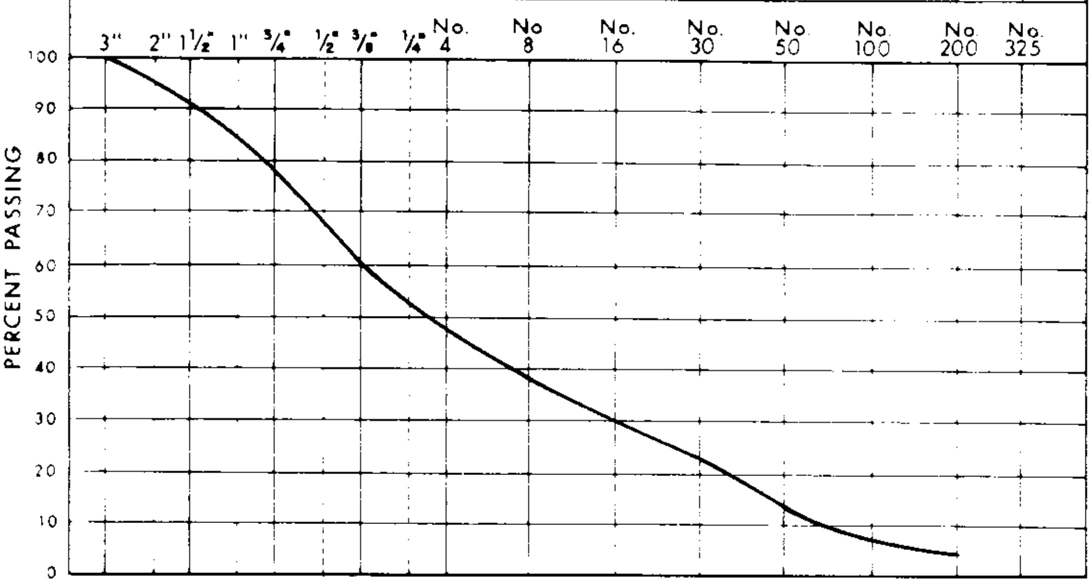
SIEVE ANALYSIS REPORT

SAMPLE N75-117D-B13-1 DEPTH 1.0 - 7.5

DATE SAMPLED July 30, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 110

GRAVEL SIZES		SAND SIZES			FINES
24 %	29 %	10 %	18 %	14 %	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	95.9
1½"	91.6
1"	83.6
¾"	76.4
½"	67.2
⅜"	59.9
¼"	
No. 4	47.2
No. 8	38.0
No. 16	30.0
No. 30	21.9
No. 50	12.7
No 100	6.7
No. 200	4.6

COMMENTS

OVERSIZE (>3") = 4.7%

SAMPLE

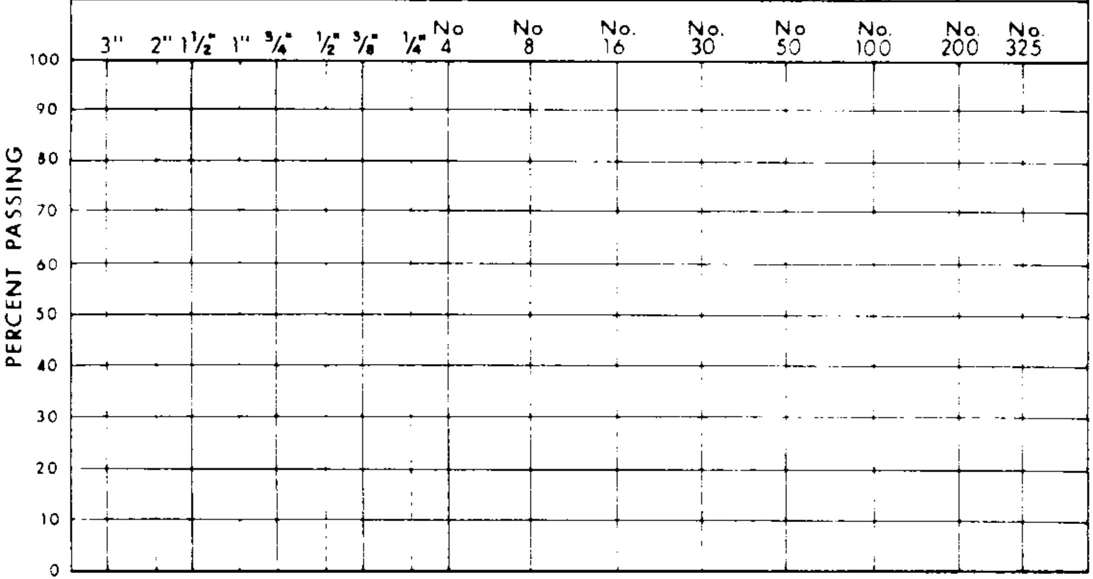
DEPTH

DATE SAMPLED

SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No 16	
No. 30	
No 50	
No.100	
No 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117D-B13

PAGE
240

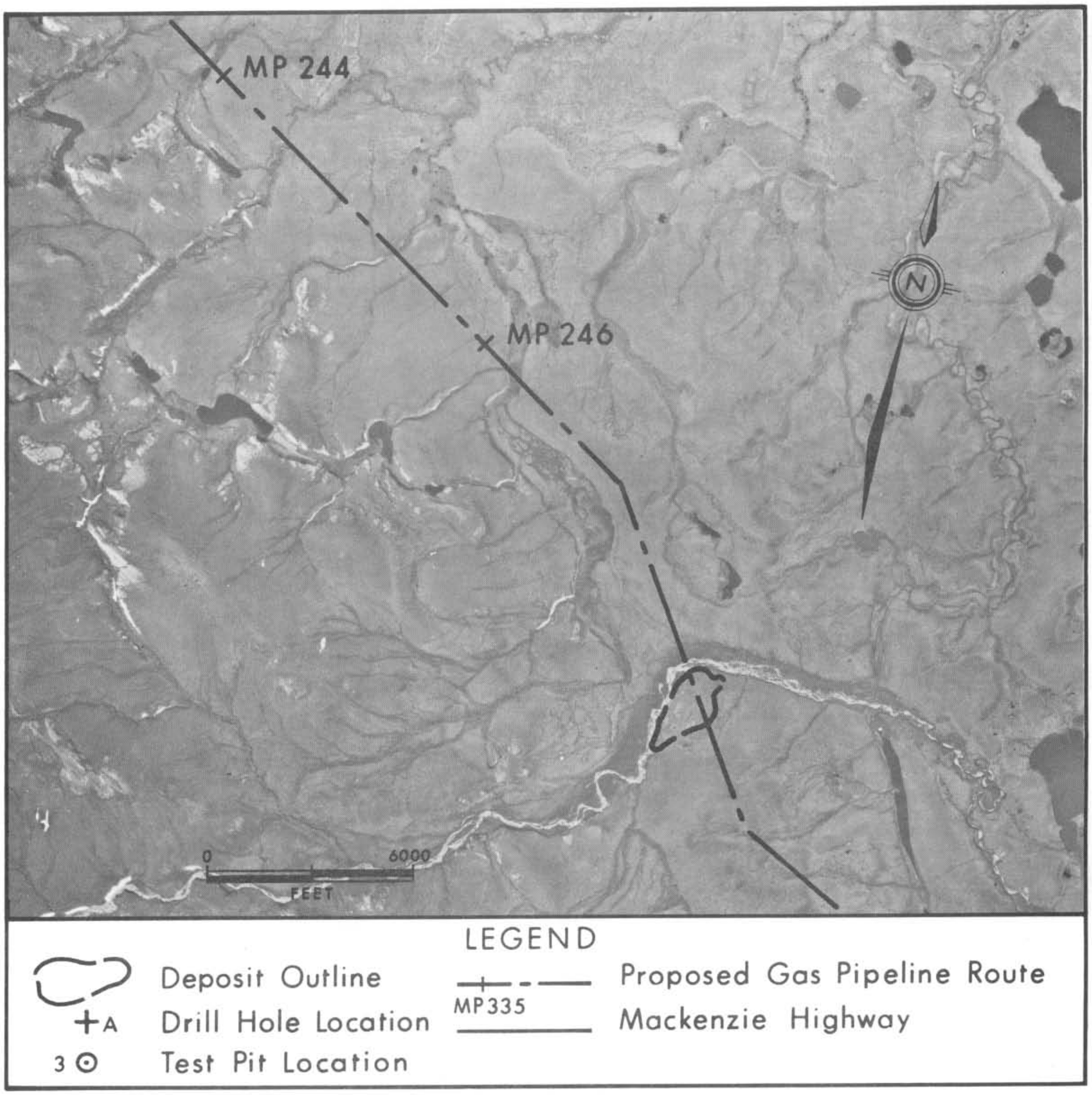
DEPOSIT 117D-B14

Physical Setting: Deposit 117D-B14 is located on the southeast bank of a tributary to Spring River about 10 miles southwest of Stokes Point. The pipeline right of way crosses the deposit at mile 240.

Material: Well graded gravel.

Volume: 3,000,000 cubic yards.

Assessment: Deposit 117D-B14 is a good source of granular material and the proposed gas pipeline crosses the deposit. Granular material from this deposit would need further testing to decide its application to pipeline construction.



Airphoto No. A14361-99
Approximate Scale: 1" = 5250'

Latitude: 69° 16' N
Longitude: 139° 06' W

DEPOSIT 117D-B14

PHYSICAL SETTING

Deposit 117D-B14 is located on the southeast bank of a tributary of Spring River, about 10 miles southwest of Stokes Point. The pipeline right of way crosses the deposit at mile 249.

This deposit is a remnant of a large kame delta. The present stream has incised itself 30 feet below the level of the kame delta. The surface of this deposit is moderately well to well drained with overburden consisting of ice-rich peat and silt ranging from 0 to 2 feet. Patches of overburden up to 10 feet thick may be present. Generally, the ice content of this deposit is low, except where ice wedges are present.

BIOLOGICAL SETTING

This site was not inspected during the program from an environmental viewpoint. Most of it is covered by tundra vegetation dominated by sedges.

The stream is a major spawning and rearing area for grayling. It is also utilized by arctic char and ninespined stickleback during the summer but is frozen during winter.

MATERIAL

The outwash in this deposit consists of stratified, well graded gravel containing abundant cobbles and boulders.

VOLUME

This deposit has an area of 64 acres and an estimated volume of 3,000,000 cubic yards based on a thickness of 30 feet, which is exposed in the stream bank.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B14 is a good source of granular materials. Location of areas to be exploited would be dictated by haul distances, overburden thicknesses, insitu material quality, and material requirements. The gravel would require further testing before being used in pipeline construction.

Access to the deposit with equipment could be achieved by barge to Stokes Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by using blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

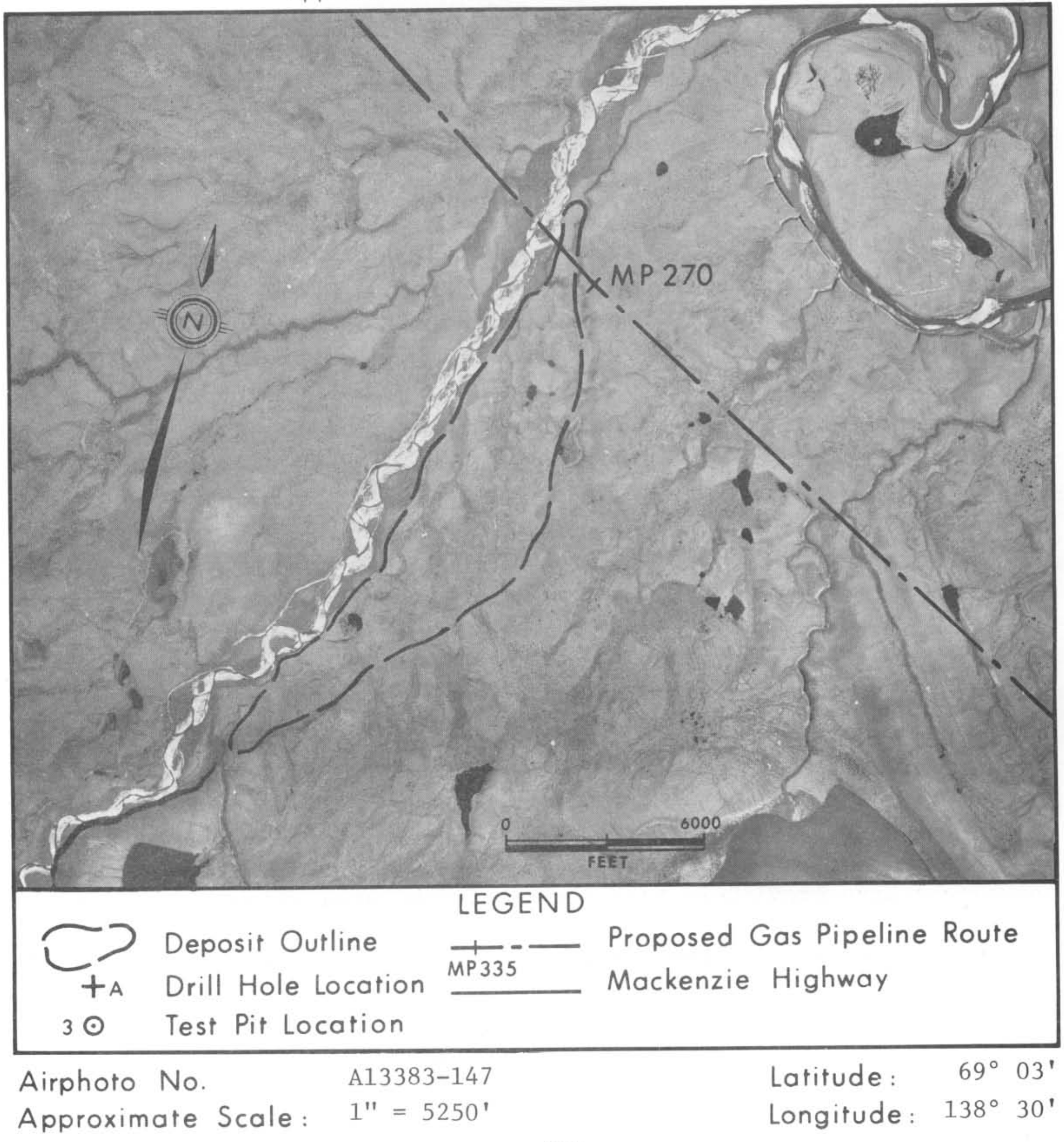
DEPOSIT 117D-B15

Physical Setting: Deposit 117D-B15 is east of Trail River, about 4 miles from its confluence with the Babbage River. The proposed gas pipeline route crosses the northern end of the deposit at mile 270.

Material: Well graded gravel.

Volume: 17,000,000 cubic yards.

Assessment: Deposit 117D-B15 is a good source of granular material but the available volume may be limited by drainage and overburden thickness. Haul distance along the proposed gas pipeline right of way is short as the deposits northern tip is actually crossed by the pipeline. Granular material from the deposit requires testing to decide its application to pipeline construction.



Airphoto No. A13383-147
Approximate Scale: 1" = 5250'
Latitude: 69° 03' N
Longitude: 138° 30' W

DEPOSIT 117D-B15

PHYSICAL SETTING

Deposit 117D-B15 lies on the east side of the Trail River, about 4 miles above its confluence with the Babbage River. The proposed pipeline right of way crosses the northern tip of the deposit at mile 269.5.

Deposit 117D-B15 is a series of fluvial terraces that stand 5 to 20 feet above the level of Trail River floodplain. The terraces slope gently north, paralleling Trail River, and are poorly drained, with a few ponds and small pools developed along ice-wedge polygons. Ice contents can be expected to be low in the gravel, although ice wedges will be common, as indicated by ice-wedge polygons developed on the terrace. Overburden consisting of ice-rich peat and organic silt probably ranges between 2 and 10 feet over most of the terrace. Areas of thin overburden are concentrated adjacent to Trail River floodplain.

BIOLOGICAL SETTING

Most of the deposit is covered by tundra vegetation composed of sedge tussocks with isolated willows.

The deposit may be grazed by caribou. The adjacent Trail River floodplain provides habitat for moose, caribou, wolf, and a number of birds. Snow geese have previously been sighted in the area and could be expected to use the area again. The Trail River is a major spawning area for grayling.

MATERIAL

Gravel in this terrace is probably stratified, relatively clean, and well graded.

VOLUME

Deposit 117D-B15 covers an area of 1080 acres, and contains a volume of 17,000,000 cubic yards based on a thickness of 10 feet. Thicknesses of other fluvial terrace gravels in the region indicate that 10 feet is a conservative estimate.

DEVELOPMENT AND REHABILITATION

Deposit 117D-B15 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, overburden thicknesses, insitu material quality, and material requirements. The gravel in this deposit would require testing before being used for any purpose.

Access to the deposit with equipment could be achieved by barge to Phillip Bay and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by using blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions may also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates. e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

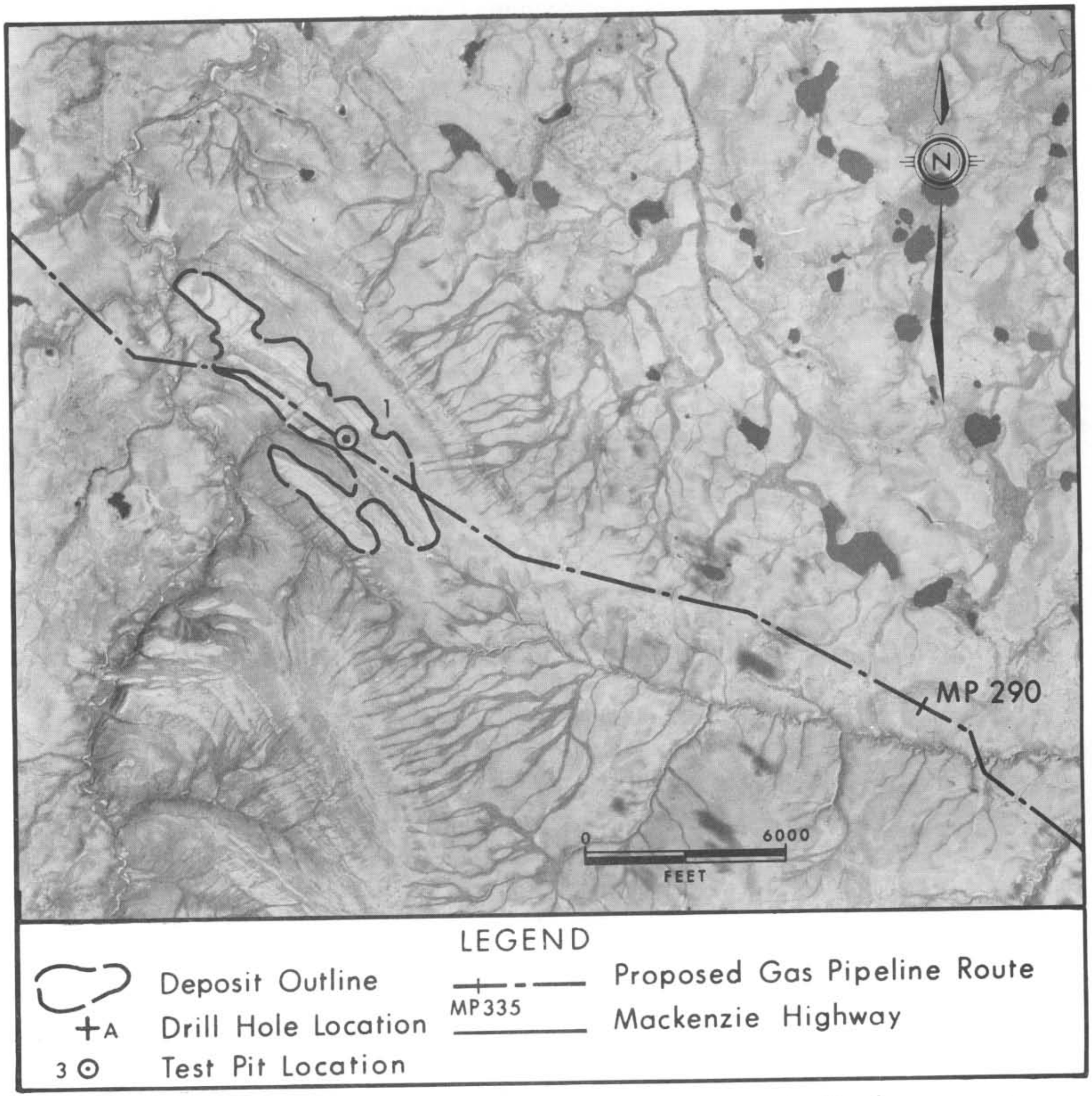
DEPOSIT 117A-B1

Physical Setting: Deposit 117A-B1 is weathered sandstone in an upland area west of Conglomerate Creek, about 10 miles southwest of Sabine Point at mile 286 of the proposed gas pipeline.

Material: Gravel; well graded, fine to coarse, with a trace of sand.

Volume: 2,500,000 cubic yards.

Assessment: Deposit 117A-B1 is a good source of granular material and the proposed gas pipeline crosses the deposit at MP286. Granular material from this deposit could be used for general fill, backfill in pipeline construction, and building pads.



Airphoto No. A14363-47
Approximate Scale: 1" = 5250'

Latitude: 68° 56' N
Longitude: 137° 56' W

DEPOSIT 117A-B1

PHYSICAL SETTING

Deposit 117A-B1 is weathered sandstone in an upland area west of Conglomerate Creek about 10 miles southwest of Sabine Point. Mile 286 of the proposed pipeline route is in the centre of the deposit.

A disintegrated and weathered layer of sandstone overlies more competent sandstone which dips steeply to the southwest. The exposed area of disintegrated rock has a smooth, rounded, gently sloping surface, with steeper side slopes to the north and west. The deposit is free of overburden, and is well-drained. The active layer is 3 to 4 feet deep, and the ice content is very low. The terrain to the north, east, and west of the deposit is rolling moraine with many small creeks and lakes, and occasional patches of ice-wedge polygons.

BIOLOGICAL SETTING

Patches of sedge and moss occur in sheltered areas on the bedrock. Willows up to 4 feet high are present along stream channels and in protected depressions. The area is not environmentally sensitive as it has no suitable fish habitat nearby, and is only occasionally visited by upland bird species.

MATERIALS

The weathered bedrock layer contains fair quality granular material consisting of angular, platy, gravel-sized sandstone fragments with a trace of fine sand with frequent platy fragments to 14 inches in length. The material is dry and dense.

VOLUME

The weathered part of the outcrop covers about 420 acres. The total volume is about 2,500,000 cubic yards based on an average depth of 4 feet.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B1 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Excavations would take place on high ground where no streams are present. Granular material from this deposit could be used for general fill, backfill in pipeline construction, and building pads. The gravel would require further testing before being considered for concrete production.

Access to the deposit with equipment could be achieved by barge to King Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. The deposit is on the proposed pipeline right of way and haul distances would be short.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be maintained over the deposit. Alternatively, dugout pit development could be established by blasting. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, and concrete and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The pit area and haul road would be inspected for any damage to the environment, and remedial measures would be effected before the site was abandoned.

TEST HOLE No. N75-117A-B1-1

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL - mainly coarse, angular, (trace sand), light brown, dry, frequent cobbles to 6'', isolated rock fragments to 14"; 1" thick, dense, clean		UF								Using pick-axe and shovels
1												1	
2							MA, G = 95% S = 3% F = 2% GW	B1	☒			2	rock fragments increase with depth
3												3	Bedrock
			3.5 Bottom of pit				Cu = 5.5 Cc = 1.2						

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 68°56'05''N, 137°56'29''W	ELEVATION:	
DRWN. BY: G.B.	AIRPHOTO No.: A 14406-57, 118	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP.: 7°C	CANADIAN ARCTIC GAS STUDY LIMITED
	METHOD: TEST PIT		

START: D 30 M 07 Y 75 TIME: 23:00 FINISH: D 30 M 07 Y 75 TIME: 24:00

TEST HOLE No. N75-117A-B1-1

SHEET 1 OF 1

PC-9,SK373

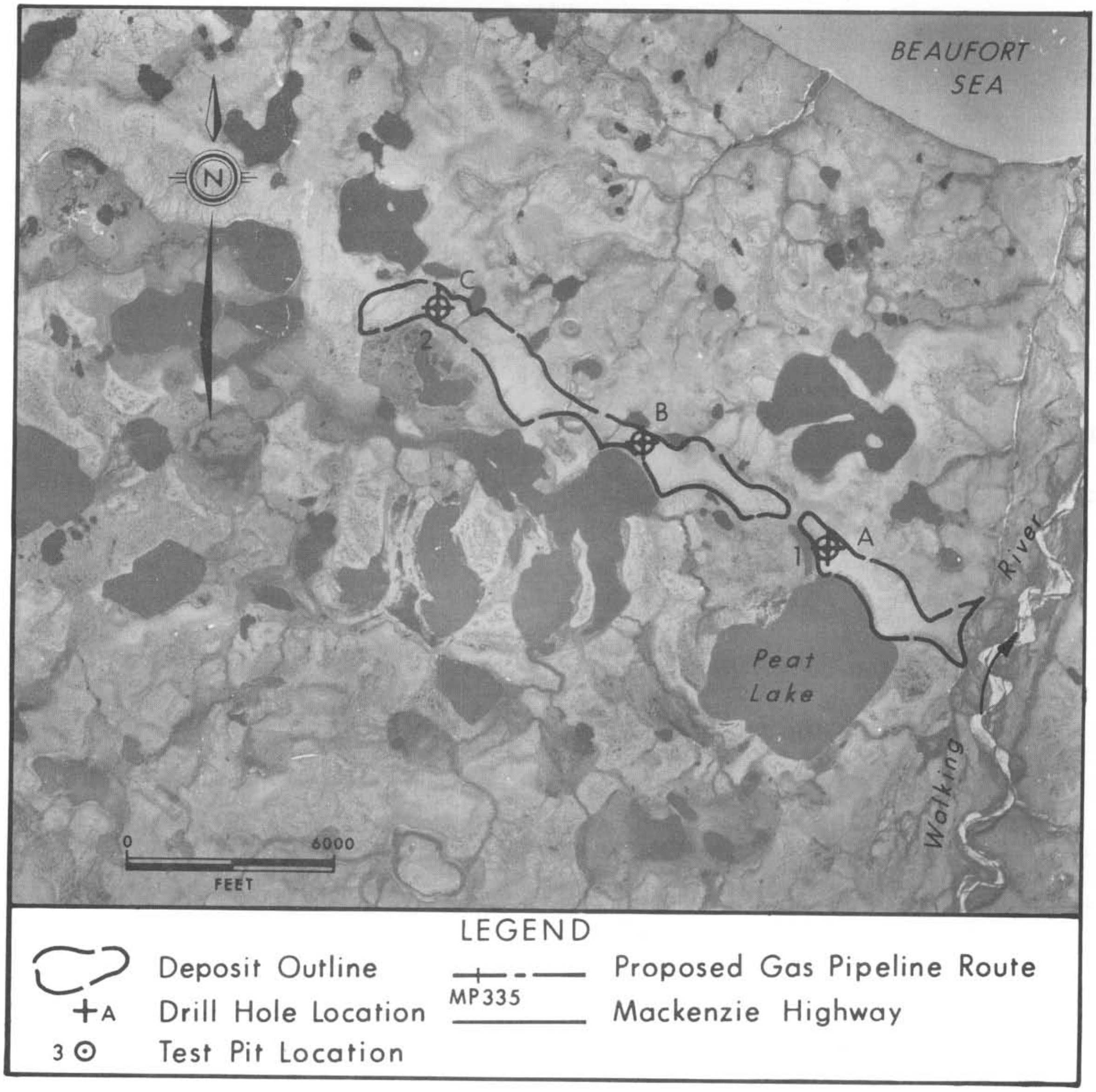
DEPOSIT 117A-B2

Physical Setting: Deposit 117A-B2 is the terraced remnant of coalescing outwash fans on the west side of Walking River 4 miles south of Shingle Point and 6 miles north of mile 300 on the proposed gas pipeline route.

Material: Gravel; fine to coarse, and coarse, medium, and fine sand, trace fines.

Volume: 12,000,000 cubic yards.

Assessment: Deposit 117A-B2 is a good source of granular material but the available volume may be limited by drainage and overburden thickness. Haul distance from the deposit to the proposed gas pipeline right of way exceeds 6 miles. Material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate.



Airphoto No. A13751-37

Approximate Scale: 1" = 5250'

Latitude: 68° 56' N

Longitude: 137° 10' W

DEPOSIT 117A-B2

PHYSICAL SETTING

Deposit 117A-B2 is the terraced remnant of coalescing outwash fans on the west side of Walking River 4 miles south of Shingle Point, and 6 miles north of mile 300 of the proposed pipeline route.

The terrace is approximately 2000 feet wide and 4 miles long and parallels the coastline. The southeast end of the terrace borders on the Walking River. The inland side of this deposit is a steeply sloping bank, 70 to 100 feet high, whereas the coastward edge ends in a 20 - to 30-foot bank. The surface of the outwash slopes gently to the south except for small knobs of gravel.

The periphery of the terrace is moderately well drained, and is covered by less than 1 foot of peat. The remainder of the deposit is imperfectly drained, and much of it has a 5 - to 10-foot cover of ice-rich peat and silt.

The outwash material overlies a sequence of preglacial fluvial sediments ranging from silt to gravel. Layers of massive ice are present in some of these materials. The deposit appears to have low to moderate ice contents. Drill hole C, which encountered only clay and silt, is situated on a local pond deposit within the terrace. The thickness of the soil types may vary considerably.

The terrain surrounding the terrace is very marshy with numerous lakes and extensive areas of ice-wedge polygons.

BIOLOGICAL SETTING

The top of the terrace is covered primarily with sedge tussocks, mosses and lichens. The slopes support some dwarf birch and willow.

Nearby lakes are used by swans, geese, and other waterfowl for nesting and feeding during the summer. These lakes are too shallow to support overwintering fish other than ninespine stickleback. Peat lake has a mean depth of 1.1 m and probably freezes to the bottom in winter.

MATERIALS

The deposit is mainly stratified, subrounded dense gravel and sand, and varies from clean well graded gravel in some places to silty fine grained sand in other areas.

The well graded gravel is good quality granular material, and the silty sand is fair quality material.

Further drilling is required to delineate the extent of the various material types.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B2 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, overburden thicknesses, insitu material quality, and material requirements. Excavations would be kept away from lakes in the area to protect them from siltation. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

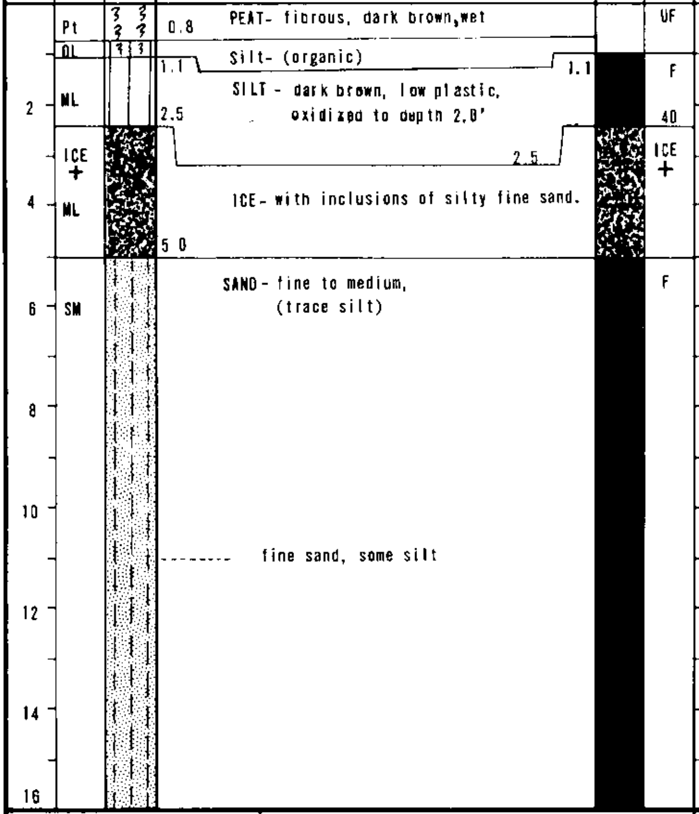
Initially the peat cover and overburden would be stripped from the borrow area and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG



DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt	0.8 PEAT- fibrous, dark brown,wet	UF								3 7/8'' Walmac
	OL	Silt- (organic) 1.1 1.1									
2	ML	SILT - dark brown, low plastic, oxidized to depth 2.0' 2.5	F 40								
	ICE +	2.5	ICE +								
4	ML	ICE- with inclusions of silty fine sand. 5 0									
6	SM	SAND- fine to medium, (trace silt)	F								
8										8	01:55
10		fine sand, some silt									
12											
14											
16										16	

LOGGED BY: J.I.S	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°57'11''N, 137°13'04''W	ELEVATION:	
DRWN. BY: R.H.	AIRPHOTO No.: A 13751-37	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.: Approx. 4°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 31 M 07 Y 75 **TIME:** 01:50 **FINISH:** D 31 M 07 Y 75 **TIME:** 02:10

TEST HOLE No. N75-117A-B2-A

SHEET 1 **OF** 3

PC-9,SK373

TEST HOLE No. N75-117A-B2-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	SM		SAND (cont'd)		F							16	
18												18	01:57 01:59
20			trace coarse sand		70 85								
22													
24	GP		24.0 GRAVEL- coarse, trace fine sand, pebbles occ. to 1''		10 15							24	Ice crystals and inclusions
26													
28			28.0 fine gravel (to ¾'') coarse sand. 29.0										
30	ML		SILT- clayey, trace fine gravel, high plastic, dark grey 31.0 31.0										
32	ICE +		ICE- with soil inclusions		ICE +							32	

LOGGED BY: J.J.S	FACILITY:	PROJECT: 13011
CHKD: R.H.	LAT. & LONG: 68°57'11''N, 137°13'04''W	ELEVATION:
DRWN. BY: A.M.	AIRPHOTO No.: A 13751-37	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: Approx. 4°C
	METHOD: AIR	

START: D 31 M 07 Y 75 TIME: 01:50

FINISH: D 31 M 07 Y 75 TIME: 02:10

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B2-A

SHEET 2 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B2-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	ICE +		ICE + (cont'd)		ICE +							32	
34													
36			36.0 (little) fine gravel										
												37	02:08
38													
40			40.0 (trace) fine gravel										
42													
44													
			45.0 (trace) fine gravel										
46			46.5 (trace) fine sand/silt										
48			48.0 End of hole									48	02:11

LOGGED BY: J.J.S

CHKD: D.O.

DRWN. BY: A.M.

CHKD: D.O.

FACILITY:

LAT. & LONG: 68°57'11''N, 137°13'04''W

AIRPHOTO No.: A 13751-37

RIG: HELI-DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: Approx. 4° C

START: D 31 M 07 Y 75 TIME: 01:50

FINISH: D 31 M 07 Y 75 TIME: 02:10

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B2-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0	Pt	? ? ?	PEAT									0	21:20 4¼'' Walmac (used)
0.3	OL	? ?	SILT - (organic), fibres and roots to 3.0', low plastic, dark brown mottling, light brown.		UF								
1.3	ML		SILT - low plastic, dark brown, some sand (fine-med) from 4.0' to 7.5'		F 15 to 20							1.3	random ice observed when exposed
7.5	GW		GRAVEL- coarse to fine, trace medium to coarse sand.		10 20							8.0 10.0 15	change 3 7/8'' Walmac (used) temporarily stuck at 10.0' 21:35

Depth scale: 0, 2, 4, 6, 8, 10, 12, 14, 16

LOGGED BY: J.J.S	FACILITY:	PROJECT: 13011	
CHKD: W.W.	LAT. & LONG: 68°56'N, 137°10'W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 1375 1-37	PIPE MILEAGE:	
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.: 5^0C	
	METHOD: AIR		
START: D 30 M 07 Y 75 TIME: 21:20		FINISH: D 30 M 07 Y 75 TIME: 22:35	

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES
COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B2-B

SHEET 1 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GW		GRAVEL (cont'd)		F								
18			18.0 cobble 18.5									18	21:40 reaming hole 21:54 3 7/8'' Tricone (used)
20													
22			little fine sand										
24			trace medium to coarse sand									24	change bit to 3 7/8'' Walmac
26													
28												29	22:18 trip down
30													
32													

LOGGED BY: J.J.S	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: W.W.	LAT. & LONG: 68°56'N, 137°10'W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 1375 1-37	PIPE MILEAGE:	
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 5°C	
	METHOD: AIR		

START: D 30 M 07 Y 75 TIME: 21:20 FINISH: D 30 M 07 Y 75 TIME: 22:35

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B2-B

SHEET 2 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B2-B

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	GW		GRAVEL- little fine to coarse sand		F								
34													
36			37.0										
	SP		38.0 SAND- fine to medium										
38	GW		GRAVEL- coarse to fine										
40													
42			42.0										
	GP		GRAVEL- fine, little medium to coarse sand. 43.0										
44	GW		GRAVEL- coarse to fine										
46													
48			48.0 End of hole									48	22:35

LOGGED BY: J.J.S	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: W.W.	LAT. & LONG: 68°56'N, 137°10'W	ELEVATION:	
DRWN. BY: A.M.	AIRPHOTO No.: A 13751-37	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.: 5°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 30 M 07 Y 75 TIME: 21:20

FINISH: D 30 M 07 Y 75 TIME: 22:35

TEST HOLE No. N75-117A-B2-B

SHEET 3 OF 3

PC-9,SK373

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ○ Water content % — Plastic limit ├──┤ Liquid limit — 40 60 80 100 120 140 ▲ — 0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt	0.5 PEAT- fibrous, dk. brown, moist	UF							16:05 4¼'' Walmac
2	OL	SILT-(organic), trace medium to coarse sand, dk. brown, roots to ¼'' diam. (2.0)	Vr							
4	ML	SILT - trace med. to coarse sand, dark brown, fine roots, pockets, light brown (mottled) to 1.0' 6.0								
6	CI-CH	CLAY - silty, medium to high plastic, dk. grey, moist 8.0 8.0	10						7	depth uncertain, to 3 7/8'' Walmac (new bit)
8 10 12 14 16	ICE	ICE clear ice	ICE						16	pure white cuttings in air return

LOGGED BY:	J.I.S.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	68°57'11''N, 137°13'04''W	ELEVATION:	
DRWN. BY:	A.M.	AIRPHOTO No.:	A13751-37	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI-DRILL	AIR TEMP:	Approx. 7°C
		METHOD:	AIR		

START: D 31 M 07 Y 75 **TIME:** 16:05 **FINISH:** D 31 M 07 Y 75 **TIME:** 16:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B2-C
SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B2-C

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	ICE		ICE (cont'd) clear ice		ICE								
18	ML		18.0 18.0 SILT—some fine gravel, little fine sand, medium grey		F							18	16:18
20					15-25								
22													
24	ICE		24.0 24.0 ICE- clear		ICE								
26													
28												28	16:19
	ML		29.0 29.0 SILT- little coarse to med. sand, trace fine gravel, low plastic, medium grey		F								
30													
32												32	

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011
CHKD: R.H.	LAT. & LONG: 68°57'11''N, 137°13'04''W	ELEVATION:
DRWN. BY: A.M.	AIRPHOTO No.: A 13751-37	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: Approx. 7°C
	METHOD: AIR	

START: D 31 M 07 Y 75 TIME: 16:05

FINISH: D 31 M 07 Y 75 TIME: 16:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B2-C

SHEET 2 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	ML		32.5 SILT		F							32	
	ICE		ICE, clear		ICE								
34			34.5 34.5										
	GM		GRAVEL - coarse, trace fine sand, dirty, pebbles to 2"		F								
36													
38					20							38	16:31
40			----- fine sand, trace silt, pebbles to 1"										
42													
44			44.0 End of hole									44	16:45 lost circulation at depth 44.0' no cutting return

LOGGED BY: J.J.S.	FACILITY	PROJECT: 13011
CHKD: R.H.	LAT. & LONG: 68°57'11"N, 137°13'04"W	ELEVATION:
DRWN. BY: A.M.	AIRPHOTO No.: A 1375 1-37	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: Approx. 7°C
	METHOD: AIR	

START: D 31 M 7 Y 75 TIME: 16:05

FINISH: D 31 M 7 Y 75 TIME: 16:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B2-C

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B2-C

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % — Plastic limit ├──┤ Liquid limit — scale 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.5 PEAT – dark brown, dry, fibrous.		UF								Using shovels
1	GW- GM		GRAVEL – fine to coarse, subrounded, and sand, coarse to fine, grey, trace silt, moist, stratified, isolated cobbles to 8'', numerous rootlets to depth 35' dense.									1	
2							MA, combined samples 1-6 G= 57% S= 36% F = 7%	B1	☒			2	A layer of sand, coarse to fine at depth 1.7'-2.0'.
3								B2	☒			3	
4			4.0 damp					B3	☒			4	
5	SW		5.0 SAND – coarse to fine; and gravel, fine, grey, isolated cobbles to 7''.	5.3	Vx 5			B4	☒			5	Using jack-hammer
6			6.5					B5	☒			6	
7	GW		GRAVEL – as between 4.0'-5.0' 7.5 Bottom of pit.					B6	☒			7	

LOGGED BY: I.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 68°55'44''N, 137°06'36'' W	ELEVATION:	
DRWN. BY: R.J.S.	AIRPHOTO No.: A 13751-37	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP: 10°C	
	METHOD: TEST PIT		
START: D 31 M 07 Y 75 TIME: 16:45	FINISH: D 31 M 07 Y 75 TIME: 19:40		CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B2-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B2-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.1 PEAT - light brown, dry, surface gravel.										
1	GW		GRAVEL - coarse to fine, subangular to subrounded, some mcf sand, dark brown, moist, occasional cobbles, rootlets, loose, oxidized, weathered.		UF								Using shovels
2			2.5 — — damp				MA, combined samples 2 - 5 Oversize = 5.6% G = 62% S = 34% F = 4% (GW)	B 2 - 5				2	
3			3.0 — no rootlets									3	
			3.6 — — wet										
4			4.3 — — saturated									4	
5			5.0 Bottom of pit									5	Water level at depth 5.0'

LOGGED BY: J.J.S.
CHKD: R.H.
DRWN. BY: N.L.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°57'11''N, 137°13'04''W
AIRPHOTO No.: A 13751-37
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 7°C

START: D 31 M 07 Y 75 TIME: 16:00
FINISH: D 31 M 07 Y 75 TIME: 17:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B2-2
SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B2-3

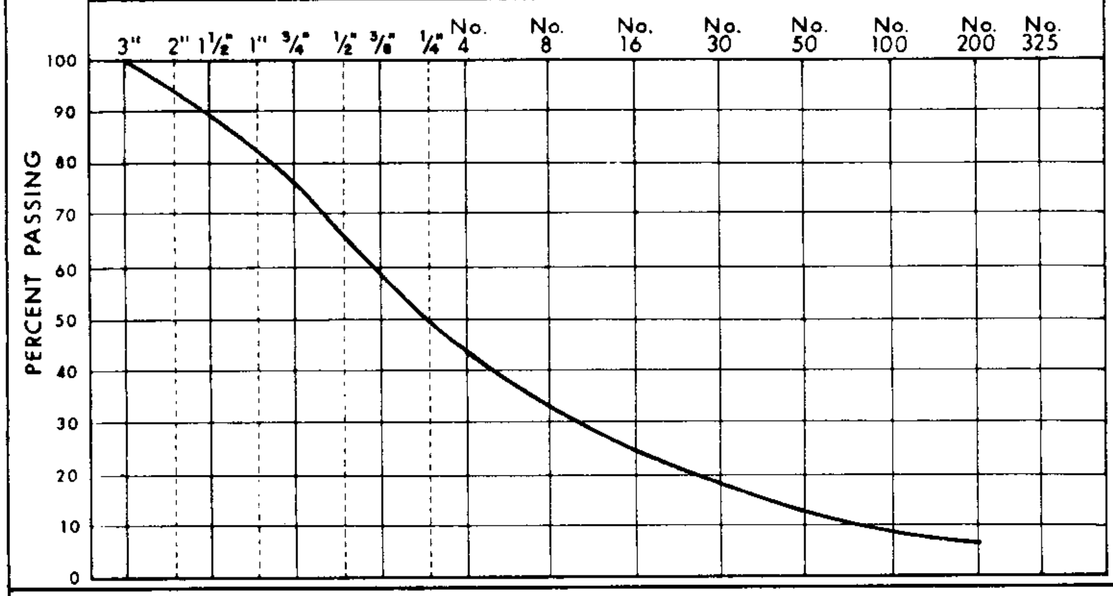
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B2-1 DEPTH 2.0 - 7.5

DATE SAMPLED July 31, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 129

GRAVEL SIZES		SAND SIZES			FINES
24 %	33 %	12%	14 %	10 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.4
1½"	88.6
1"	81.7
¾"	75.7
½"	66.0
⅜"	58.0
¼"	
No. 4	43.0
No. 8	32.4
No. 16	24.9
No. 30	19.2
No. 50	13.7
No. 100	9.6
No. 200	7.1

COMMENTS

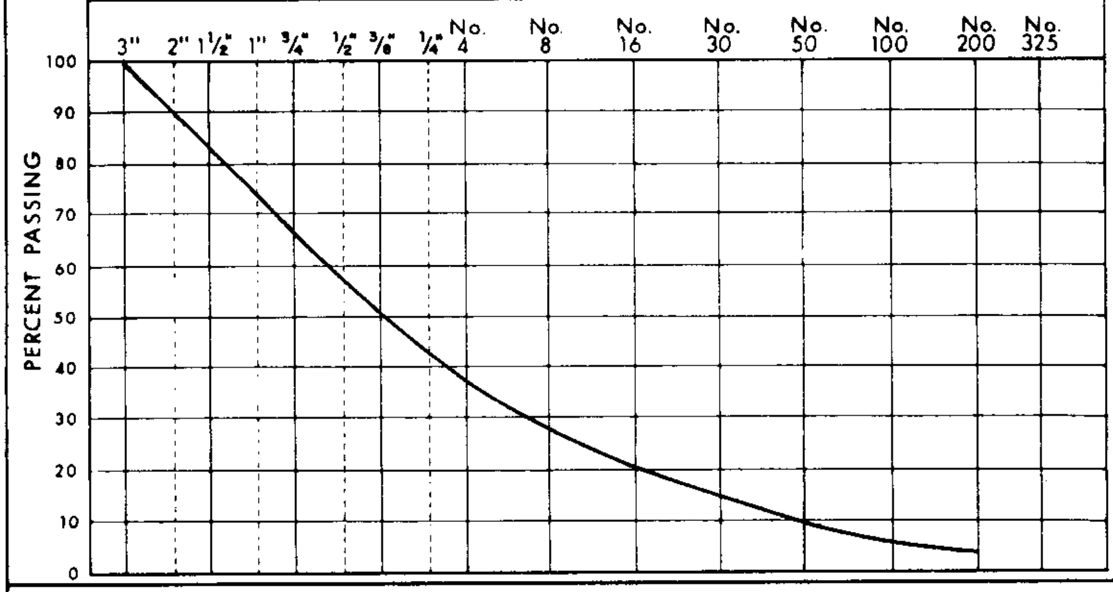
OVERSIZE (>3") = 0.0%

SAMPLE N75-117A-B2-2 DEPTH 2.0 - 5.0

DATE SAMPLED July 31, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 204

GRAVEL SIZES		SAND SIZES			FINES
32 %	30 %	12 %	14 %	8%	4 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	92.7
1½"	82.3
1"	73.5
¾"	67.6
½"	58.4
⅜"	51.6
¼"	
No. 4	37.5
No. 8	28.1
No. 16	20.7
No. 30	14.9
No. 50	10.0
No. 100	6.2
No. 200	4.3

COMMENTS

OVERSIZE (>3") = 5.6%

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No.

N75-117A-B2

PAGE

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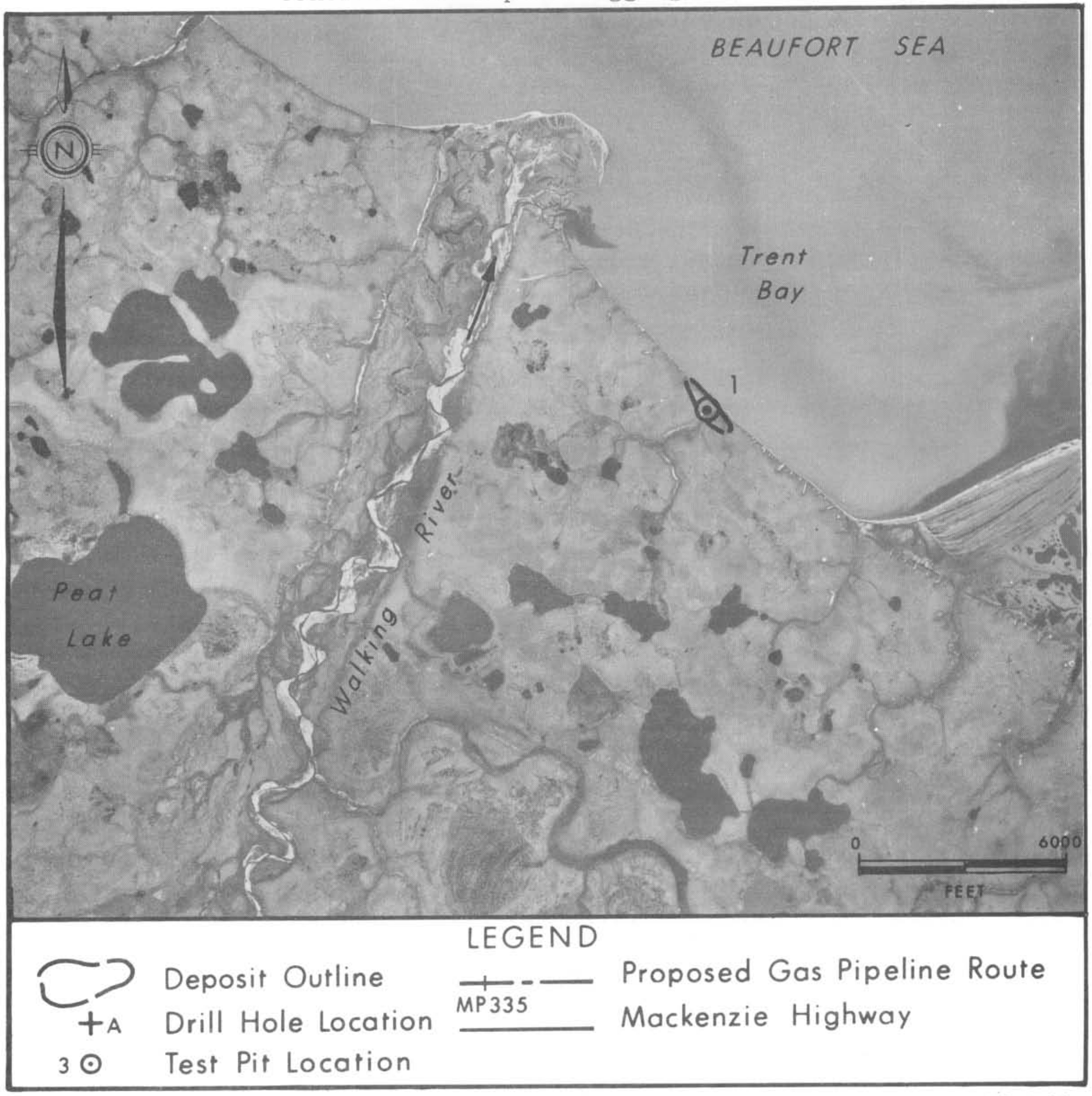
DEPOSIT 117A-B3

Physical Setting: Deposit 117A-B3 is a 60 - to 80-foot escarpment along the Arctic coast near the Shingle Point D.E.W. line station and is 8 miles north of mile post 300 of the proposed gas pipeline.

Material: Gravel; well graded, fine to coarse, some sand, trace fines.

Volume: 4,000,000 cubic yards.

Assessment: Deposit 117A-B3 is a good source of granular material. Haul distance from the deposit to the proposed gas pipeline route exceeds 8 miles, although it is at the coast and could be barged or hauled over ice. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate.



Airphoto No. A13751-32
Approximate Scale: 1" = 5250'

Latitude: 68° 56' N
Longitude: 137° 14' W

DEPOSIT 117A-B3

PHYSICAL SETTING

Deposit 117A-B3 is a 60 - to 80-foot escarpment along the Arctic coast near the Shingle Point D.E.W. line station. It is about 8 miles north of the proposed pipeline route.

The gravel escarpment extends northwest along the coastline beyond the mouth of the Walking River, and southeast past the Blow River Delta. The Shingle Point gravel pit is currently located in the side of a gulley which intersects the escarpment. The coastline is protected by the Shingle Point Spit and Escape Reef.

At the top of the escarpment till and gravelly colluvium 2 to 10 feet in depth overlies the gravel. The colluvium is thinnest near the edge of the embankment. The upland is moderately well to well drained.

BIOLOGICAL SETTING

Vegetation composed of sedge tussocks and scattered clumps of willow cover the upland overlooking the coastal escarpment.

The coastline provides extensive summer habitat and nesting grounds for waterfowl and shore birds and the offshore area supports many types of marine mammals and fish. Environmental hazards such as garbage disposal should be strictly controlled during all seasons.

MATERIALS

The escarpment and adjacent areas contain good quality granular material. The deposit is composed of preglacial and glacial gravels with occasional lenses of till, peat, and silt with wood fragments. The gravel is dense, stratified and subrounded with little sand and frequent cobbles and boulders up to 10 inches in diameter. Ice contents are low.

VOLUME

The depth of gravel is at least 70 feet. The small section of the escarpment and adjoining area adjacent to the developed pit and Shingle Point has an area of 45 acres and a total volume, based on a depth of 70 feet and low ice contents, of 4,000,000 cubic yards. Volumes could be increased by extending the area of development along the coastline escarpment.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B3 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Shingle Point. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way or wharf locations at Shingle Point.

Development of this deposit would involve excavating borrow material from the face of the escarpment. This type of development could be accomplished by using blasting techniques or conventional earthmoving techniques depending on the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	REMARKS
0 – 5.5	GW-GM	GRAVEL - coarse to fine, subrounded, little sand, coarse to medium, dark grey, wet, stratified, silt inclusions to depth 2.0', dense. [* Combined sieve analysis of samples 1 - 4 and 6 - 12 = "GRAVEL, fine to coarse, some sand, trace silt" (GW-GM)]		UF	MA, combined samples 1 - 4 and 6 - 12 Oversize = 3.7% G = 71% S = 24% F = 5%	B1 B2 B3 B4 B5	☒			Using shovels (2) 1''- 2'' layer of fine sand
5.5 – 8	GM	GRAVEL - fine, subrounded, little sand, coarse to fine, little silt, grey, stratified, dense.				B6 B7	☒			

LABORATORY TEST DATA

▲ Dry density (pcf) ⊙ Water content %

Plastic limit ├──┤ Liquid limit

40 60 80 100 120 140 ▲

0 20 40 60 80 100 ⊙

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 68^{0}56' 18''N, 137^{0}14'14''W	ELEVATION:	
DRWN. BY: G.C.B.	AIRPHOTO No.: A 23838-26	PIPE MILEAGE:	
CHKD: D.D.	RIG:	AIR TEMP.: 10^{0}C	
	METHOD: TEST PIT (EXPOSURE)		

START: D 31 M 07 Y 75 TIME: 21:15 FINISH: D 01 M 08 Y 75 TIME: 01:45

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B3-1

SHEET 1 OF 2

PC-9,SK373

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % — Plastic limit ├──┤ Liquid limit — scale: 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL - coarse and fine, subrounded, little sand, coarse to medium, grey, wet, stratified, frequent cobbles, isolated boulders to 10'', medium dense.		UF		MA (cont'd)	B8	☒				Using shovels
9								B9	☒			9	
10								B10	☒			10	
11								B11	☒			11	
12													
13								B12	☒			13	
14												14	
15												15	
		16.0	End of log										

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 68°56'18''N, 137°14'14''W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
DRWN. BY: G.C.B.	AIRPHOTO No.: A 23838-26	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP.: 10°C	
	METHOD: TEST PIT (EXPOSURE)		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 31 M 07 Y 75 TIME:

FINISH: D 01 M 08 Y 75 TIME: 01:45

TEST HOLE No. N75-117A-B3-1

SHEET 2 OF 2

PC-9,SK373

TEST HOLE No. N75-117A-B3-1

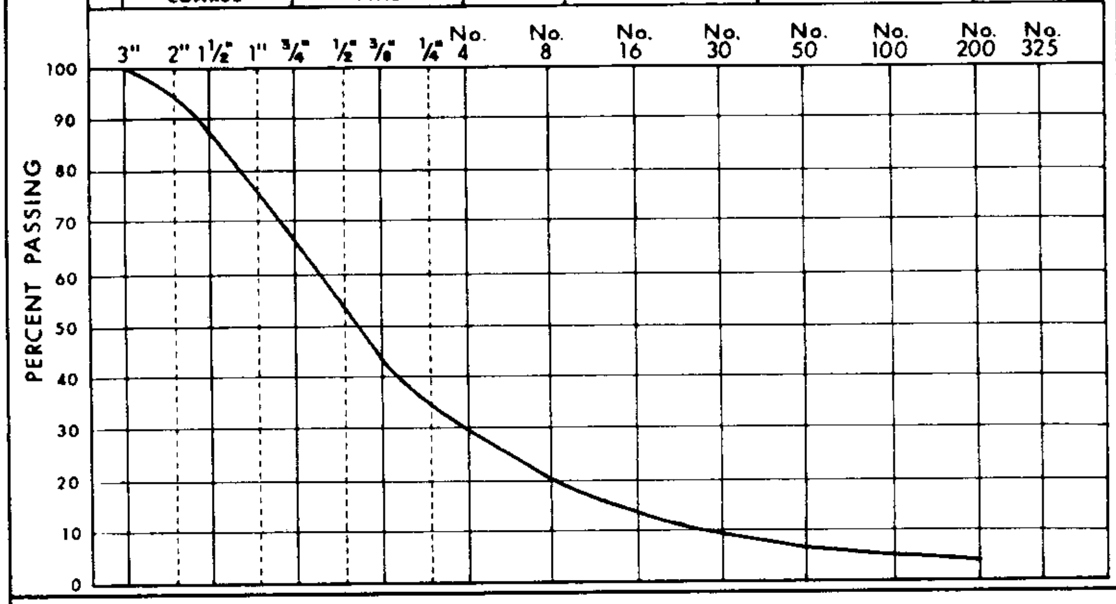
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B3-1 DEPTH 1.0 - 14.5

DATE SAMPLED July 31, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 107

GRAVEL SIZES		SAND SIZES			FINES
32 %	39 %	10 %	12 %	2 %	5 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	95.4
1½"	86.7
1"	76.2
¾"	67.6
½"	53.4
⅜"	44.1
¼"	
No. 4	28.6
No. 8	20.3
No. 16	14.1
No. 30	9.6
No. 50	6.6
No. 100	5.3
No. 200	4.7

COMMENTS

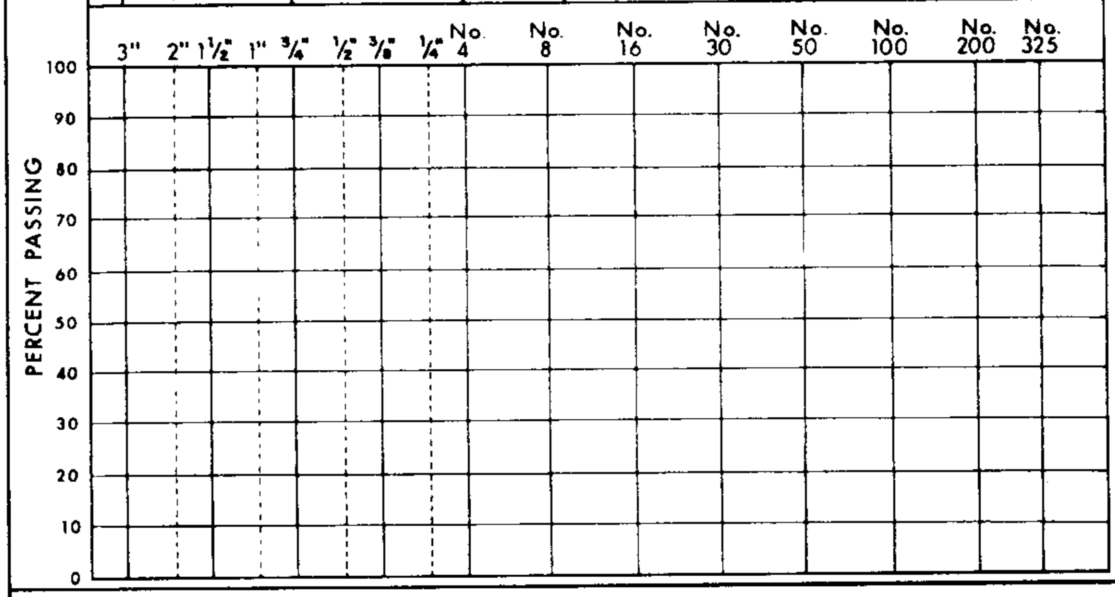
OVERSIZE (>3") = 3.7%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-117A-B3

PAGE 279

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-117A-B3-1 DATE SAMPLED : July 31, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1 - 18 DATE TESTED : December, 1975 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 1.86 %
FINE AGGREGATE : LOSS = 9.24 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 21.1 %

ORGANIC IMPURITIES TEST

NUMBER : 4+
COAL REMOVED : 4
COAL & ROOTLETS REMOVED : 4
COAL CONTENT : 0.02%
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Strong to very strong, Good	20.1
Sandstone		30.6
Siltstone	Medium strong, Good	9.0
Cherty Conglomerate	Potentially reactive, Fair	3.15
Chert		4.0
Flint		5.55
PN = 135	INTERPRETATION : Fair quality from a petrographic point of view. See Comments	72.4

COMMENTS : See also - Fine Aggregate. Total sample of fine and coarse aggregate contains a very high (21.55%) percent of cherty fragments. Additional tests recommended to determine behaviour of the chert. Passible high absorptive capacity and low frost resistance.

NORTHERN
Engineering Services Company Limited

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

DEPOSIT No. N75-117A-B3

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. : N75-117A-B3-1
DATE SAMPLED : July 31, 1975
SAMPLED BY : NESCL
DEPTH (FT.) : 1 - 18'
DATE TESTED : December, 1975
TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 1.86 %
FINE AGGREGATE : LOSS = 9.24 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 21.1 %

ORGANIC IMPURITIES TEST

NUMBER : 4+
COAL REMOVED : 4
COAL & ROOTLETS REMOVED : 4
COAL CONTENT : 0.02%
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, FINE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Strong to very strong, Good	11.1
Sandstone		5.7
Siltstone	Medium strong, Good	1.95
Flint	Potentially reactive, Fair	4.45
Chert		4.4
PN = 135	INTERPRETATION : See "Coarse Aggregate".	27.6

COMMENTS :

See also "Coarse Aggregate" page

NORTHERN Engineering Services Company Limited

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

DEPOSIT No. N75-117A-B3

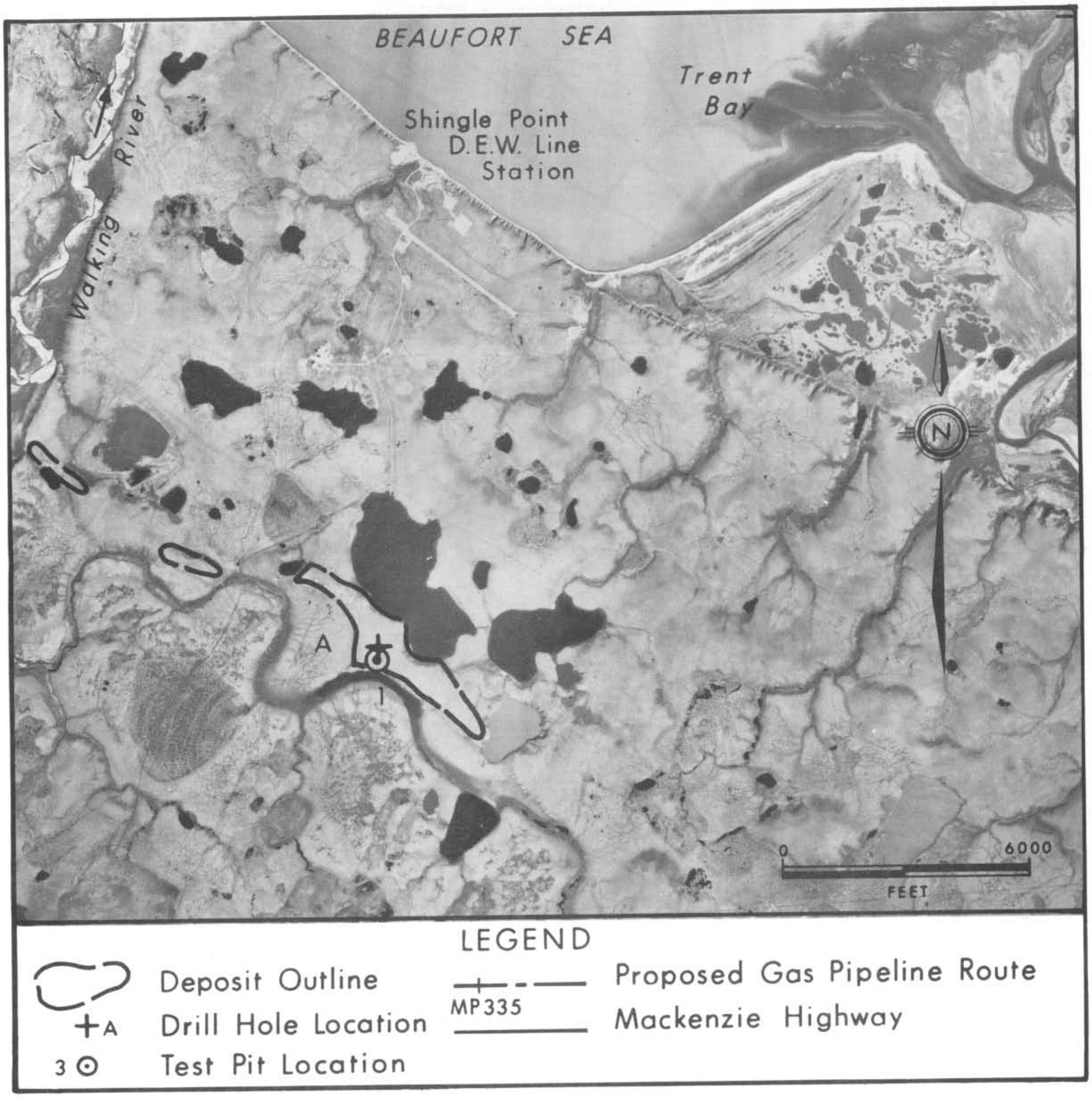
DEPOSIT 117A-B4

Physical Setting: Deposit 117A-B4 consists of remnants of kame deltas bordering the east bank of the Walking River 2 miles south of Shingle Point D.E.W. line station and 5 miles north of mile 305 of the proposed gas pipeline.

Material: Gravel; well graded, fine to coarse, and sand, trace fines.

Volume: 4,800,000 cubic yards.

Assessment: Deposit 117A-B4 is a good source of granular material. Haul distances to the pipeline right of way from the deposit exceed 5 miles. Distance to the Shingle Point D.E.W. line station exceeds 3 miles. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and concrete aggregate.



Airphoto No. A23838-26
Approximate Scale: 1" = 5250'

Latitude: 68° 54' N
Longitude: 137° 15' W

DEPOSIT 117A-B4

PHYSICAL SETTING

Deposit 117A-B4 consists of remnants of kame deltas bordering the east bank of Walking River, about 2 miles south of Shingle Point D.E.W. line station. Mile 300 of the proposed pipeline route lies 5 miles south of the deposit.

The kame deltas extend parallel to the coastline for 2 miles east from Walking River, and are located between a morainal area to the north and a flat meltwater channel, 50 to 60 feet below the terraces, on the south. The surfaces of the kame deltas, which slope gently southward, are moderately well to well drained except for imperfectly drained areas near their centres. Slopes facing the meltwater channel are steep.

Outwash material overlies preglacial gravel and sand, which may contain some layers of massive ice. Ice content in the upper 35 feet should generally be low. The drill hole encountered gravel to a depth of 36 feet, and sand below that to the bottom of the hole at 48 feet. Exposures in the east bank of Walking River indicate that the depth of sand and gravel may be substantially greater than 48 feet.

Most of this deposit is covered by less than 1 foot of peat and silt although central areas may have 3 to 6 feet of ice-rich peat and silt. The morainal area north of the deposit has numerous lakes and occasional patches of ice-wedge polygons. The meltwater channel to the south is marshy, containing many small lakes and streams and extensive areas of ice-wedge polygons.

BIOLOGICAL SETTING

The kame deltas are covered by vegetation dominated by sedge tussocks and moss. Some dwarf willow and birch are present on the slopes.

Swans and other waterfowl use the nearby lakes for nesting. The Walking River contains grayling, white fish and stickleback; some of which move into the creek and small lake to the south during spring and summer.

Because of its proximity to an operating D.E.W. line station, the area has already been subject to some disturbance.

MATERIALS

The deposit contains good quality granular material. It consists of stratified, dense, subrounded gravel and sand with isolated cobbles up to 4 inches in diameter.

VOLUMES

The deposit consists of remnants of kame deltas. The northwest remnant covers about 15 acres and has a total volume, based on a depth of 30 feet and moderate ice content, of 450,000 cubic yards. The central remnant has an area of about 12 acres and a total volume of about 350,000 cubic yards. The southeast remnant covers about 120 acres and has a total volume of about 4,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B4 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Excavations would be kept away from nearby lakes to protect the lakes from siltation. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

Initially the peat cover and overburden would be stripped from the deposit and stockpiled around the edge of the excavation area away from the natural drainage channels.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be maintained over the area. This type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. A buffer strip to prevent siltation of the creek to the south would be left. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment, and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.5 PEAT - dark brown, moist 0.5		UF								
2	OL		SILT-(organic) trace fine sand, dark brown mottled light brown. High organic content 3.0 3.0	▒ ▤	Nb Vs 25								15:00 3 7/8" Walmac
4	GM		GRAVEL - coarse, silty, trace sand. Pebbles to 1.5", subrounded. (6.0)	■	F								high ice content
6 8 10 12 14	GW		GRAVEL - coarse, little fine to medium sand, pebbles to 3"	■	Vc ?							8	15:08 Vc, ice coatings noted on granular material cuttings.
16			some med. to coarse sand, coarse gravel to 3"	■	20							16	

LOGGED BY: J.J.S

CHKD: D.O.

DRWN. BY: J.M.B.

CHKD: D.O.

FACILITY:

LAT. & LONG: 68°54'04"N, 137°15'16"W

AIRPHOTO No.: A 23038-26

RIG: HELI-DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: 4°C

START: D 01 M 08 Y 75 TIME: 15:00

FINISH: D 01 M 08 Y 75 TIME: 16:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B4-A

SHEET 1 **OF** 3

PC-9,SK373

TEST HOLE No. N75-117A-B4-A

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % — Plastic limit ├──┤ Liquid limit — 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GW		(GRAVEL) cont'd		F 20							16	
18												18	15:17 15:21
20													
			21.0 fine gravel, (trace to little) coarse sand (inferred pebbles ≤ 2")										
22													
24													
			25.5 cobble, 4"										
26													
28												28	15:40
	GW												
30													
32												32	

LOGGED BY: J.J.S	FACILITY:
CHKD: D.O.	LAT. & LONG: 68°54'04" N, 137°15'16" W
DRWN. BY: J.M.B.	AIRPHOTO No.: A 23838-26
CHKD: D.O.	RIG: HELI-DRILL
	METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 4°C

START: D 01 M 08 Y 75 TIME: 15:00
FINISH: D 01 M 08 Y 75 TIME: 16:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B4-A

SHEET 2 OF 3

PC-9.SK373

TEST HOLE No. N75-117A-B4-A

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % — Plastic limit ├──┤ Liquid limit — 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32			(GRAVEL) cont'd		F							32	
	GW		fine gravel, coarse to medium sand.										
34													
			35.5 --- cobble, 4"										
			36.0										
36													
	SW		SAND - fine to coarse, some coarse gravel to 2"										
38												38	15:55
40													
42			decreasing gravel content, finer sand increases.		30								
44													
46													
48			48.0 End of hole									48	16:00

LOGGED BY: J J.S	FACILITY:	PROJECT: 13011
CHKD: D.O.	LAT. & LONG.: 68°54'04" N, 137°15'16" W	ELEVATION:
DRWN. BY: J.M.B.	AIRPHOTO No.: A 23838-26	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 4°C
	METHOD: AIR	

START: D 01 M 08 Y 75 TIME: 15:00

FINISH: D 01 M 08 Y 75 TIME: 16:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B4-A

SHEET 3 OF 3

TEST HOLE No. N75-117A-B4-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT - little coarse to fine sand, dark brown, some fibres. 0.5		UF								Using shovels
1	SW		SAND - coarse to fine, some gravel, sub-rounded, rusty brown, moist, isolated cobbles to 4'', dense. 1.8				MA, combined samples 1 - 7 G = 59% S = 36% F = 5%	B1	☒			1	
2	GW-GM		GRAVEL - fine to coarse,and sand, trace silt, dark grey, damp, stratified isolated cobbles to 4.0'', dense.					B2	☒			2	
3								B3	☒			3	
4								B4	☒			4	
5			5.2					B5	☒			5	Using jack-hammer
				+ + +	Vx 5			B6	☒				
6			6.0 Bottom of pit					B7	☒			6	

LOGGED BY:	J.G.R.	FACILITY:		PROJECT:	13011
CHKD:	R.H.	LAT. & LONG:	68°53'59''N, 137°15'18''W	ELEVATION:	
DRWN. BY:	G.C.B.	AIRPHOTO No.:	A 23838-26	PIPE MILEAGE:	
CHKD:	D.O.	RIG:		AIR TEMP.:	4°C
		METHOD:	TEST PIT		

START: D 01 M 08 Y 75 TIME: 20:15 FINISH: D 01 M 08 Y 75 TIME:

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B4-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B4-1

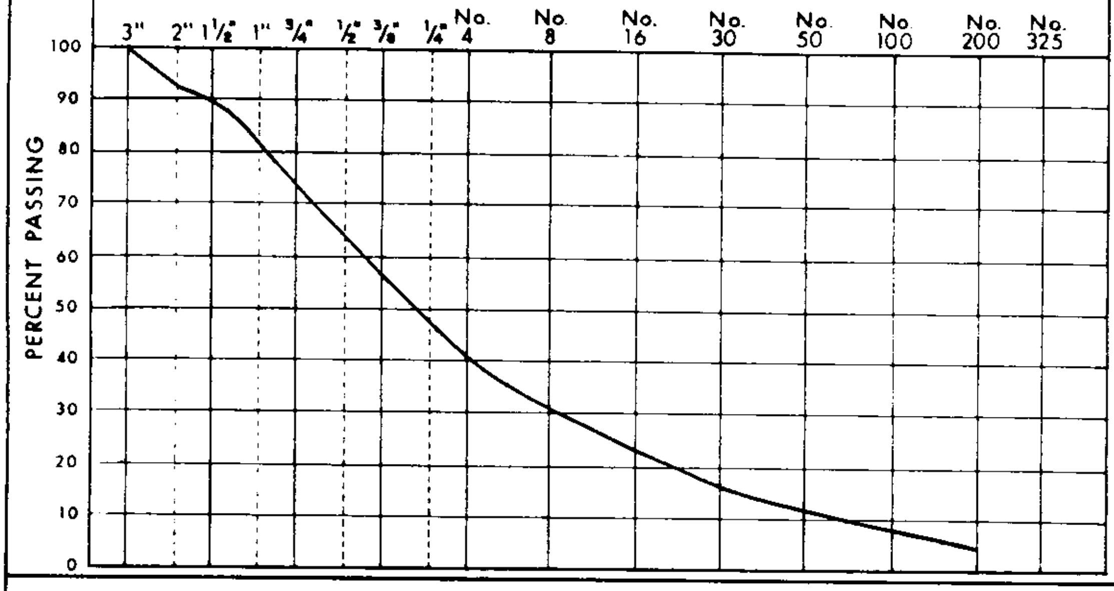
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B4-1 DEPTH 1.0 - 6.1

DATE SAMPLED August 1, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 111

GRAVEL SIZES		SAND SIZES			FINES
26%	33 %	11%	15 %	10 %	5%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	91.9
1½"	90.1
1"	80.7
¾"	73.6
½"	64.6
⅜"	56.0
¼"	
No. 4	40.8
No. 8	31.3
No. 16	23.7
No. 30	17.6
No. 50	11.6
No. 100	7.1
No. 200	4.8

COMMENTS

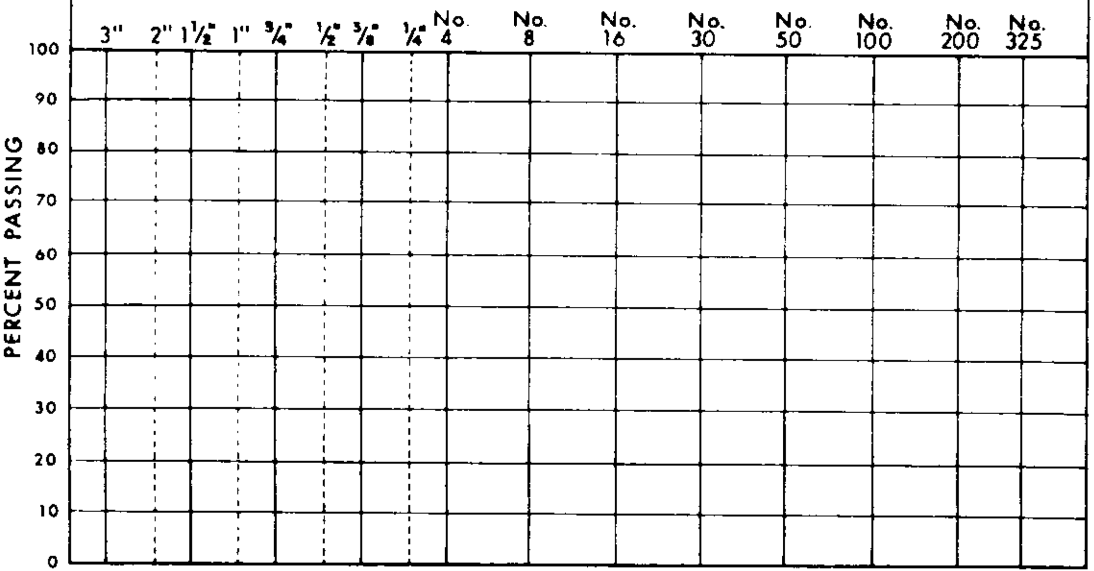
OVERSIZE (>3") = 0.0%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

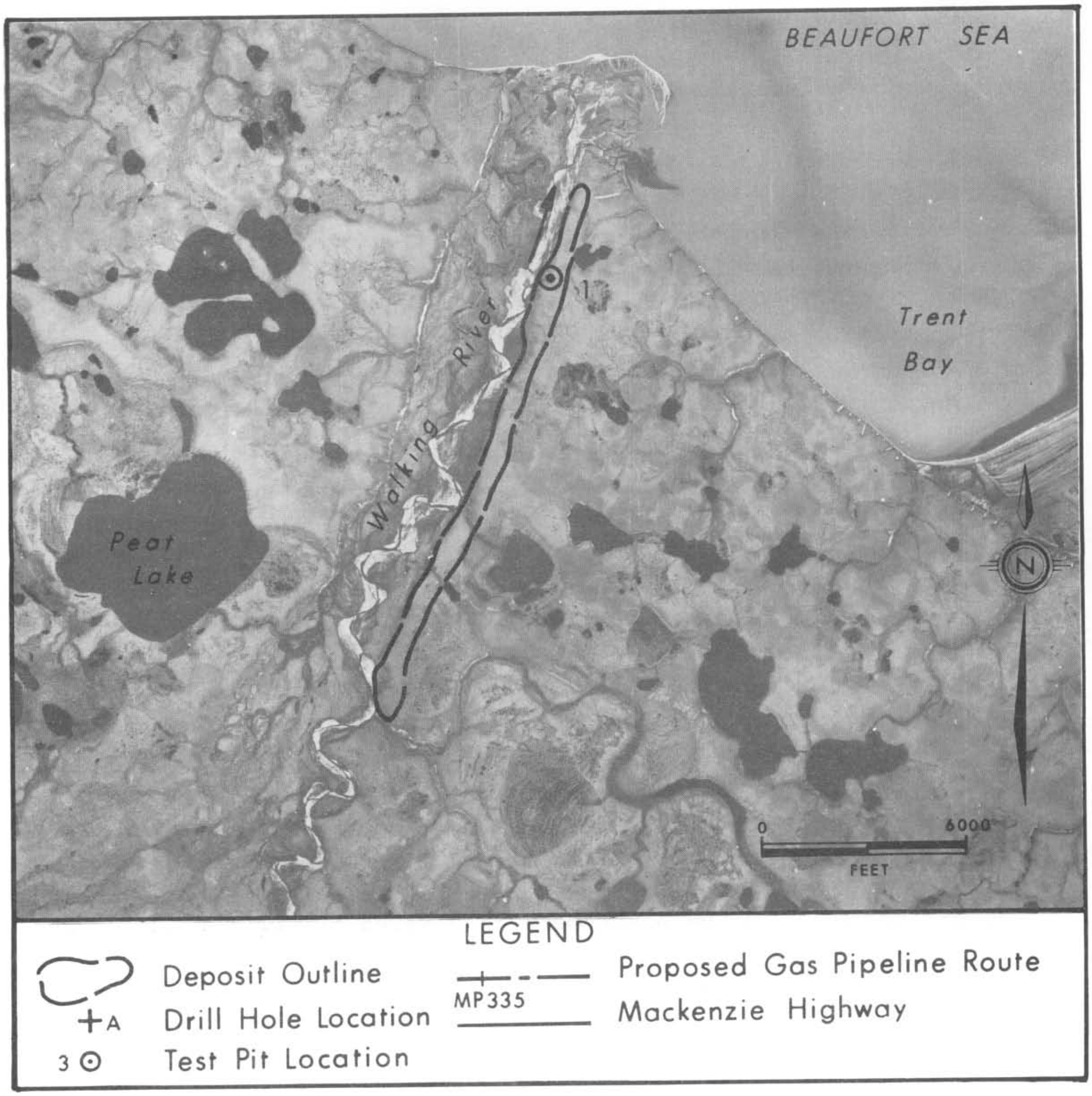
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117A-B4

DEPOSIT 117A-B5

Physical Setting:	Deposit 117A-B5 is the east wall of the Walking River valley. The area is located 1 mile west of Shingle Point D.E.W. Line Station and 7 miles north of mile 302 of the proposed gas pipeline.
Material:	Gravel; well graded, fine to coarse, and coarse, medium, and fine sand, clean.
Volume:	17,000,000 cubic yards.
Assessment:	Deposit 117A-B5 is a good source of granular material. Haul distance to the proposed gas pipeline right of way exceeds 7 miles overland. The deposit is 2 miles from Shingle Point D.E.W. Line Station wharf site. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and concrete aggregate.



Airphoto No.	A13751-33	Latitude:	68° 56' N
Approximate Scale:	1" = 5250'	Longitude:	137° 18' W

DEPOSIT 117A-B5

PHYSICAL SETTING

Deposit 117A-B5 is the east wall of the Walking River valley. The area investigated is located 1 mile west of Shingle Point D.E.W. line station and about 7 miles north of the proposed pipeline route.

The valley wall is 75 to 100 feet high and extends southwest from the Arctic coast for 3 miles along the river. The river is actively eroding the valley wall in a few places. Slopes to the river are steep and covered by gravelly colluvium.

The upland immediately adjacent to the valley bank has less than 2 feet of overburden and is well drained. Away from the slope the upland is moderately well drained, but the cover of peat, ice-rich silt and till increases to depths of 10 feet.

The deposit is a complex of glacial and preglacial gravels and may contain occasional lenses of till, peat and sand. Ice contents are generally very low. A similar gravel escarpment with a considerable volume of granular material exists on the west bank of the valley.

BIOLOGICAL SETTING

The upland adjacent to the escarpment is covered by vegetation composed primarily of sedge tussocks and moss. The slope supports scattered dwarf willow and birch. Swans, geese and other waterfowl use nearby lakes for nesting and feeding during the summer. Walking River has spawning populations of grayling, three species of whitefish, and ninespine stickleback. The river is probably frozen to the bottom in the winter thus excluding the possibility of overwintering.

MATERIALS

The valley wall contains good quality granular material including stratified, subrounded, medium dense gravel with some fine to coarse sand, isolated cobbles and a trace of silt in the upper 5 feet. Gravel sizes and sand content vary from stratum to stratum. The soil is moist at the top of the slope and wet near the bottom.

VOLUME

The deposit covers an area of about 180 acres. Gravel and sand are exposed in the valley wall for a depth of 80 feet. The total volume of gravel, based on a depth of 70 feet, is 17,000,000 cubic yards. The volume could be substantially increased by also including the west wall of the river valley.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B5 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Excavations would be kept away from areas where the Walking River stream channel is close to the valley wall to protect the stream environment. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points. Walking River would not necessarily have to be crossed during development.

Development of this deposit would involve excavating borrow material from the face of the valley wall. This could be accomplished by using blasting or conventional earthmoving techniques depending on the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage campatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT - black, dry, fibrous		VF		w% MA, combined samples 1 - 11 G = 61% S = 36% F = 3% (GW)						Using shovels
0.5	GW		GRAVEL - coarse and fine, subangular, some sand, coarse to fine, trace silt, light brown, moist, stratified, isolated cobbles to 4'', dense										
1													
2													
3													
4													
5			(5.0)									5	
			GRAVEL - coarse and fine, subrounded, little sand, coarse to fine, rusty brown, moist, 2'' gray layer of coarse sand, medium dense			⊙	4.1	B1	☒				
6												6	
7													
8													

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°56'34''N, 137°18'02''W	ELEVATION:	
DRWN. BY: F.B.	AIRPHOTO No.: A 13751-32	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP: 10°C	
	METHOD: TEST PIT (EXPOSURE)		
START: D 31 M 07 Y 75 TIME: 21:30	FINISH: D 01 M 08 Y 75 TIME: 01:30		CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B5-1

SHEET 1 **OF** 1

PC-9,SK373

TEST HOLE No. N75-117A-B5-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL (cont'd)		UF		W%						Using shovels
9													
10			10.0 — dark grey, no fine sand									10.5	
11						⊙	2	B2	☒			11.5	
12			11.8 — rusty brown layer 11.8' to 12.5' 12.5 — little coarse to medium sand (no fine sand), stratified										
13													
14													
15			15.0										
	GP		GRAVEL - fine, average size ½'', little sand, coarse to medium, dark grey, moist, stratified, medium dense										
16													

LOGGED BY: J.G.R.
CHKD: D.O.
DRWN. BY: F.B.
CHKD: D.O.
FACILITY:
LAT. & LONG: 68°56'34''N, 137°18'02''W
AIRPHOTO No.: A 13751-32
RIG:
METHOD: TEST PIT (EXPOSURE)
PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 10°C
START: D 31 M 07 Y 75 TIME: 21:30
FINISH: D 01 M 08 Y 75 TIME: 01:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

NORTHERN Engineering Services Company Limited

TEST HOLE No.
N75-117A-B5-1
SHEET 2 OF 7

PC-9,SK373

TEST HOLE No. N75-117A-B5-1

- 300 -

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GP		GRAVEL (cont'd)		UF		W%						Using shovels
17												17	
						⊙	3	B3	☒				
18												18	
						⊙	2	B4	☒				
19												19	
20													
21			21.0 —— some sand										
22													
23			23.0 —— sand layer, coarse to medium 23.3 ——										
24													

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°56'34''N, 137°18'02''W	ELEVATION:	
DRWN. BY: F.B.	AIRPHOTO No.: A 13751-32	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP: 10°C	
	METHOD: TEST PIT (EXPOSURE)		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 31 M 07 Y 75 TIME: 21:30 FINISH: D 01 M 08 Y 75 TIME: 01:30

TEST HOLE No. N75-117A-B5-1

SHEET 3 OF 7

PC-9,SK373

TEST HOLE No. N75-117A-B5-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GP		GRAVEL (cont'd)		UF		w%						Using shovels
						⊙	2	B5	☒				
25												25	
26													
27													
28			28.0 —— isolated cobbles to 5'' - rounded, wet, stratification continues										
29												29	
						⊙	2	B6	☒				
30												30	
31												31	
						⊙	3	B7	☒				
32												32	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°56'34''N, 137°18'02''W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
DRWN. BY: F.B.	AIRPHOTO No.: A 13751-32	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP: 10°C	
	METHOD: TEST PIT (EXPOSURE)		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 31 M 07 Y 75 TIME: 21:30	FINISH: D 01 M 08 Y 75 TIME: 01:30		

TEST HOLE No.

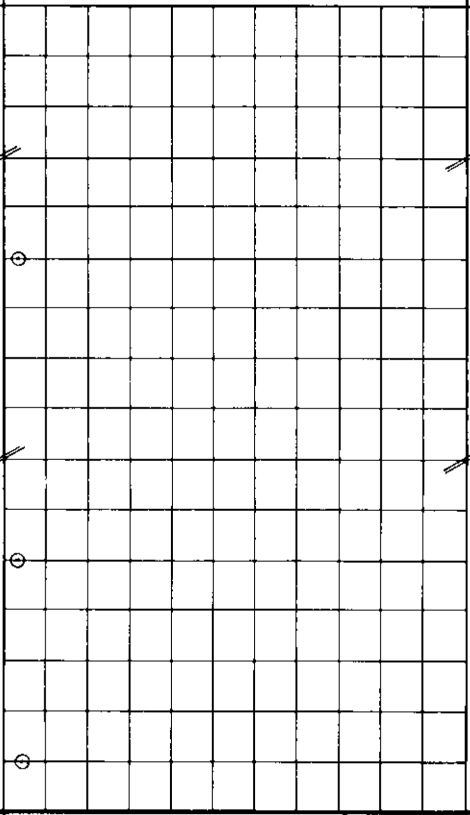
N75-117A-B5-1

SHEET 4 OF 7

PC-9,SK373

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ○ Water content % — Plastic limit ├──┤ Liquid limit — 40 60 80 100 120 140 ▲ — 0 20 40 60 80 100 ○



DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL - coarse to fine, subrounded, some sand, coarse to fine, dark grey, wet, stratified		UF		W%						Using shovels
33													
39												39	
						○	3	B8	☒				
40		40.0	sand and average sizes ¾'' - 1.0''									40	
41													
47												47	
						○	3	B9	☒				
48												48	
49												49	
						○	4	B 10	☒				
50												50	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°56'34''N, 137°18'02''W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
DRWN. BY: F.B.	AIRPHOTO No.: A 13751-32	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP.: 10°C	
	METHOD: TEST PIT (EXPOSURE)		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 31 M 07 Y 75 TIME: 21:30 FINISH: D 01 M 08 Y 75 TIME: 01:30

TEST HOLE No. N75-117A-B5-1

SHEET 5 OF 7

PC-9,SK373

TEST HOLE No. N75-117A-B5-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
50	GW		GRAVEL (cont'd)		UF		w%						Using shovels
51													
62			62.0 gravel layer with trace coarse sand									62	
						○	2	B11	☒				
63			63.0									63	
68			68.0 sand layer to 69.0', medium to coarse										
69			69.0										
70													
71													
72													

LOGGED BY: J.G.R.
CHKD: D.O.
DRWN. BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°56'34''N, 137°18'02''W
AIRPHOTO No.: A 1375 I-32
RIG:
METHOD: TEST PIT (EXPOSURE)

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 10°C

START: D 31 M 07 Y 75 TIME: 21:30
FINISH: D 01 M 08 Y 75 TIME: 01:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B5-1

SHEET 6 OF 7

PC-9,SK373

TEST HOLE No. N75-117A-B5-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
72	GW		GRAVEL (cont'd)		UF								Using shovels
73													
74			74.0										
	SP		SAND - medium to coarse, and gravel, fine subrounded, dark grey, wet, stratified, isolated cobbles to 4''										
80			80.0 End of log										

LOGGED BY: J.G.R.
CHKD: D.O.
DRWN. BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: $68^{0}56'34''$N, $137^{0}18'02''$W
AIRPHOTO No.: A 13751-32
RIG:
METHOD: TEST PIT (EXPOSURE)

PROJECT: 130 11
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 10^{0}C

START: D 31 M 07 Y 75 TIME: 21:30
FINISH: D 01 M 08 Y 75 TIME: 01:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B5-1

SHEET 7 OF 7

PC-9,SK373

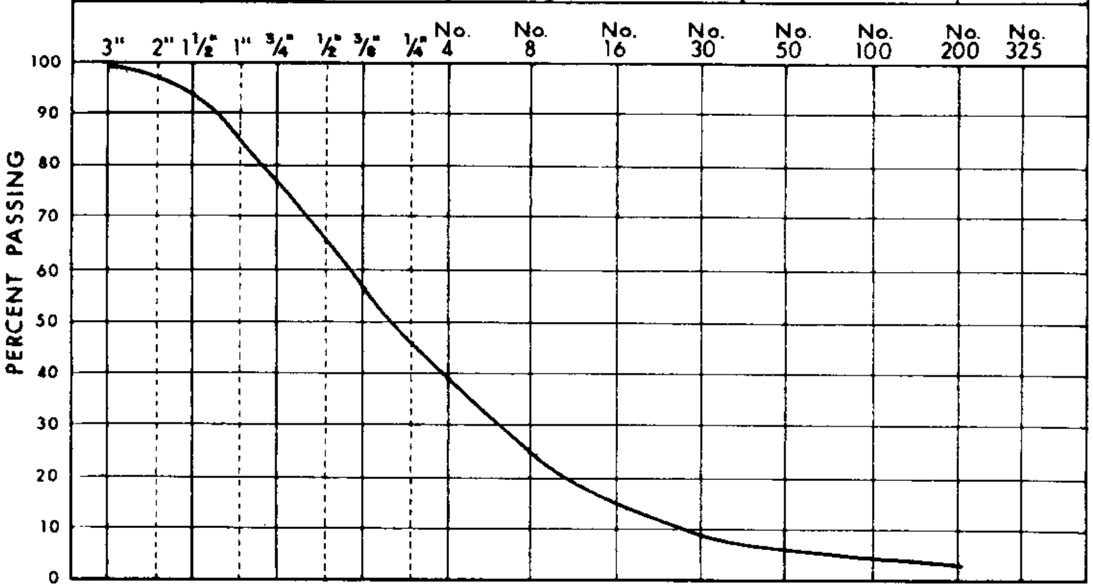
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B5-1 DEPTH 6.0 - 63.0

DATE SAMPLED July 31, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 58

GRAVEL SIZES		SAND SIZES			FINES
24 %	37 %	18 %	13 %	5 %	3%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	97.6
1½"	94.2
1"	83.9
¾"	76.3
½"	64.9
⅜"	55.8
¼"	
No. 4	39.3
No. 8	25.1
No. 16	15.7
No. 30	9.7
No. 50	5.8
No. 100	4.1
No. 200	3.3

COMMENTS

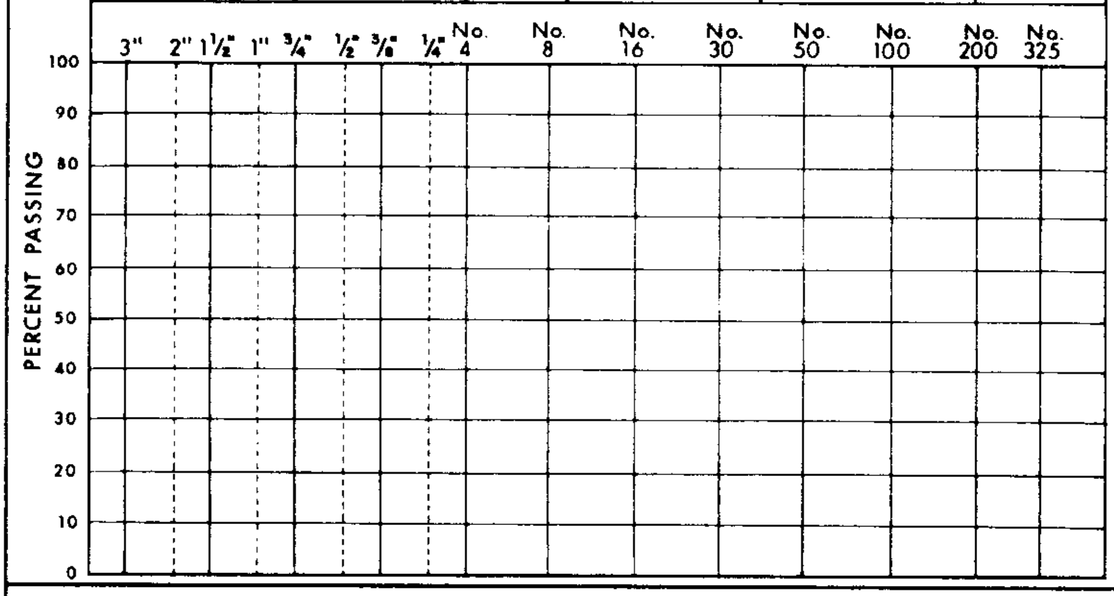
OVERSIZE (>3") = 0.0%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117A-B5

PAGE
305

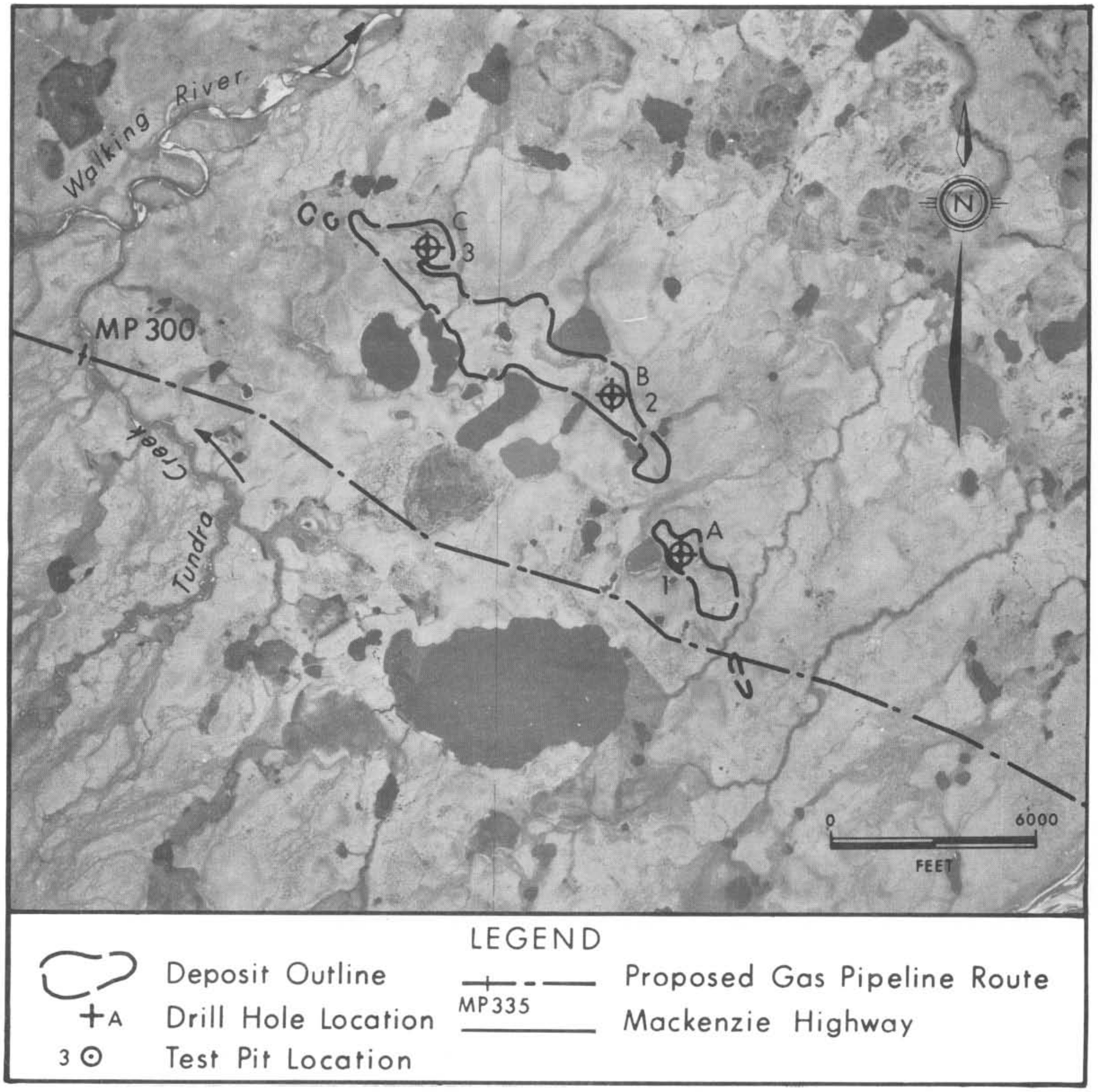
DEPOSIT 117A-B6

Physical Setting: Deposit 117A-B6 is an esker complex located between the Blow and Walking Rivers approximately 6 miles south of the Shingle Point D.E.W. Line Station. The proposed gas pipeline route crosses the southeastern end of the deposit.

Material: Gravel; well graded, fine to coarse, and coarse, medium, and fine sand.

Volume: 14,000,000 cubic yards.

Assessment: Deposit 117A-B6 is a good source of granular material. Haul distance to the pipeline is short as the right of way actually crosses the extreme southeastern tip of the deposit. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete aggregate.



Airphoto No. A13751-30

Approximate Scale: 1" = 5250'

Latitude: 68° 51' N

Longitude: 137° 18' W

DEPOSIT 117A-B6

PHYSICAL SETTING

Deposit 117A-B6 is an esker complex located between the Blow and Walking Rivers approximately 6 miles south of the Shingle Point D.E.W. line station. Mile 304 of the proposed pipeline is at the southeastern end of the deposit.

The esker complex trends northwest-southeast and stands 20 to 100 feet above the surrounding terrain. The deposit is 3 miles long and has a rolling to hummocky surface with slopes that vary from gentle to steep.

The deposit is generally well drained, except for scattered shallow depressions and broad flat areas where drainage is imperfect. Gravel and boulders are exposed on some hilltops and slopes. About half of the deposit has less than 6 inches of peat cover, although up to 6 feet of peat and ice-rich organic silt exist on poorly drained areas.

The thickness of the deposit is variable, and further drilling is required to establish a more exact profile of the deposit. The ice content of the gravel is probably low to a depth of about 30 feet, although drill hole A indicated some massive ice layers. The active layer is only 1 foot thick in areas with peat cover, but may be up to 5 feet thick under areas of bare gravel.

The terrain surrounding the esker is flat and marshy, with scattered lakes and ice-wedge polygons 60 feet in diameter.

BIOLOGICAL SETTING

Most gently sloping and flat areas are covered by tundra vegetation composed primarily of sedge tussocks, moss and dwarf willow. On some hills and slopes a broken cover of moss, grass, sedge and scattered dwarf willow exists. Marshy hollows support sedge meadows. Thick stands of willow up to 5 feet high are present in some depressions.

Waterfowl and shorebirds use the nearby small lakes for feeding and nesting in summer. These lakes do not provide suitable fish habitat. Tundra Creek and Walking River are the nearest waters of importance to fish. Snow geese have previously been sighted in the area and could be expected to use the area again.

MATERIALS

The esker is composed of good quality granular material. It consists of subrounded, stratified, medium dense gravel and sand with isolated cobbles up to 7 inches in diameter and a trace of silt in the upper 2 feet. The content of sand and gravel sizes varies from stratum to stratum. Boulders of granite, quartzite and conglomerate frequently appear at the surface but were not encountered in either the test pits or the drill holes.

VOLUME

The deposit has two parts. The northwest portion has an area of approximately 400 acres and a total volume, based on a depth of 30 feet and moderate ice content, of 12,000,000 cubic yards. The southwest portion has an area of approximately 65 acres and a total volume of 2,000,000 cubic yards. The total volume may be greater than estimated here as a result of variability in deposit thickness.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B6 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Excavations would be kept away from lakes or streams to prevent siltation and to protect their natural setting. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

Where necessary the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established over the area. If very large quantities of borrow are required, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradation. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artifically dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be carried out to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.4 PEAT - fibrous, dark brown, spongy 1.0		UF								4¼'' Walmac
2	OL		SILT - (organic), dark brown, mottled light brown, damp (2.5)		F								
4	ML		SILT - dark brown, damp 5.5										
6 8 10 12	GP		GRAVEL - fine, some med. to coarse sand, clean 13.0 13.0									7	3 7/8'' Walmac
14			ICE 14.5 14.5		ICE								
16	GP		GRAVEL - fine, little medium to coarse sand		F 30							16	

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011
CHKD: D.O.	LAT. & LONG: 68°50'30''N, 137°16'41''W	ELEVATION:
DRWN. BY: J.M.B.	AIRPHOTO No.: A 13751-31	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.: 4°C
	METHOD: AIR	

START: D 01 M 08 Y 75 TIME: 20:40 FINISH: D 01 M 08 Y 75 TIME: 21:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B6-A

SHEET 1 OF 3

PC-9,5K373

TEST HOLE LOG

LABORATORY TEST DATA
▲ Dry density (pcf) ○ Water content %
Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GP				F							16	
			17.0 little fine to coarse sand, trace silt										
18												18	21:01
20					60								
22	GW		22.0 GRAVEL -coarse, trace silt		30								
24			24.0 coarse to fine, subangular, little medium sand										
26													
28					15							28	21:14 21:18
30													
32												32	

LOGGED BY: J.J.S.
CHKD: D.D.
DRWN. BY: J.M.B.
CHKD: D.D.

FACILITY:
LAT. & LONG: 68°50'30''N, 137°16'41''W
AIRPHOTO No.: A 13751-31
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 40°C

START: D 01 M 08 Y 75 TIME: 20:40
FINISH: D 01 M 08 Y 75 TIME: 21:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B6-A
SHEET 2 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B6-A

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ○ Water content % Plastic limit ├────┤ Liquid limit

40 60 80 100 120 140 ▲

0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	GW		(GRAVEL) cont'd		F 15							32	
38.0	ICE +		38.0 ICE + occasional dirty pieces of ice		ICE +								
43.0	ML		43.0 SILT - trace fine sand, dark grey		F 30								
47.5			47.5 ICE 47.5										
48.0			End of hole		ICE							48	21:30

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°50'30''N, 137°16'41''W	ELEVATION:	
DRWN. BY: J.M.B.	AIRPHOTO No.: A 13751-31	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 4°C	
	METHOD: AIR		
START: D 01 M 08 Y 75 TIME: 20:40	FINISH: D 01 M 08 Y 75 TIME: 21:30		CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B6-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B6-A

TEST HOLE LOG

LABORATORY TEST DATA

▲ Dry density (pcf) ○ Water content %

Plastic limit ├──┤ Liquid limit

40 60 80 100 120 140 ▲

0 20 40 60 80 100 ○

DEPTH (FT)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT)	REMARKS
	Pt	0.4 PEAT - dark brown, moist, spongy 0.8	UF							12:55 4¼'' Walmac
2	OL	SILT - (organic), dark brown, mottled browns 2.0	F 10							
4	ML	SILT - trace med. to fine sand, dark brown 4.5								
6	GP	GRAVEL - fine to coarse, little med. to coarse sand, pebbles to 1.5''								
8			20							
10		9.0 little coarse, trace fine sand							9	13:10 To 3 7/8'' 13:16 Walmac
12		12.5 cobble, 4''							11.5	13:22 To 3 7/8'' tricone rock bit
14		ice chunks in cuttings	25							
16									15	13:39 To 3 7/8'' Walmac
									16	

LOGGED BY: J.J.S.

CHKD: D.O.

DRWN. BY: J.M.B.

CHKD: D.O.

FACILITY:

LAT. & LONG: 68°51'10''N, 137°17'54''W

AIRPHOTO No.: A 13751-31

RIG: HELI-DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: 4°C

START: D 02 M 08 Y 75 TIME: 12:55

FINISH: D 02 M 08 Y 75 TIME: 18:20

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED

CALGARY ALBERTA

ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B6-B

SHEET 1 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GP		(GRAVEL) cont'd		F							16	
18													
												19	13:44 gasket on compressor 17:48 damaged
20													
22													
			23.0 some fine to coarse sand		30								
24			24.0 gravel mainly fine, (to 2''), little medium to coarse sand, trace fine sand									24	ice chunks
26													
28												28	17:58 18:04
30													
32			increasing ice		40							32	

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°51'10''N, 137°17'54''W	ELEVATION:	
DRWN. BY: J.M.B.	AIRPHOTO No.: A 13751-31	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 4°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 02 M 08 Y 75 TIME: 12:55 FINISH: D 02 M 08 Y 75 TIME: 18:20

TEST HOLE No.

N75-117A-B6-B

SHEET 2 OF 3

PC-9,SK373

TEST HOLE No.N75-117A-B6-B

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	GP		(GRAVEL) cont'd		F							32	reamed hole
34													
36					30								
38			38.0 End of hole									38	18:13 18:20 On unhooking kelly rod felt gas or air from drillstem. Difficulty at 20' depth on withdrawing stem.

LOGGED BY:	J.J.S.	FACILITY:		PROJECT:	13011
CHKD:	D.O.	LAT. & LONG:	68°51'10''N, 137°17'54''W	ELEVATION:	
DRWN. BY:	J.M.B.	AIRPHOTO No.:	A 13751 - 31	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI-DRILL	AIR TEMP:	4°C
		METHOD:	AIR		

START: D 02 M 08 Y 75 **TIME:** 12:55 **FINISH:** D 02 M 08 Y 75 **TIME:** 18:20

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES
COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B6-B

SHEET 3 **OF** 3

PC-9,SK373

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit; 40 60 80 100 120 140 ▲; 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.3 PEAT - fibrous, dark brown, moist		UF								4¼'' Walmac
	ML		SILT - dark grey, mottled light brown, trace gravel to 1'' 2.0	1.3									subrounded pebbles
2			GRAVEL - coarse, little sand		F 15								
	GW												
4													
6			6.0 ---- cobble										
8			8.0 ---- cobble, 4''									8	4¼'' Tricone
10												10	17:35 3 7/8'' Walmac
12													
			13.0 ---- trace sand, gravel, mainly fine, to 1''		35								
14													
16												16	

LOGGED BY: J.J.S.
CHKD: D.O.
DRWN. BY: J.M.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: $68^0 51'54''$N, $137^0 20'40''$W
AIRPHOTO No.: A 13751-31
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 4^0C

START: D 01 M 08 Y 75 TIME: 17:11
FINISH: D 01 M 08 Y 75 TIME: 18:10

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B6-C

SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B6-C

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ○ Water content % — Plastic limit ├──┤ Liquid limit — ▲ 40 60 80 100 120 140; ○ 0 20 40 60 80 100

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GW		(GRAVEL) cont'd		F 35							16	
18													
19.0	SP		SAND - fine to medium, little fine gravel, trace silt		40							19	17:42
20													
22													
24													
25.0	GP ?		GRAVEL - fine, sandy, trace silt		20								
26													
28												29	17:46 17:51
30.0			---- fine to coarse sand										
30													
32												32	

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011
CHKD: D.O.	LAT. & LONG: 68°51'54"N, 137°20'40"W	ELEVATION:
DRWN. BY: J.M.B.	AIRPHOTO No.: A 13751-31	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 4°C
	METHOD: AIR	

START: D 01 M 08 Y 75 TIME: 17:11

FINISH: D 01 M 08 Y 75 TIME: 18:10

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B6-C

SHEET 2 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B6-C

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	GP		(GRAVEL) cont'd		F							32	
34		34.0	fine gravel, little sand, trace silt		75								
36		37.0										37	18:00 18:03
38	SP ?		SAND										
40		41.0											
	ICE+	41.7	ICE – sandy, silty		ICE+								
42	GP		GRAVEL – fine, some medium to coarse sand (trace silt)		F 60								
44													
46													
48		48.0	End of hole									48	Walmac bit completely worn 18:10

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.D.	LAT. & LONG: 68°51'54''N, 137°20'40''W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
DRWN. BY: J.M.B.	AIRPHOTO No.: A 13751-31	PIPE MILEAGE:	
CHKD: D.D.	RIG: HELI-DRILL	AIR TEMP: 4°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 01 M 08 Y 75 TIME: 17:11	FINISH: D 01 M 08 Y 75 TIME: 18:10		

TEST HOLE No.

N75-117A-B6-C

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B6-C

TEST HOLE LOG

LABORATORY TEST DATA
▲ Dry density (pcf) ○ Water content %
Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	DEPTH (FT.)	REMARKS
0.3	Pt	PEAT - dark brown, dry, fibrous	UF					Using shovels
	GW	GRAVEL - fine to coarse, subrounded, and cmf sand, dark grey, moist, stratified, isolated cobbles to 6'', few fibres to depth 3.7', medium dense						
2				MA, combined samples 1 - 6 G = 60% S = 38% F = 2%	B1	☒	2	
3					B2	☒	3	
4.0		little coarse to medium sand, damp			B3	☒	4	
5					B4	☒	5	
6.0		layer of gravel, coarse to fine, subrounded, some coarse sand			B5	☒	6	
6.5		(same as from 4.0' to 6.0')						
7.3			Vx 10		B6	☒	7	Using jack-hammer
7.8		Bottom of pit					7.8	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 68°50'28''N, 137°16'39''W	ELEVATION:	
DRWN. BY: D.J.M.	AIRPHOTO No.: A 13751-31	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP: 4°C	
	METHOD: TEST PIT		

START: D 01 M 08 Y 75 TIME: 21:00 FINISH: D 01 M 08 Y 75 TIME: 22:45

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

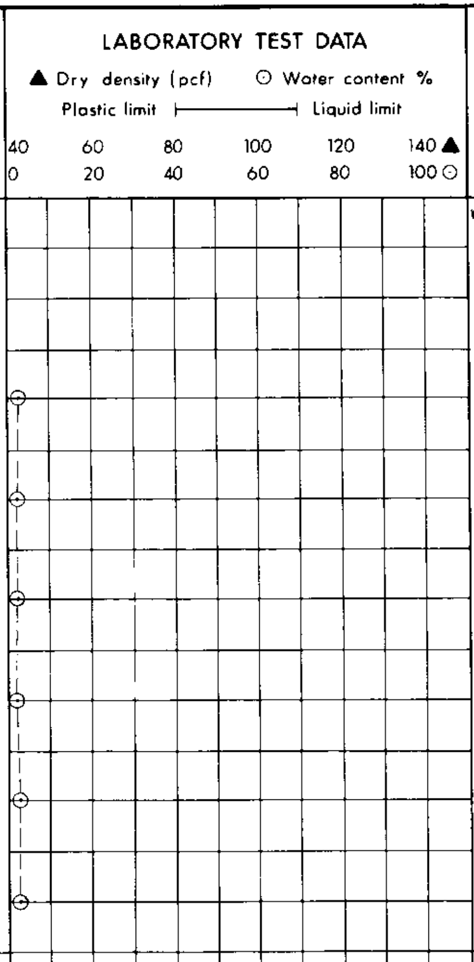
TEST HOLE No.
N75-117A-B6-1
SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B6-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	SW		SAND – coarse to fine; some gravel, coarse and fine, subrounded; trace silt, trace organic and fibres.		UF	W%						Using shovels
0.5	GW		GRAVEL – fine to coarse, and medium to coarse sand, grey, moist, stratified, isolated cobbles to 7'', dense.									
1											1	
2.0			no silt; damp, loose.			MA, combined samples 1-6 3.2 Oversize = 2.6% G = 58% S = 39% F = 3%	B1	☒			2	
3.0			little coarse, medium sand.			2.9	B2	☒			3	layer of fine, rounded gravel at 3.0' – 3.4'
4						2.6	B3	☒			4	
5						2.4	B4	☒			5	Layer of gravel, fine and rounded at 4.7' – 5.0'.
5.5			some sand.									
6						2.7	B5	☒			6	
7						2.6	B6	☒			7	
7.5			Bottom of pit									



LOGGED BY: J.G.R	FACILITY:	PROJECT: 13011
CHKD: R.H.	LAT. & LONG: 68°51'10''N, 137°17'54'' W	ELEVATION:
DRWN. BY: D.J.M.	AIRPHOTO No.: A 13751-31	PIPE MILEAGE:
CHKD: D.O.	RIG: -	AIR TEMP: 10°C
	METHOD: TEST PIT	

START: D 01 M 08 Y 75 TIME: 15:30

FINISH: D 01 M 08 Y 75 TIME: 18:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B6-2

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B6-2

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.8	SW	SAND - coarse to fine, and gravel, fine, subrounded, light brown, dry, some fibres, medium dense.	UF								Using shovels
(1.5)	SP	SAND - medium to fine, trace silt, rusty brown, moist, stratified, few fibres.								1	
4.0		SAND - coarse and medium, and gravel, coarse to fine, subrounded, dark grey, damp, stratified, very few isolated cobbles to 4", dense. (combined = GW-SW)			MA, combined samples 1 - 5 G = 49% S = 49% F = 2%	B1 B2 B3	☒ ☒ ☒			2 3	Combined sample: "GRAVEL - fine to coarse, and sand" (GW-SW)
6.0	GW	GRAVEL - coarse and fine, subrounded, and sand, coarse to fine, grey, damp, isolated rounded cobbles to 4".				B4 B5	☒ ☒			4 5	
6.5		sand content increased	Nb							6	Using jack-hammer
7.0		Bottom of pit									

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: G.C.B.
CHKD: D.O.
FACILITY:
LAT. & LONG: 68°51'54''N, 137°20'50''W
AIRPHOTO No.: A 13751-31
RIG:
METHOD: TEST PIT
PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 4.5°C
START: D 01 M 08 Y 75 TIME: 12:20
FINISH: D 01 M 08 Y 75 TIME:

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B6-3
SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B6-3

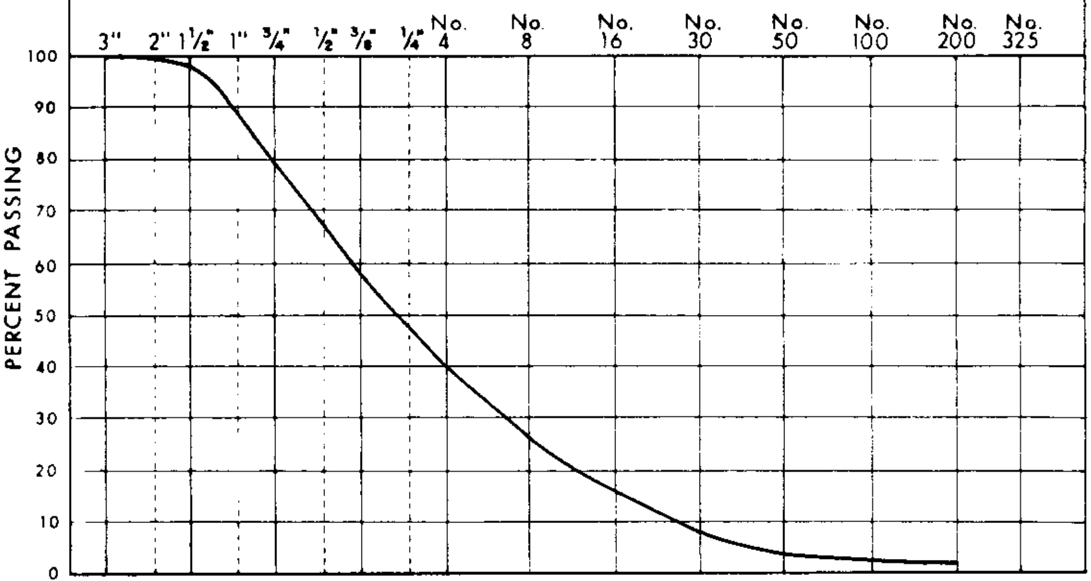
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B6-1 DEPTH 2.0 - 8.0

DATE SAMPLED August 1, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 76

GRAVEL SIZES		SAND SIZES			FINES
21 %	39 %	15 %	20 %	3 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	97.5
1"	86.5
¾"	79.2
½"	67.2
⅜"	57.1
¼"	
No. 4	39.5
No. 8	25.9
No 16	25.1
No. 30	7.6
No 50	3.6
No. 100	2.1
No. 200	1.5

COMMENTS

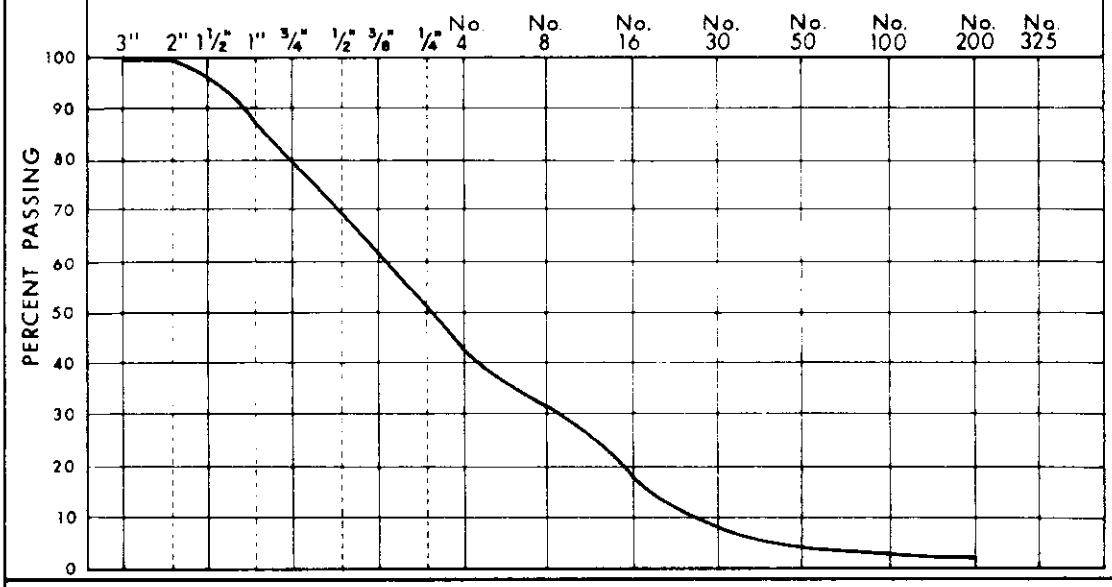
OVERSIZE (>3") = 0.0%

SAMPLE N75-117A-B6-2 DEPTH 0.5 - 7.5

DATE SAMPLED August 1, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 132

GRAVEL SIZES		SAND SIZES			FINES
21 %	37 %	14 %	22 %	3%	3%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	94.6
1"	87.0
¾"	79.4
½"	68.9
⅜"	60.1
¼"	
No. 4	41.9
No. 8	30.1
No. 16	18.3
No. 30	8.7
No. 50	4.2
No. 100	3.0
No. 200	2.6

COMMENTS

OVERSIZE (>3") = 2.6%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services
Company Limited

DEPOSIT No.
N75-117A-B6

PAGE
325

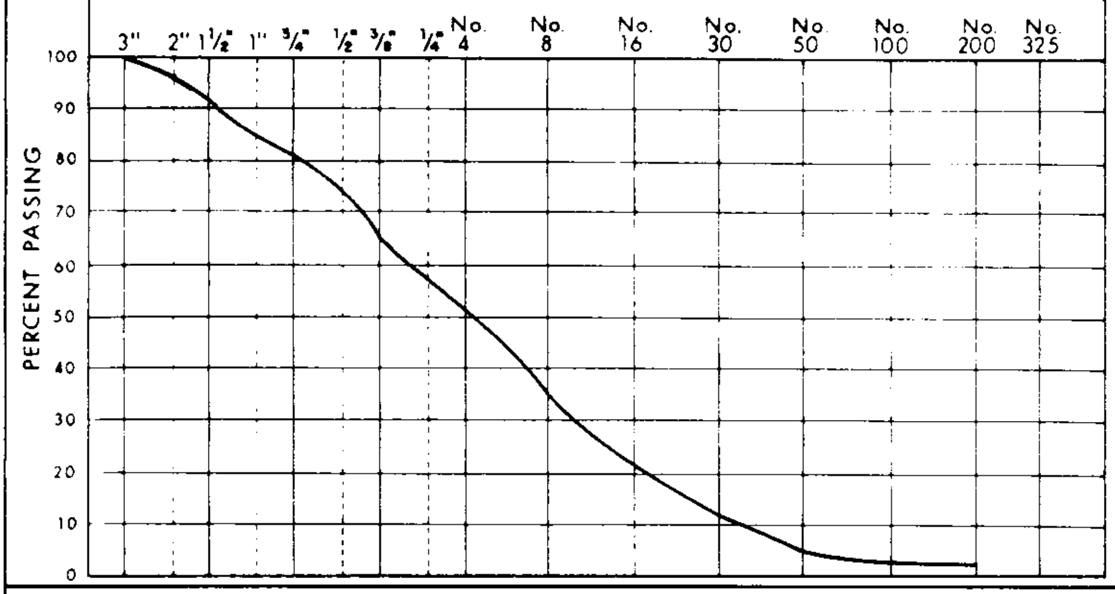
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B6-3 DEPTH 1.5 - 5.0

DATE SAMPLED August 1, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 109

GRAVEL SIZES		SAND SIZES			FINES
19 %	30 %	21 %	22 %	6 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	95.5
1½"	90.6
1"	84.8
¾"	80.8
½"	72.4
⅜"	65.1
¼"	
No. 4	51.1
No. 8	35.3
No. 16	21.2
No. 30	11.4
No. 50	5.9
No 100	3.3
No. 200	2.4

COMMENTS

OVERSIZE (>3") = 0.0%

SAMPLE

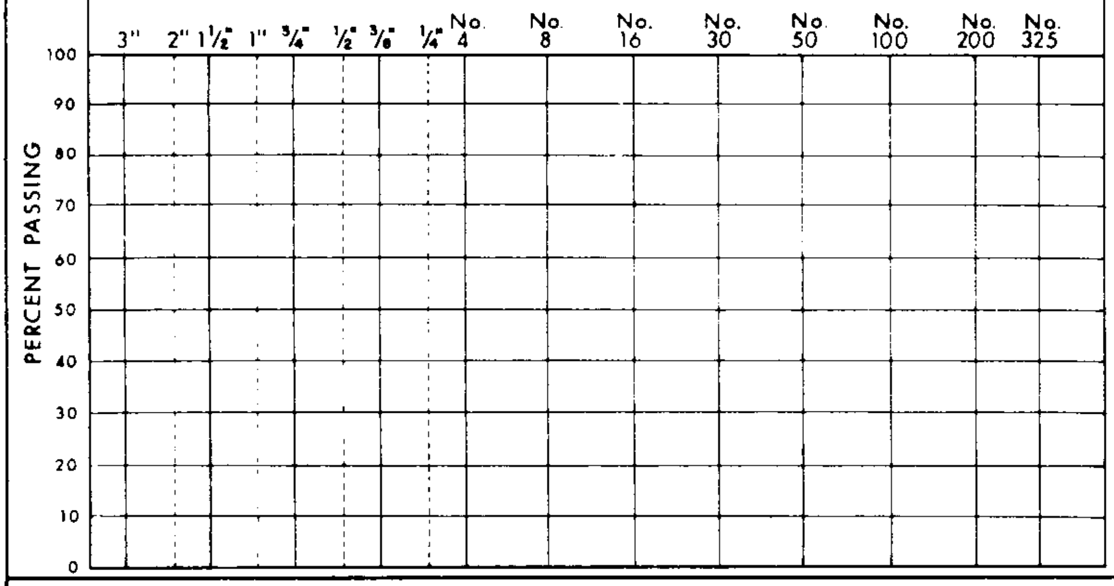
DEPTH

DATE SAMPLED

SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117A-B6

PAGE
326

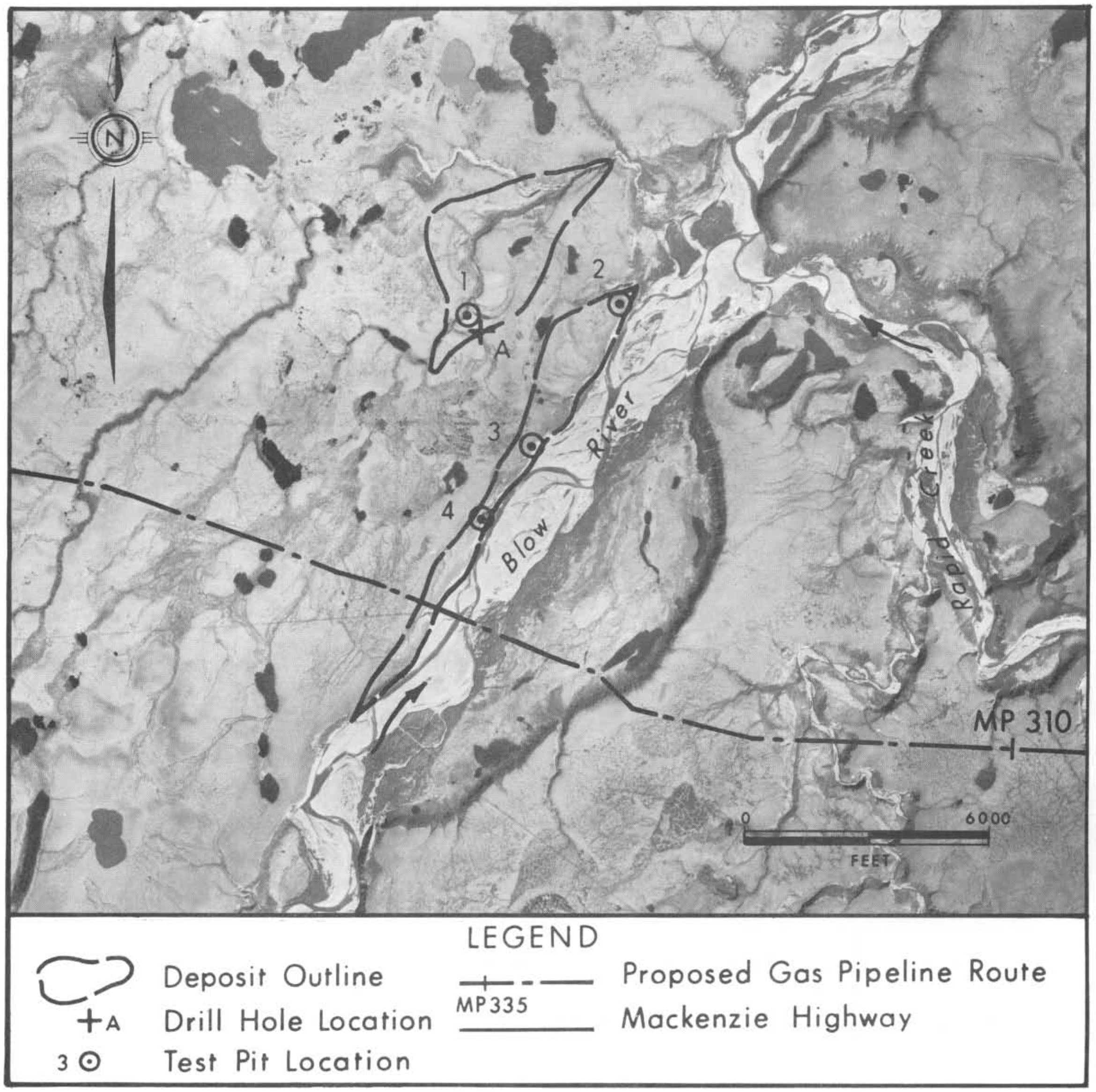
DEPOSIT 117A-B7

Physical Setting: The deposit consists of a series of fluvial terraces on the west side of Blow River near the confluence of Blow River and Rapid Creek. The proposed gas pipeline route crosses the deposit.

Material: Gravel; well graded, fine to coarse, and coarse, medium, and fine sand, trace fines.

Volume: 16,500,000 cubic yards.

Assessment: Deposit 117A-B7 is a good source of granular material but the available volume may be limited by drainage and overburden thickness. The proposed pipeline crosses the southern tip of the deposit. Granular material from this deposit could be used for general fill, backfill in pipeline construction, subgrade material for building pads, and asphalt and concrete aggregate.



Airphoto No.	A23838-28	Latitude:	68° 50' N
Approximate Scale:	1" = 5250'	Longitude:	137° 10' W

DEPOSIT 117A-B7

PHYSICAL SETTING

Deposit 117A-B7 consists of a series of fluvial terraces on the west side of Blow River at the confluence of Blow River and Rapid Creek. Mile 306.5 of the proposed pipeline right of way is at the southern tip of the deposit.

The terraces stand 120 to 150 feet above the Blow River floodplain and are separated by scarps of 10 to 30 feet. In the steep bank of the Blow River, gravel over shale is exposed. A small 30-foot deep valley bisects the northwestern part of the deposit.

The depth of gravel is from 10 to 20 feet thick in lower terraces along the river. It is more than 40 feet over most of the deposit. Ice contents are low. The active layer is 1 foot thick in areas of peat cover, but thicker where gravel is exposed.

The deposit is moderately well to well drained near the river bank and near terrace edges. The terraces are imperfectly to poorly drained toward their centres.

Gravel is exposed in the faces of terrace scarps and stream banks, and on well drained areas near terrace scarps. About one-third of the deposit has less than 6 inches of peat cover. Elsewhere, the deposit is covered by 4 to 10 feet of peat and ice-rich organic silt. Ice-wedge polygons 20 feet in diameter are present on parts of the terraces with thick cover.

BIOLOGICAL SETTING

Patches of sedge, moss, grass and lichen are present on well drained areas. Tundra vegetation composed primarily of sedge tussocks and moss covers poorly drained areas. Willow up to 6 feet high occurs on some slopes.

Small ponds in the area provide summer feeding and nesting for shore birds and ducks. The Blow River is a major spawning and rearing ground for grayling. Whitefish and inconnu utilize the delta. Arctic char are rare and no spawning concentrations have been found.

MATERIALS

The terraces are composed of good quality granular material consisting of stratified, medium dense to dense, subangular to rounded gravel with some fine to coarse sand, a trace of silt, and isolated cobbles. The content of gravel and sand sizes varies between strata.

VOLUME

The deposit has two main sections. The northwestern area covers about 300 acres and has a total volume of 12,000,000 cubic yards based on an average depth of 40 feet and moderate ice content. The eastern section, adjacent to the Blow River, extends over 200 acres and has a total volume of 45,000,000 cubic yards based on an average depth of 20 feet and moderate ice content. The deposit could be extended by including areas of terrace with relatively thick overburden.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B7 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, cover thicknesses, and material requirements. Excavations would be kept away from the Blow River stream channel to prevent siltation. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. The Blow River would not have to be crossed during development if material from the deposit was used only to the west of Blow River.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artifically dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT)	REMARKS
	Pt		PEAT - spongy, dark brown, wet 0.8		UF								19:00 3 7/8'' Walmac
2	OL		SILT-(organic) 1.0 low plastic, dark brown, mottled light brown. 3.0		F 30- 40								
4	ML		SILT – low plastic, medium grey. Ice rich 6.0										
6	ML		SILT - dark grey, low plastic 7.7										
8 10 12 14	GW		GRAVEL - fine to coarse, little sand, (trace silt) wood chips, pebbles to approx. 1" 15.0		20							9	19:06
16	SP		SAND - fine to medium, trace fine gravel.		10								

LOGGED BY: J.J.S	FACILITY	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°50'22''N, 137°09'51''W	ELEVATION:	
DRWN. BY: J.M.B.	AIRPHOTO No.: A 13232-43	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 4°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 02 M 08 Y 75 TIME: 19:00 FINISH: D 02 M 08 Y 75 TIME: 22:10

TEST HOLE No. N75-117A-B7-A

SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B7-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16			(SAND) cont'd		F								
18	SP											18	19:17
			(19.0) SAND - (19.0' to 19.5', fine sand only,) fine sand, uniform grain										
20	SP				10								
			21.0 GRAVEL - fine to coarse, some medium to coarse sand, (trace silt) pebbles to approx. 1''.										
22	GP												
24			24.0 GRAVEL - fine, silty, some sand, pockets of silt.										
	GM				15								
26													
												27	Change to 3 7/8'' tricone rock bit. Walmac bit badly worn.
28			(28.0) GRAVEL - fine, clean, moist										
	GP												
30													Withdraw stem
												31	Change to 3 7/8'' Walmac.
32			boulders, coarser gravel		5								

LOGGED BY:	J.J.S	FACILITY:		PROJECT:	13011
CHKD:	D.O.	LAT. & LONG:	68°50'22''N, 137°09'51''W	ELEVATION:	
DRWN. BY:	J.M.B.	AIRPHOTO No.:	A 13232-43	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI-DRILL	AIR TEMP:	4°C
		METHOD:	AIR		

START: D 02 M 08 Y 75 TIME: 19:00

FINISH: D 02 M 08 Y 75 TIME: 22:10

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B7-A

SHEET 2 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B7-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	GP		33.0 boulders,light brown,rock cuttings.		F							33	coarse sand from higher levels in air return. lost circulation Walmac bit almost totally destroyed. To 3 7/8'' tricone
34					5								
36												37	20:50 reduced air circulation from 37' to 39'.
38			39.0 coarse to 3'', (easier drilling)									39	21:03 Tricone bit worn out. New tricone bit.
40			possible medium to fine sand.		10–15								
42													
44			hole getting wetter, possibly due to thaw of frozen material by drilling.										
46													No cutting return
48			48.0 End of hole									48 0	Sloughing

LOGGED BY: J.J.S	FACILITY	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°50'22''N, 137°09'51''W	ELEVATION:	
DRWN. BY: J.N.B.	AIRPHOTO No.: A 13232-43	PIPE MILEAGE:	
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 4°C	
	METHOD: AIR		
START: D 02 M 08 Y 75 TIME: 19:00	FINISH: D 02 M 08 Y 75 TIME: 22:10		

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B7-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140▲ / 0 20 40 60 80 100⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.3	Pt	PEAT - some fine sand, dark brown, dry, fibrous.		UF								Using shovels
2.0	GP	GRAVEL - fine, subrounded, some sand, coarse to fine, rusty brown, dry, stratified, isolated cobbles to 5'', dense.										
	GW	GRAVEL - fine to coarse, and cmf sand, pebbles rounded, grey, moist, stratified, medium dense, isolated cobbles to 4''.				MA, combined samples 1 - 7 G = 69% S = 30% F = 1%	B1	☒			2	
							B2	☒			3	
							B3	☒			4	
4.3		— — and coarse to medium sand.					B4	☒			5	sloughing begins
5.2		— — includes fine sand.					B5	☒			6	using jack-hammer
							B6	☒			7	
8.2				Vx 5%			B7	☒				
8.5		Bottom of pit at 8.5'										

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: G.C.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°50'22''N, 137°09'51''W
AIRPHOTO No.: A 13232-43
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 4°C

START: D 02 M 08 Y 75 TIME: 13:25
FINISH: D 02 M 08 Y 75 TIME: 16:00

1975 BORROW INVESTIGATION

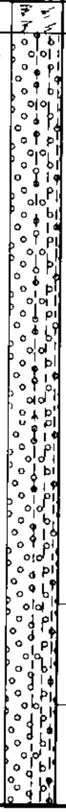
NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B7-1
SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B7-1

TEST HOLE LOG



DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT)	REMARKS
0.3	Pt		PEAT - dark brown, dry, fibrous		UF								Using shovels
	GW-GM		GRAVEL - mainly fine, subangular, and sand, coarse to fine, light brown, moist, stratified, isolated cobbles to 6'', dense										
6.0			— includes fine sand				MA, combined samples 1 - 3 oversize = 10.5% G = 57% S = 36% F = 7%	B1	☒			6	
7.0			— trace silt										
8												8	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: D.J.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°50'28''N, 137°09'35''W
AIRPHOTO No.: A 13232-43
RIG:
METHOD: TEST PIT (EXPOSURE)

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 10°C

START: D 02 M 08 Y 75 TIME: 14:00
FINISH: D 02 M 08 Y 75 TIME: 18:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B7-2

SHEET 1 OF 6

PC-9,SK373

TEST HOLE No. N75-117A-B7-2

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW- GM		GRAVEL (cont'd)		UF								Using shovels
9													
10													
11													
12									☒			12	
			(GRAVEL) - fine to coarse, and coarse to fine sand, trace fines										
13													
								B2					
14													
15												15	
16													

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011
CHKD: R.H.	LAT. & LONG: 68°50'28''N. 137°09'35''W	ELEVATION:
DRWN. BY: D.J.M.	AIRPHOTO No.: A 13232-43	PIPE MILEAGE:
CHKD: D.O.	RIG:	AIR TEMP: 10°C
	METHOD: TEST PIT (EXPOSURE)	

START: D 02 **M** 08 **Y** 75 **TIME:** 14:00 **FINISH:** D 02 **M** 08 **Y** 75 **TIME:** 18:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B7-2

SHEET 2 OF 6

PC-9,SK373

TEST HOLE No. N75-117A-B7-2

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW-GM		GRAVEL (cont'd)		UF								Using shovels
17													
18													
19													
20													
21							(MA combined 1-3)		☒			21	
22													
23			23.0 (GRAVEL) - fine to coarse, subangular, some sand, coarse to fine, light brown, damp, stratified, isolated cobbles to 8'', dense					B3					
24												24	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: D.J.M.
CHKD: D.O.
FACILITY:
LAT. & LONG: 68°50'28''N, 137°09'35''W
AIRPHOTO No.: A 13232-43
RIG:
METHOD: TEST PIT (EXPOSURE)
PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 10 °C
START: D 02 M 08 Y 75 TIME: 14:00
FINISH: D 02 M 08 Y 75 TIME: 18:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B7-2

SHEET 3 OF 6

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW- GM		GRAVEL (cont'd)		UF		MA, samples 4 - 7 oversize = 13.2% -3'' material: G = 63% S = 29% F = 8%						Using shovels
25			(GRAVEL) - fine to coarse, some cmf sand, trace fines					B4				25	
26													
27												27	
28								B5					
29													
30												30	
31													
32													

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: D.J.M.
CHKD: D.O.

FACILITY:
LAT. & LONG.: 68°50'28''N, 137°09'35''W
AIRPHOTO No.: A 13232-43
RIG:
METHOD: TEST PIT (EXPOSURE)

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 10°C

START: D 02 M 08 Y 75 TIME: 14:00
FINISH: D 02 M 08 Y 75 TIME: 18:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B7-2
SHEET 4 OF 6

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW-GM		GRAVEL (cont'd)		UF								Using shovels
33													
34													
35													
36							(MA 4 - 7)		☒			36	
37													
38								B6					
39												39	
40												40	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: D.J.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°50'28''N, 137°09'35''W
AIRPHOTO No.: A 13232-43
RIG:
METHOD: TEST PIT (EXPOSURE)

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 10°C

START: D 02 M 08 Y 75 TIME: 14:00
FINISH: D 02 M 08 Y 75 TIME: 18:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B7-2

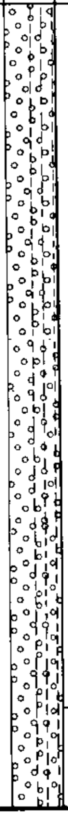
SHEET 5 OF 6

PC-9,SK373

TEST HOLE No. N75-117A-B7-2

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW- GM		GRAVEL (cont'd)		UF								Using shovels
41													
42							(MA 4 - 7)		☒			42	
43								B7					
44													
45												45	
46													
47			47.0 —— trace silt										
48			48.0 Bottom of pit									48	



LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: D.J.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°50'28''N, 137°09'35''W
AIRPHOTO No.: A 13232-43
RIG:
METHOD: TEST PIT (EXPOSURE)

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 10°C

START: D 02 M 08 Y 75 TIME: 14:00
FINISH: D 02 M 08 Y 75 TIME: 18:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B7-2

SHEET 6 OF 6

PC-9,SK373

TEST HOLE No. N75-117A-B7-2

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├───┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.3 PEAT - trace fine sand, dark brown, dry		UF								Using shovels
	GW		GRAVEL - mainly fine, subrounded, and coarse to fine sand, dark grey, damp, stratified, isolated cobbles to 4''										
1													
2							MA sample B1 G = 58% S = 41% F = 1%	B1	☒			2	
3			3.0 — (GRAVEL) - fine to coarse, and coarse to fine sand, pebbles subrounded, grey, damp, stratified, medium dense										
4							MA, combined samples 2 - 6 oversize = 3.9% G = 62% S = 36% F = 2%	B2	☒			4	
5												5	
6													
7								B3	☒			7	
8												8	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 68°49'42''N, 137°09'34''W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
DRWN. BY: D.J.M.	AIRPHOTO No.: A 13232-43	PIPE MILEAGE:	CANADIAN ARCTIC GAS STUDY LIMITED
CHKD: D.O.	RIG:	AIR TEMP: 10°C	
	METHOD: TEST PIT (EXPOSURE)		
START: D 02 M 08 Y 75 TIME: 18:50	FINISH: D 02 M 08 Y 75 TIME: 21:30		

TEST HOLE No.

N75-117A-B7-3

SHEET 1 OF 2

PC-9,SK373

TEST HOLE No.N75-117A-B7-3

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit |———| Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	GW		GRAVEL (cont'd) and sand		UF								Using shovels
9													
10												10	
11			11.0										
	SP		SAND					B4	☒				
12			12.0 — little gravel									12	
								B5	☒				
13								B6	☒			13	
14			14.0 Bottom of pit									14	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: D.J.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°49'42''N, 137°09'34''W
AIRPHOTO No.: A 13232-43
RIG:
METHOD: TEST PIT (EXPOSURE)

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 10°C

START: D 02 M 08 Y 75 TIME: 18:50
FINISH: D 02 M 08 Y 75 TIME: 21:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B7-3

SHEET 2 OF 2

PC-9,SK373

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % · Plastic limit ├──┤ Liquid limit · 40 60 80 100 120 140 ▲ · 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.3 PEAT - dark brown, dry fibrous		UF								Using shovels and pick-axe
	GW-GM		GRAVEL - fine to coarse, some cmf sand, rusty brown, dry, stratified, isolated rounded cobbles to 7'', dense										
1													
2							MA, combined samples 1 - 7 G = 65% S = 28% F = 7%	B1	☒			2	Excessive sloughing
3			3.0 — — moist, light brown					B2	☒			3	
								B3	☒				
4								B4	☒			4	
								B5	☒				
								B6	☒				
5			5.0 Bottom of pit					B7	☒			5	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	
CHKD: R.H.	LAT. & LONG: 68°49'28''N, 137°09'45''W	ELEVATION:	
DRWN. BY: D.J.M.	AIRPHOTO No.: A 13232-43	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP: 10°C	
	METHOD: TEST PIT		

START: D 02 M 08 Y 75 TIME: 18:20 FINISH: D 02 M 08 Y 75 TIME: 20:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B7-4

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B7-4

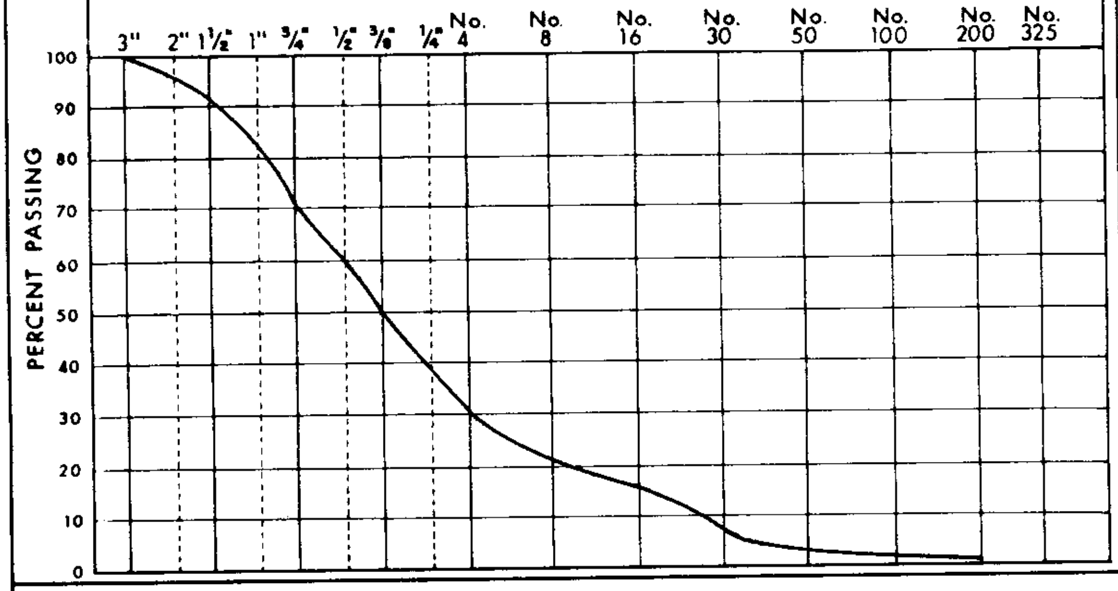
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B7-1 DEPTH 2.0 - 8.0

DATE SAMPLED August 2, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 116

GRAVEL SIZES		SAND SIZES			FINES
28 %	41 %	11 %	15 %	4 %	1 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	95.5
1½"	90.7
1"	81.8
¾"	71.7
½"	59.3
⅜"	48.4
¼"	
No. 4	30.7
No. 8	20.8
No. 16	14.1
No. 30	7.9
No. 50	3.0
No. 100	1.4
No. 200	1.0

COMMENTS

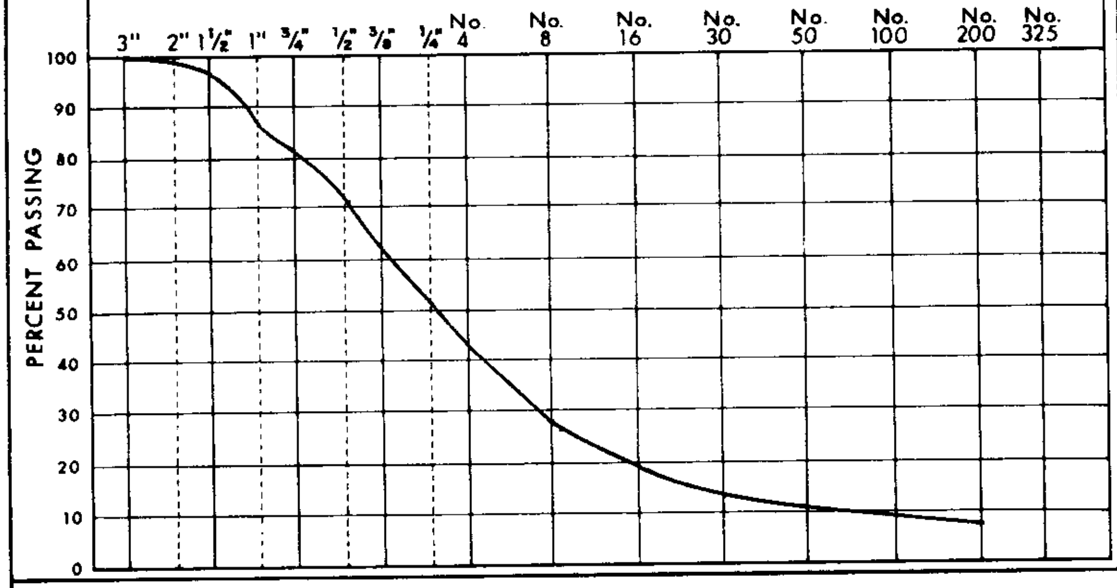
OVERSIZE (>3") = 0.0%

SAMPLE N75-117A-B7-2 DEPTH 6.0 - 24.0

DATE SAMPLED August 2, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 74

GRAVEL SIZES		SAND SIZES			FINES
18 %	39 %	15 %	15 %	6 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	97.1
1"	87.7
¾"	81.5
½"	70.6
⅜"	61.0
¼"	
No. 4	43.3
No. 8	29.0
No. 16	19.1
No. 30	13.4
No. 50	10.6
No. 100	8.2
No. 200	7.2

COMMENTS

OVERSIZE (>3") = 10.5 %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

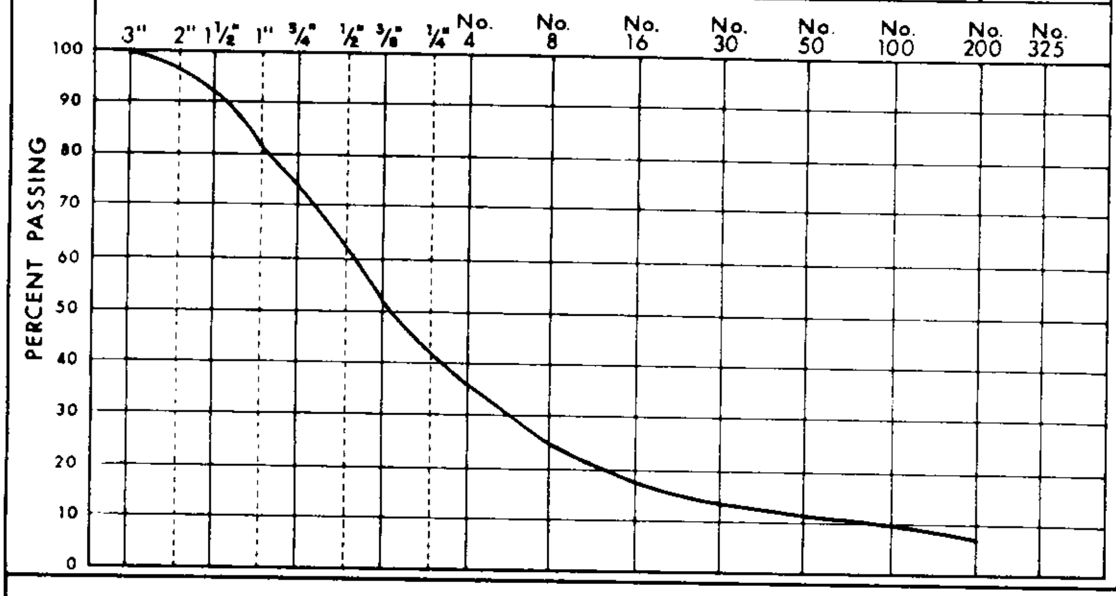
DEPOSIT No.
N75-117A-B7

SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B7-2 DEPTH 24.0 - 45.0
DATE SAMPLED August 2, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 75

GRAVEL SIZES		SAND SIZES			FINES
27 %	36 %	12%	12 %	5 %	8 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	96.3
1½"	92.5
1"	81.2
¾"	72.8
½"	61.2
⅜"	52.1
¼"	
No. 4	36.6
No. 8	24.3
No. 16	17.7
No. 30	13.7
No. 50	11.1
No. 100	9.3
No. 200	7.8

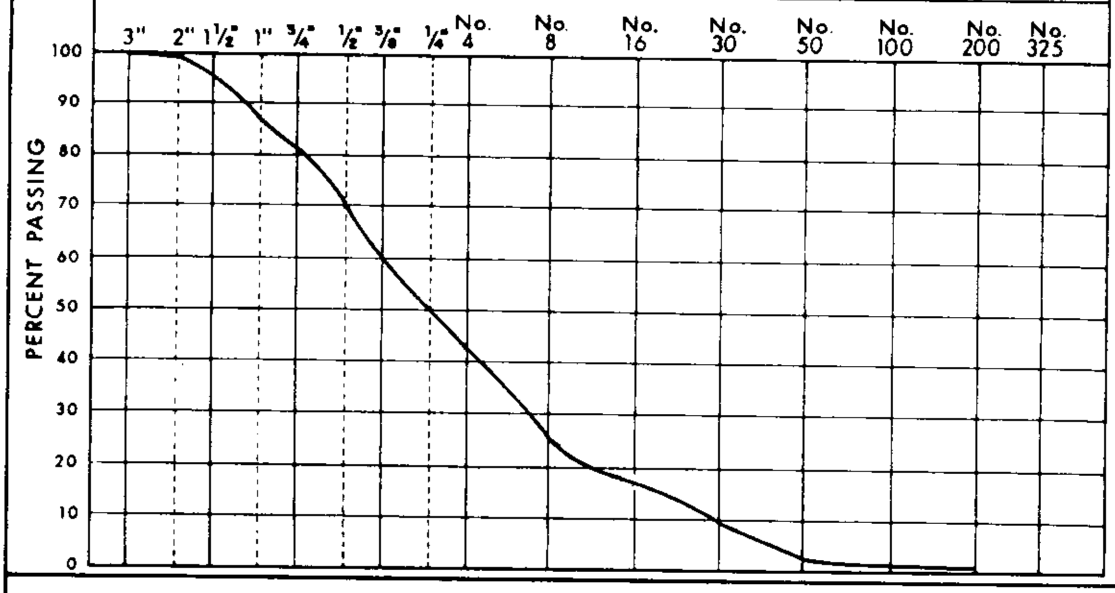
COMMENTS

OVERSIZE (>3") = 13.2 %

SAMPLE N75-117A-B7-3 DEPTH 2.0 - 2.5
DATE SAMPLED August 2, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 87

GRAVEL SIZES		SAND SIZES			FINES
19 %	39 %	20%	17 %	4 %	1 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	94.5
1"	85.9
¾"	81.4
½"	69.4
⅜"	59.1
¼"	
No. 4	41.8
No. 8	25.1
No. 16	16.7
No. 30	9.8
No. 50	2.8
No. 100	1.0
No. 200	0.8

COMMENTS

OVERSIZE (>3") = 0.0 %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No.
N75-117A-B7

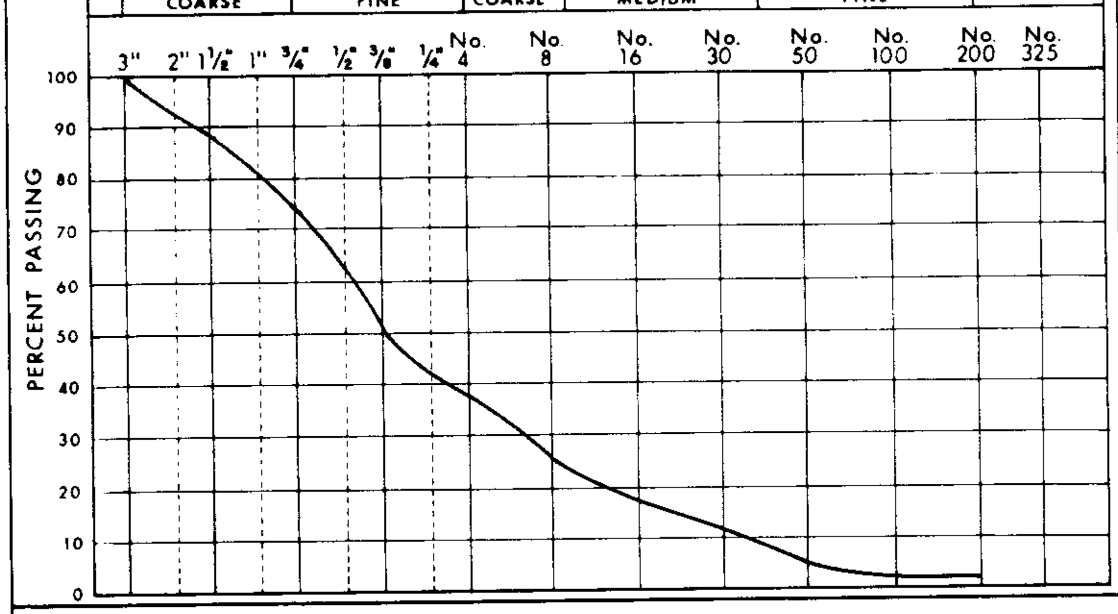
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B7-3 DEPTH 4.0 - 15.0

DATE SAMPLED August 2, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 88

GRAVEL SIZES		SAND SIZES			FINES
26 %	36 %	14%	16 %	6 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	91.8
1½"	89.0
1"	80.8
¾"	73.8
½"	62.9
⅜"	51.1
¼"	
No. 4	37.8
No. 8	25.4
No. 16	17.5
No. 30	10.8
No 50	4.9
No 100	2.1
No. 200	1.7

COMMENTS

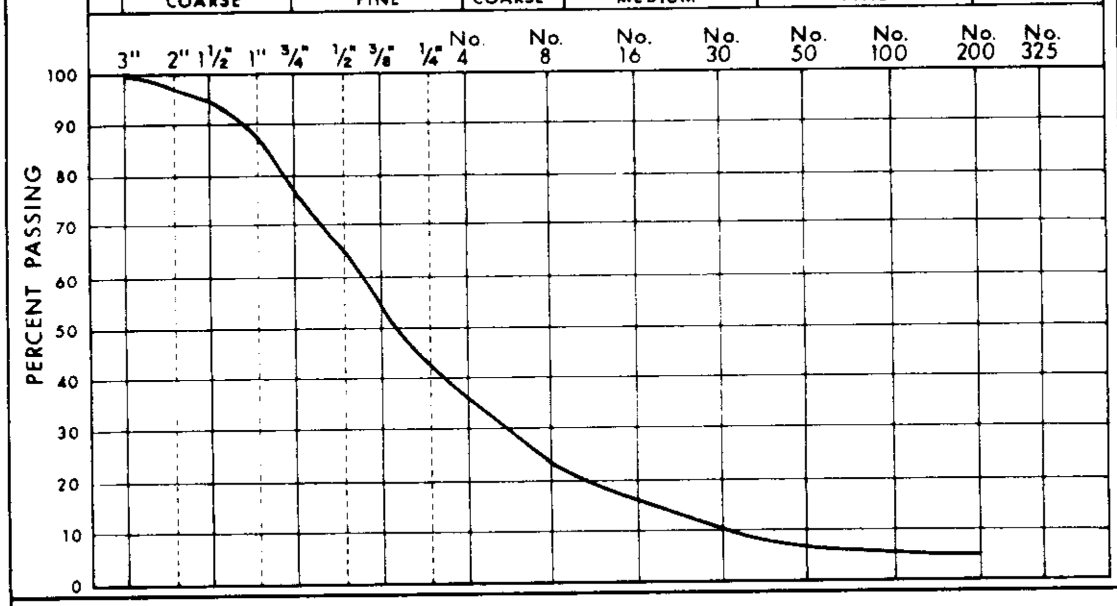
OVERSIZE (>3") = 3.9%

SAMPLE N75-117A-B7-4 DEPTH 2.0 - 5.0

DATE SAMPLED August 2, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 96

GRAVEL SIZES		SAND SIZES			FINES
23 %	42 %	14 %	13 %	1 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	96.9
1½"	94.5
1"	85.2
¾"	76.7
½"	63.7
⅜"	52.7
¼"	
No. 4	35.4
No. 8	23.6
No 16	15.9
No. 30	10.2
No. 50	7.5
No. 100	6.9
No. 200	6.7

COMMENTS

OVERSIZE (>3") = 0.0%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No. N75-117A-B7

PAGE 347

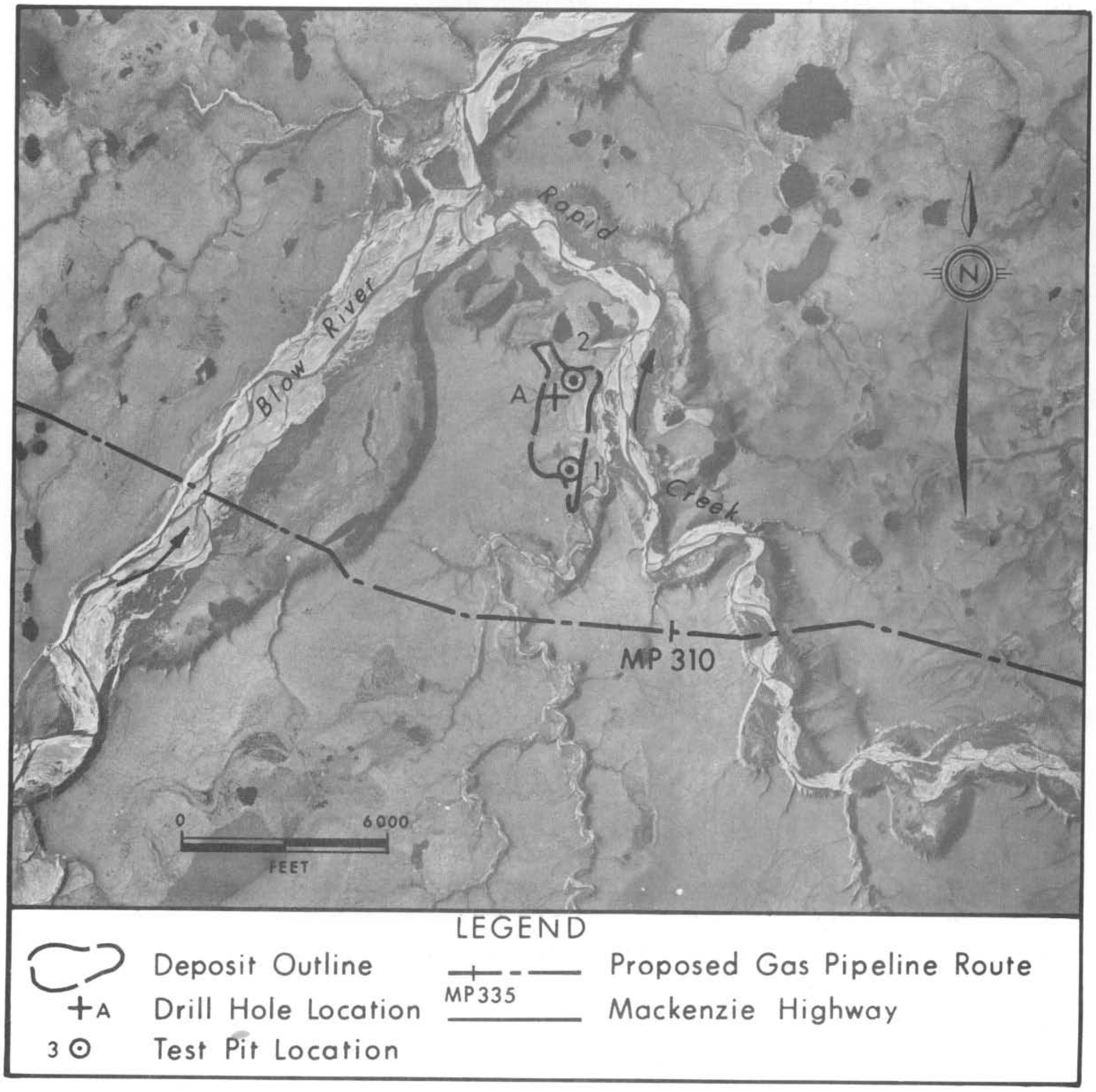
DEPOSIT 117A-B8

Physical Setting: Deposit 117A-B8 is a series of fluvial terraces on the west bank of Rapid Creek, 1 mile south of the Blow River - Rapid Creek junction and 1 mile north of mile 309 of the proposed gas pipeline.

Material: Gravel; well graded, coarse to fine, some coarse, medium, and fine sand, trace fines.

Volume: 3,500,000 cubic yards.

Assessment: Deposit 117A-B8 is a good source of granular material but the available volume may be limited by drainage and overburden thickness. Access to the proposed gas pipeline route is good, across flat terrain. Materials would be suitable for general fill, backfill in pipeline construction, and building pad subgrade material.



Airphoto No. A13232-43
Approximate Scale: 1" = 5250'

Latitude: 68° 49' N
Longitude: 137° 04' W

DEPOSIT 117A-B8

PHYSICAL SETTING

Deposit 117A-B8 is a series of fluvial terraces on the west bank of Rapid Creek 1 mile south of the junction of Blow River and Rapid Creek, and 1 mile north of mile 309 of the proposed pipeline.

The terraces, which stand 75 to 100 feet above Rapid Creek, are separated by 10 to 20 feet high scarps and have surfaces sloping gently northwest. The adjacent stream-cut scarp has steep slopes.

The area within 50 to 100 yards of the stream bank is well drained with less than 6 inches of patchy vegetative cover. Away from the outer edges of the terraces, the deposit is imperfectly to poorly drained and overburden thickness may reach 12 feet in some depressions.

The river bank above Rapid Creek has 25 to 30 feet of gravel overlying shale. The ice content of the gravel is low, although some massive ice layers are present in the overlying peat and silt in the poorly drained areas. The active layer is 1 to 2 feet deep where vegetative cover is present, and more than 4 feet on bare gravel.

The area between the deposit and the pipeline route is an imperfectly drained, flat to gently sloping plain, which is incised by a small stream valley.

BIOLOGICAL SETTING

Patches of moss and lichen appear in dry areas over exposed gravel. Elsewhere, the deposit is covered primarily by sedge tussocks, moss, dwarf willow and dwarf birch.

Rapid Creek is a major spawning and rearing ground for grayling. Whitefish spp. and barbot use the mouth as a feeding area. Care should be taken to avoid siltation of the stream.

MATERIALS

The terrace contains good quality material consisting of stratified, subangular to subrounded, shale-like, dense, dark gray gravel with some fine to coarse sand. Isolated cobbles and boulders up to 10 inches in diameter were noted.

VOLUME

The deposit covers approximately 150 acres and has a total volume of approximately 3,500,000 cubic yards based on a depth of 25 feet and moderate ice contents.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B8 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Excavations would be kept away from the Rapid Creek stream channel to prevent siltation of the stream and to protect the stream environment. Granular material from this deposit could be used for general fill, backfill in pipeline construction, and building pads. The gravel would require further testing before being considered for use in concrete production. The predominance of shale in the gravel may mean that this deposit could not be used for concrete aggregate production.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the pipeline right of way. Valley crossings should be avoided as they are quite steep. Other deposits are available on the opposite sides of the Blow River and Rapid Creek valleys.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation away from natural drainage channels.

Development of this deposit would involve excavating borrow material evenly from the well drained areas so that good drainage would be established over the area. This type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used.

Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artifically dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be carried out to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ⊢——⊣ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	PT		PEAT - dark brown, fibrous										13:30 4 1/4'' Walmac
2	OL		0.3 SILT-(organic) dark brown, mottled grey, damp rootlets. 2.0		UF								
			3.0 3.0		Vs 15								
4	ICE		ICE 5.0 5.0		ICE								
6 8	ML		SILT - trace fine sand, low plastic, moist organics 10.0 10.0		Vs 45							9	13:31 13:36 Change bit 3 7/8'' Walmac
10	ICE		ICE - clear 11.5 11.5		ICE								
12 14 16	GW		GRAVEL - fine, some medium to coarse sand, pebbles to approx. 1'' Decreasing sand.		F							16	

LOGGED BY: J.J.S
CHKD: D.O.
DRWN. BY: J.M.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°49'25''N, 137°05'00''W
AIRPHOTO No. A13232-43
RIG: HELI-DRILL
METHOD: WALMAC, AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 6°C

START: D 03 M 08 Y 75 TIME: 13:30
FINISH: D 03 M 08 Y 75 TIME: 14:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES
COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B8-A

SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B8-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GW		(GRAVEL)		F								
18			18.0 oxidized pockets, little fine sand.									18	13:38 13:53
20													
22													
24			24.0 little medium to coarse sand, trace silt and fine sand		10								
26													Globules of yellow material easily powdered.
28												28	14:03 14:08
30													
32			32.0									32	

LOGGED BY:	J.J.S	FACILITY:		PROJECT:	13011
CHKD:	D.O.	LAT. & LONG:	68°49'25''N, 137°05'00''W	ELEVATION:	
DRWN. BY:	J.M.B.	AIRPHOTO No.:	A 13232-43	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI-DRILL	AIR TEMP:	6°C
		METHOD:	WALMAC, AIR		

START: D 03 M 08 Y 75 TIME: 13:30 **FINISH:** D 03 M 08 Y 75 TIME: 14:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B8-A

SHEET 2 **OF** 3

PC-9,SK373

TEST HOLE No. N75-117A-B8-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	CI		32.0 CLAY - medium plastic, dark grey, claystone fragments.		F							32	bit plugged by cuttings, lost circulation. new bit.
34			34.5 — slight silt, oxidation, trace gravel to 1"										
36			36.5 — shale & claystone fragments – platy.										
38			38.0 — end shaley material									38	14:33 14:37
40	BDRK		SHALE-(and CLAYSTONE) breakable but hard, (weak rock) weathered oxidized pockets, occasional pebbles to 1½"										
42													
44													
46													
48			48.0 End of hole									48 8	14:45

LOGGED BY: J.J.S
CHKD: D.O.
DRWN. BY: J.M.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°49'25''N, 137°05'08''W
AIRPHOTO No.: A 13232-43
RIG: HELI-DRILL
METHOD: WALMAC, AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 6°C

START: D 03 M 08 Y 75 TIME: 13:30
FINISH: D 03 M 08 Y 75 TIME: 14:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-BB-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-BB-A

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG		DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.3	PEAT – trace fine sand, dark brown, dry, fibrous.		UF								Using shovels Few fibrous roots to depth 1,0'.
1	GP			GRAVEL – fine to coarse, and medium sand, rusty brown, moist, stratified, medium dense. *(gravel sizes 3'' to 1.5'', with fine gravel.)				MA, combined samples 1–7 G = 63% S = 36% F = 1%	B1	☒			1	* possibly gap-graded from 0.3' to 3.2'
2			2.5	and sand, damp.					B2	☒			2	
3			3.2						B3	☒			3	
	GW			GRAVEL – coarse and fine, subrounded; and sand, coarse to medium, dark grey, wet, stratified, dense.										
4									B4	☒			4	
5									B5	☒			5	
6									B6	☒			6	
7			7.0	Bottom of pit					B7	☒			7	Permafrost at 7,0'

LOGGED BY: I.G.R.
CHKD: R.H.
DRWN. BY: R.I.S.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°49'02''N, 137°04'15'' W
AIRPHOTO No.: A 13232–43
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 4°C

START: D 03 M 08 Y 75 TIME: 12:35
FINISH: D 03 M 08 Y 75 TIME: 15:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75–117A–B8–1
SHEET 1 OF 1

PC-9,SK373

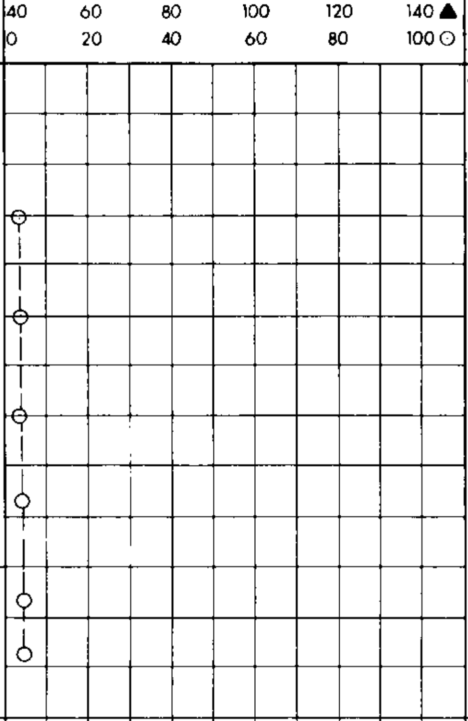
TEST HOLE No.N75-117A-B8-1

TEST HOLE LOG

LABORATORY TEST DATA

▲ Dry density (pcf) ⊙ Water content %

Plastic limit ├──┤ Liquid limit



DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.3	Pt	PEAT– little fine sand, dark brown, moist, fibrous.	UF	w%						Using shovels
	GW	GRAVEL– coarse to fine, some mcf sand, pebbles subrounded, dark grey, damp, stratified, medium dense.								
1				3.1 MA sample 1 G = 68% S = 30% F = 2% (GW)	B1	☒			1	
1.9		fine to coarse, some cmf sand, grey damp, stratified, isolated cobbles to 6'', isolated boulders to 10'', dense.								
2				3.7 MA, combined samples 2–6 G = 67% S = 28% F = 4% (GW)	B2	☒			2	
3				3.3 Oversize = 9.6%	B3	☒			3	A layer of gravel, essentially fine, at depth 3.6' – 3.9'
4				3.3	B4	☒			4	
5.0			Vx 5						5	Using jackhammer
5.5		and sand.		3.9	B5	☒				
6				4.2	B6	☒			6	
6.5		Bottom of pit.								

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION		TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 68°49'32''N, 137°04'42'' W	ELEVATION:			
DRWN. BY: R.J.S.	AIRPHOTO No.: A 13232-43	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR		N75-117A-B8-2
CHKD: D.O.	RIG:	AIR TEMP: 4°C			
	METHOD: TEST PIT				
START: D 03 M 08 Y 75 TIME: 12:30	FINISH: D 03 M 08 Y 75 TIME: 15:50		CANADIAN ARCTIC GAS STUDY LIMITED		SHEET 1 OF 1

PC-9,SK373

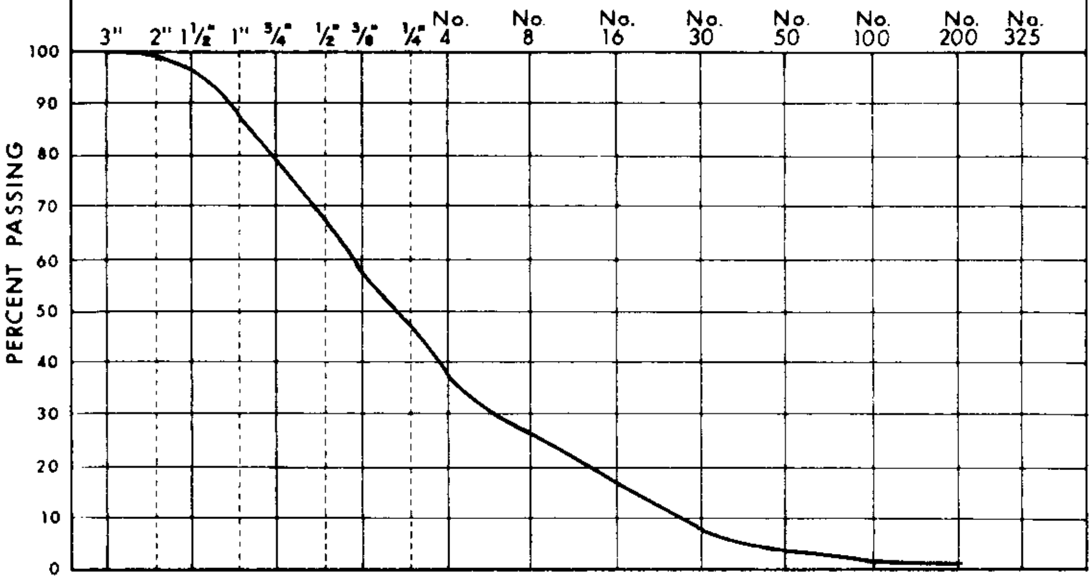
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B8-1 DEPTH 1.0 - 8.0

DATE SAMPLED August 3, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 124

GRAVEL SIZES		SAND SIZES			FINES
21 %	42 %	11 %	21 %	4 %	1%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	96.5
1"	87.7
¾"	79.4
½"	66.2
⅜"	56.3
¼"	
No. 4	36.8
No. 8	25.8
No. 16	16.3
No. 30	8.7
No 50	3.2
No.100	1.6
No. 200	1.2

COMMENTS

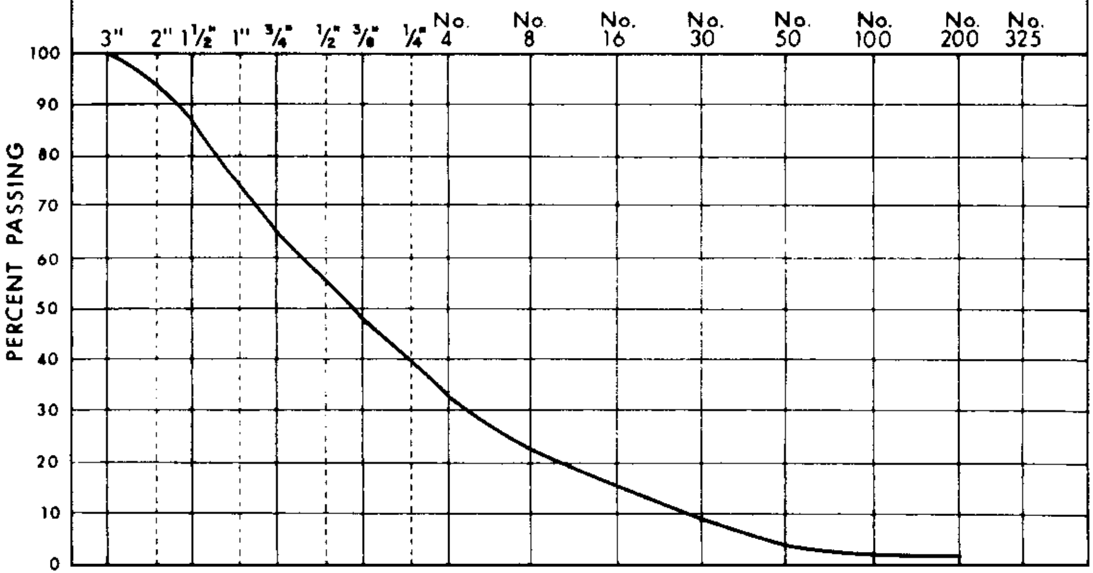
OVERSIZE (>3") = 0.0%

SAMPLE N75-117A-B8-2 DEPTH 1.0 - 2.0

DATE SAMPLED August 3, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 118

GRAVEL SIZES		SAND SIZES			FINES
35 %	33 %	11 %	14 %	5 %	2 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	93.4
1½"	85.6
1"	73.3
¾"	65.1
½"	55.2
⅜"	47.7
¼"	
No. 4	32.4
No. 8	22.7
No 16	15.4
No. 30	9.0
No. 50	3.8
No.100	2.0
No. 200	1.6

COMMENTS

OVERSIZE (>3") = 0.0%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117A-B8

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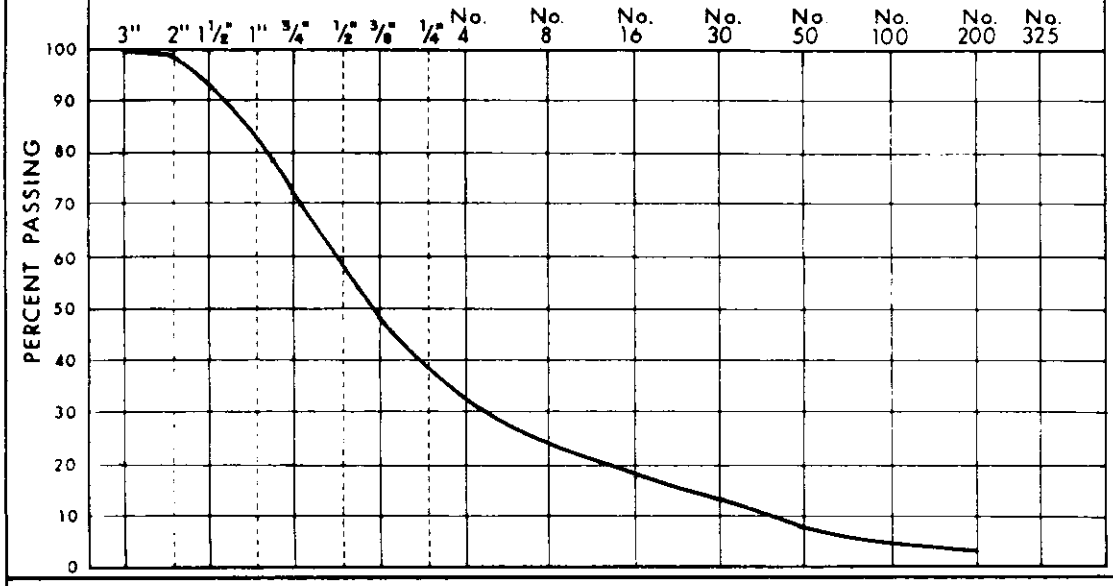
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B8-2 DEPTH 2.0 - 6.0

DATE SAMPLED August 3, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 119

GRAVEL SIZES		SAND SIZES			FINES
30 %	37 %	12 %	11 %	6 %	4 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	100.0
1½"	93.7
1"	80.6
¾"	70.2
½"	57.0
⅜"	48.2
¼"	
No. 4	32.8
No. 8	24.6
No. 16	17.8
No. 30	13.2
No. 50	7.6
No. 100	4.5
No. 200	3.7

COMMENTS

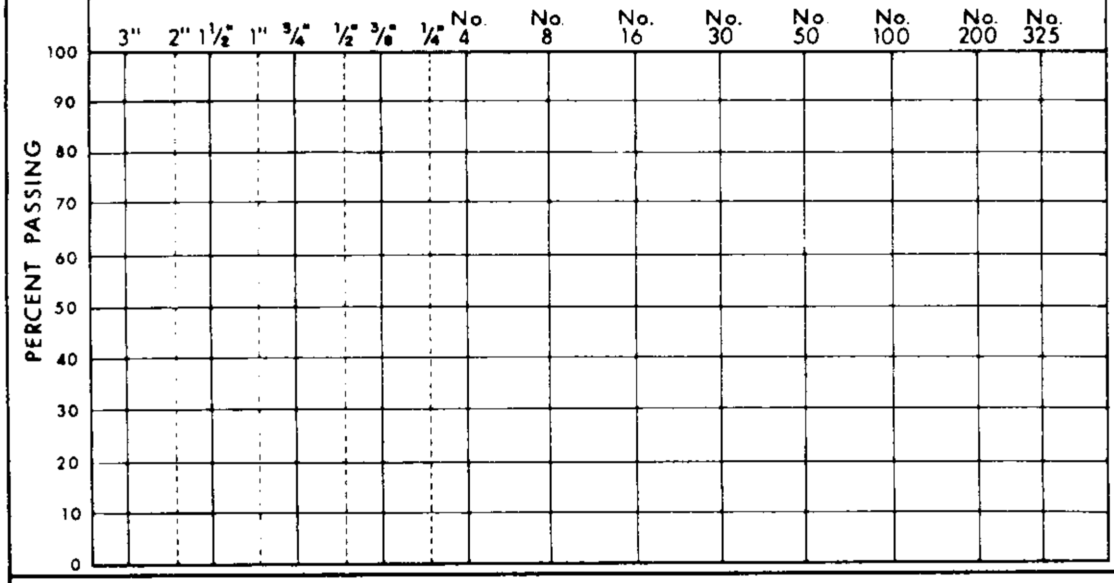
OVERSIZE (>3") = 9.6%

SAMPLE DEPTH

DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No.

N75-117A-B8

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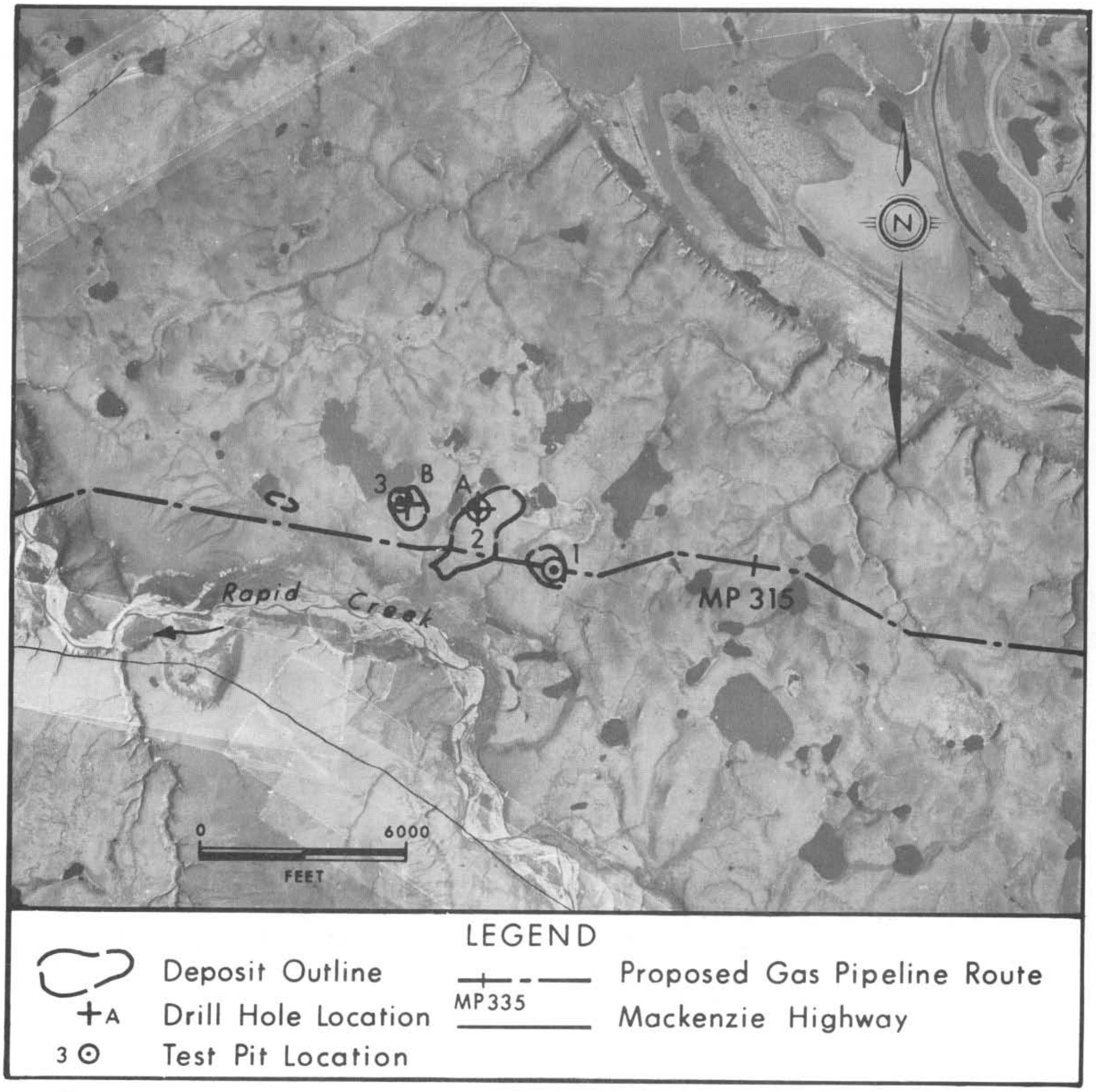
DEPOSIT 117A-B9

Physical Setting:	Deposit 117A-B9 consists of kames and kame deltas and is located east of Rapid Creek and 2 miles southwest of the Mackenzie Delta. The proposed gas pipeline route crosses the deposit.
Material:	Gravel; well graded, coarse to fine, some coarse, medium, and fine sand, trace to little fines.
Volume:	3,500,000 cubic yards.
Assessment:	Deposit 117A-B9 is a good source of granular material. The proposed gas pipeline right of way crosses the deposit, making haul distances short. Granular material from this deposit could be used for general fill, backfill in pipeline construction, and subgrade for building pads.



Airphoto No. A13232-50

Approximate Scale: 1" = 5250'

Latitude: 48° 48' N

Longitude: 136° 55' W

DEPOSIT 117A-B9

PHYSICAL SETTING

Deposit 117A-B9, which consists of kames and kame deltas, is located east of Rapid Creek about 2 miles southwest of the Mackenzie Delta. The proposed pipeline route crosses the deposit.

The western part of the deposit is a cluster of small kames approximately 10 feet high. The rest of the source consists of remnants of kame deltas, 30 to 50 feet high, with steep side slopes and surfaces sloping gently to the south. The remnants are surrounded by marshy terrain with numerous small lakes and patches of ice-wedge polygons.

The deposit is generally well drained with occasional imperfectly drained areas in the centre of the kame deltas. Gravel is exposed in patches along the edges. Most of the deposit has less than 3 feet of overburden above the gravel, although there may be up to 8 feet of peat and ice-rich silt in poorly drained areas.

The outwash materials in the kames overlie preglacial gravel, sand and silt. Thermokarst features and drill hole data indicate that the preglacial deposits contain ice-rich soil, ice lenses, or massive ice layers. The overlying outwash gravel has low to moderate ice contents. The active layer is 1 foot thick in areas of peat cover, and thicker under exposed gravel areas.

BIOLOGICAL SETTING

The deposit is covered by tundra vegetation consisting mainly of sedge tussocks, mosses, and grasses with some dwarf birch and willow on slopes and in poorly drained areas.

The area is utilized to some extent by caribou and grizzly bear. The small lakes in the surrounding area provide nesting habitat for waterfowl such as swans, arctic loons, ducks, and gulls. Arctic ground squirrels inhabit some well drained slopes.

The Rapid Creek valley to the south has good moose habitat and is an important spawning and rearing ground for grayling. Borrow operations would be kept at a sufficient distance from the stream so that the stream environment should not be affected.

MATERIALS

The outwash sediments are good quality granular material consisting of stratified, subrounded, dense gravel and sand with occasional cobbles and a trace of silt in some strata. Distribution of gravel and sand sizes varies between strata.

VOLUME

The depth of outwash material varies from 10 feet in the western part of the deposit to 30 feet in the eastern part. The kames to the west extend over 5 acres and have a total volume of 56,000 cubic yards. The kame delta remnants cover about 120 acres and have a total volume of approximately 3,500,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B9 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Granular material from this deposit could be used for general fill, backfill in pipeline construction, and building pads. The gravel would require further testing before being considered for use in concrete production.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize enviornmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. Rapid Creek would not necessarily have to be crossed during development as another deposit exists on its west side.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled separately around the edge of the excavation area away from the natural drainage channels.

Development of this deposit would involve excavating borrow material evenly from well drained areas so that good drainage would be established over the area. This type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artifically dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation techniques of the recontoured pit areas may be employed to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment, and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.6 PEAT – dark brown										20:15
			1.0		UF								
			SILT-(organic) fine roots and fibres low plastic, black. Highly organic		F								visible ice Walmac 4 1/4"
2					25								
	OL				10								
4			4.0									4	Tricone 4¼"
	GW		GRAVEL – fine to coarse, little medium to coarse sand, (trace silt and fine sand) pebbles to approx. 2"										
6													
8													
												9	20:31 Walmac 3 7/8" 20:36
10													
			11.0 ― pebbles to approx. 3", trace fine sand or silt (5%), yellow cuttings, easily broken										
12													
			14.0										
14			GRAVEL - increasing fine to medium sand and silt										
	GM												
16	?		16.0 possible coarser gravel to 2"- 3"		25								

LOGGED BY: J.J.S

CHKD: D.O.

DRWN. BY: J.M.B.

CHKD: D.O.

FACILITY:

LAT. & LONG: 68°47'54" N, 136°54'51" W

AIRPHOTO No.: A13232-50

RIG: HELI-DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: 7°C

START: D 03 M 08 Y 75 TIME: 20:15

FINISH: D 03 M 08 Y 75 TIME: 22:40

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B9-A

SHEET 1 OF 2

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16			(GRAVEL) cont'd		F							16	
	GM ?												
18													
												19	21:25
20													
22													
					15								
24			(24.0) ?										
	GW		GRAVEL—fine to coarse, trace fine to coarse sand, pebbles to approx. 3"										
26													
28												29	21:52 21:57
												30	
32													difficulty retrieving stem.
34			34 0 End of hole									34	sloughing wet

LOGGED BY: J.J.S	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°47'54"N, 136°54'51"W	ELEVATION:	
DRWN. BY: J.M.B.	AIRPHOTO No.: A13232-50	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.: 7°C	
	METHOD: AIR		
START: D 03 M 08 Y 75 TIME: 21:15	FINISH: D 03 M 08 Y 75 TIME: 22:40		CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B9-A

SHEET 2 OF 2

PC-9,SK373

TEST HOLE No. N75-117A-B9-A

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % — Plastic limit ├──┤ Liquid limit — 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT – spongy, wet.										13:30 water squeezed out. exposed stratified ice near surface
0.5	OL		SILT-(organic) low plastic, dark brown, mottled light brown. organic odour	1.0	UF F 25								
2.5	ML		SILT- trace fine sand, low plastic, dark grey		15								
6.0	GW		GRAVEL- coarse to fine, clean.		5								
7.5	ML		SILT- trace fine sand.										
			increasing ice content		20							9	3 7/8'' Walmac
11.0			clayey, medium grey.									11	''platy-shaped'' cuttings in air return.
					20								
14.0			(possible slight gravel)									14	occasional grinding.
16													

LOGGED BY: J J.S	FACILITY:	PROJECT: 13011	
CHKD: D.O.	LAT. & LONG: 68°47'58''N, 136°55'03''W	ELEVATION:	
DRWN. BY: J.M.B.	AIRPHOTO No.: A13232-50	PIPE MILEAGE:	
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 16°C	
	METHOD: AIR		
START: D 04 M 08 Y 75 TIME: 13:30		FINISH: D 04 M 08 Y 75 TIME: 15:00	

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B9-B

SHEET 1 OF 2

PC-9,SK373

TEST HOLE No. N75-117A-B9-B

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	ML		(SILT) (cont'd)		F								
			16.5 SAND – fine, silty, occas. rust pockets.										occasional grinding
18	SM											18	13:53 13:57
			19.5 some fine to medium sand										
20			20.0 (little) coarse sand, fine gravel									20	grinding. to 3 7/8" tricone rock bit
			GRAVEL – coarse, trace sand. pebbles to approx. 3"		10								
22													
												23	hole getting wet
24	GW		24.0 coarse to fine										
			25.5 25.5' - 27.5' finer gravel to coarse sand. approx. to 3/4"										
26													
			27.5										
28			28.0									28	slow progress
	SM		SAND – Silts and fine sands, inferred by drilling. 32' – some grinding and bouncing									29	14;37
34													No cutting return. Stem and bit seizing Attempted 3 7/8" Walmac Unsuccessful.
			35.0 End of hole										
			Practical refusal at 35.0'										

LOGGED BY: J.J.S	FACILITY:	PROJECT: 13011
CHKD: D.O.	LAT. & LONG: 68°47'56''N, 136°55'03''W	ELEVATION:
DRWN. BY: J.M.B.	AIRPHOTO No.: A13232-50	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.: · 16°C
	METHOD: AIR	

START: D 04 M 08 Y 75 TIME: 13:30

FINISH: D 04 M 08 Y 75 TIME: 15:00

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B9-B

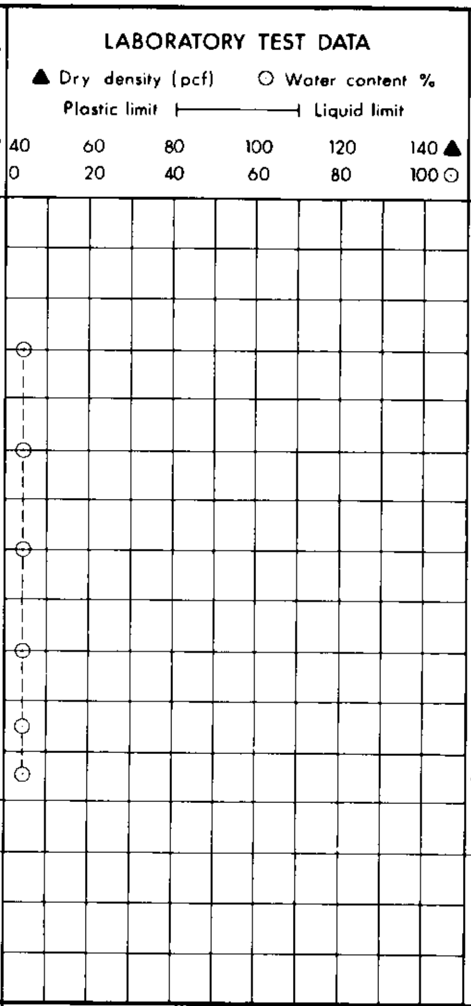
SHEET 2 OF 2

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	DEPTH (FT.)	REMARKS
0.2	Pt	PEAT - trace fine sand, dark brown, fibrous		UF	w%			Using shovels
1.0	SP	SAND,- medium to fine, trace silt, light brown, moist, stratified, isolated subrounded gravel to 1'' dense						
	GW-GM	GRAVEL - coarse and fine, subrounded, some sand, coarse to medium, dark grey, moist, stratified, numerous cobbles to 8'', dense			4 MA, combined samples 1 - 6 G = 64% S = 29% F = 7% (GW-GM)	B1	1	Using jack-hammer and pick-axe
					4	B2	2	
3.5		little sand			4	B3	3	
					+ 3'' material = 3.3% of total samples 4	B4	4	
5.0		fine sand, trace silt			4	B5	5	
					4	B6		
6.0				Vc 30		B7	6	
6.5		Bottom of pit						

LABORATORY TEST DATA



LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: D.O.	LAT. & LONG: 68°47'33''N, 136°53'59''W	ELEVATION:		N75-117A-B9-1
DRWN. BY: A.M.	AIRPHOTO No.: A 13232-50	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	
CHKD: B.O.	RIG:	AIR TEMP.: 15.5°C		
	METHOD: TEST PIT			
START: D 03 M 08 Y 75 TIME: 18:00		FINISH: D 04 M 08 Y 75 TIME: 15:00	CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

PC-9,SK373

TEST HOLE No.N75-117A-B9-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140▲ 0 20 40 60 80 100⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.2	Pt	PEAT– trace fine sand, dark brown, moist, fibrous.		VF								Using shovels
	GW-GM	GRAVEL – coarse and fine, subrounded to rounded; and sand, coarse to fine; trace silt; light brown, moist, stratified, isolated cobbles to 4.0'', dense.				MA, combined samples 1-6	B1	☒			1	
2.0		no silt, some sand, dark grey, wet, frequent cobbles to 7''.				Oversize= 4.3% G = 57% S = 36% F = 7%	B2	☒			2	
											3	Sand layer, mainly fine, at depth 3.6'-3.7'
4.5		trace silt					B3	☒			4	
5.0			+ + +	Vx 15			B4	☒			5	Using jack-hammer.
			+ + +				B5	☒			6	
7.0		Bottom of pit					B6	☒			7	

LOGGED BY: J.G.R.

CHKD: R.H.

DRWN. BY: R.J.S.

CHKD: D.O.

FACILITY:

LAT. & LONG: 68°47'56''N, 136°55'03'' W

AIRPHOTO No.: A 13232-50

RIG:

METHOD: TEST PIT

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP.: 4°C

START: D 03 M 08 Y 75 TIME: 16:40

FINISH: D 03 M 08 Y 75 TIME:

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B9-2

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No.N75-117A-B9-2

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.3	Pt		PEAT - dark brown, moist, fibrous		UF								Using shovels
1 1.2	ML		SILT - and sand, fine, low plastic, rusty brown, moist, isolated gravel, stiff									1	
2 2.5	GW-GM		GRAVEL - coarse to fine, subangular, some sand, coarse to fine, little silt, light brown, damp, isolated cobbles to 6'', dense — less fines from 2.5′ depth, subrounded gravel				MA, combined samples 1 - 5 oversize = 13.8% G = 56% S = 32% F = 12%	B1 B2	☒ ☒			2	
3 4								B3 B4	☒ ☒			3 4	Using shovels and pick-axe
5 5.2					Vc 30			B5	☒			5	using jack-hammer occasional ice lenses, ½'' thick
6.0 6			Bottom of pit									6	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 68°47'57''N, 136°56'02''W	ELEVATION:	
DRWN. BY: D.J.M.	AIRPHOTO No.: A 13232-50	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP: 7°C	
	METHOD: TEST PIT		
START: D 03 M 08 Y 75 TIME: 21:00	FINISH: D 03 M 08 Y 75 TIME:		CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B9-3

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B9-3

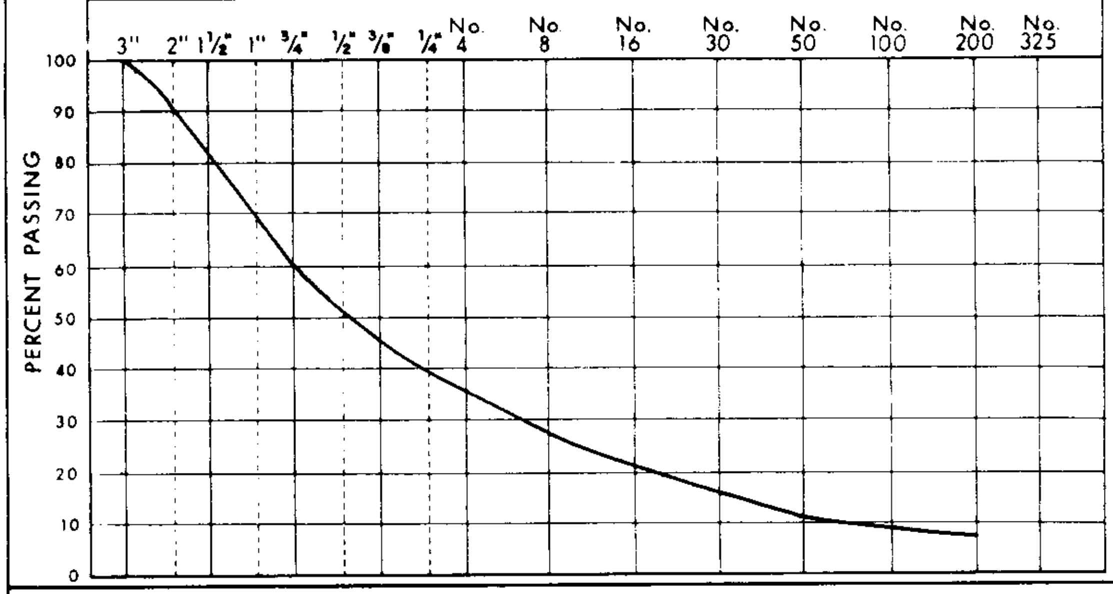
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B9-1 DEPTH 1.0 - 6.0

DATE SAMPLED August 3, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 65

GRAVEL SIZES		SAND SIZES			FINES
39 %	25 %	9 %	14 %	6 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	91.0
1½"	82.1
1"	68.7
¾"	60.7
½"	51.1
⅜"	45.4
¼"	
No. 4	35.5
No. 8	27.7
No. 16	21.6
No. 30	16.5
No. 50	12.1
No 100	8.9
No. 200	6.8

COMMENTS

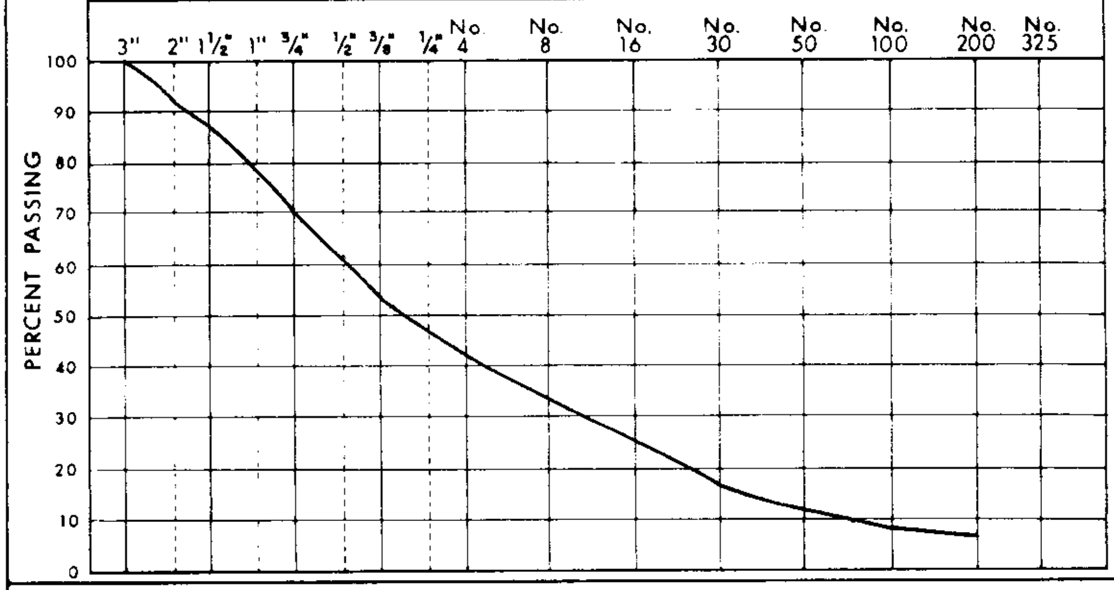
OVERSIZE (>3") = 3.3%

SAMPLE N75-117A-B9-2 DEPTH 1.0 - 6.5

DATE SAMPLED August 3, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 131

GRAVEL SIZES		SAND SIZES			FINES
30 %	27 %	9 %	20 %	7 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	91.5
1½"	86.9
1"	76.4
¾"	69.9
½"	60.5
⅜"	53.9
¼"	
No. 4	42.5
No. 8	35.1
No 16	26.1
No. 30	17.6
No 50	11.7
No 100	8.6
No 200	6.9

COMMENTS

OVERSIZE (>3") = 4.3 %

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-117A-B9

PAGE 373

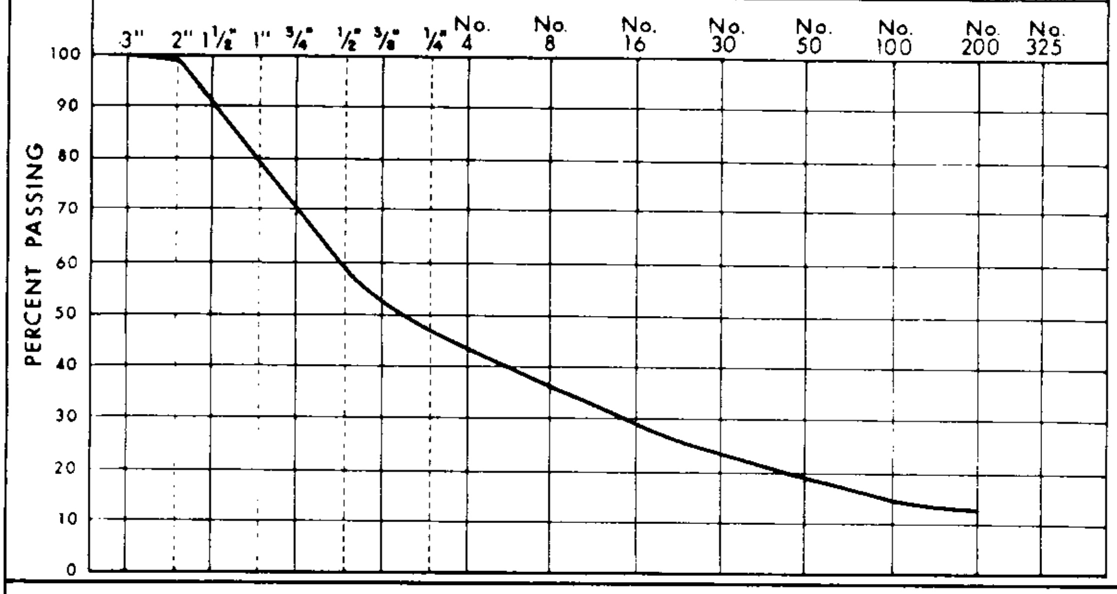
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B9-3 DEPTH 1.0 - 6.0

DATE SAMPLED August 3, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 84

GRAVEL SIZES		SAND SIZES			FINES
30 %	26 %	9 %	14 %	9 %	12 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	99.3
1½"	91.1
1"	77.1
¾"	69.9
½"	54.2
⅜"	52.8
¼"	
No. 4	43.7
No. 8	36.1
No. 16	29.6
No. 30	23.7
No. 50	18.7
No. 100	15.0
No. 200	12.3

COMMENTS

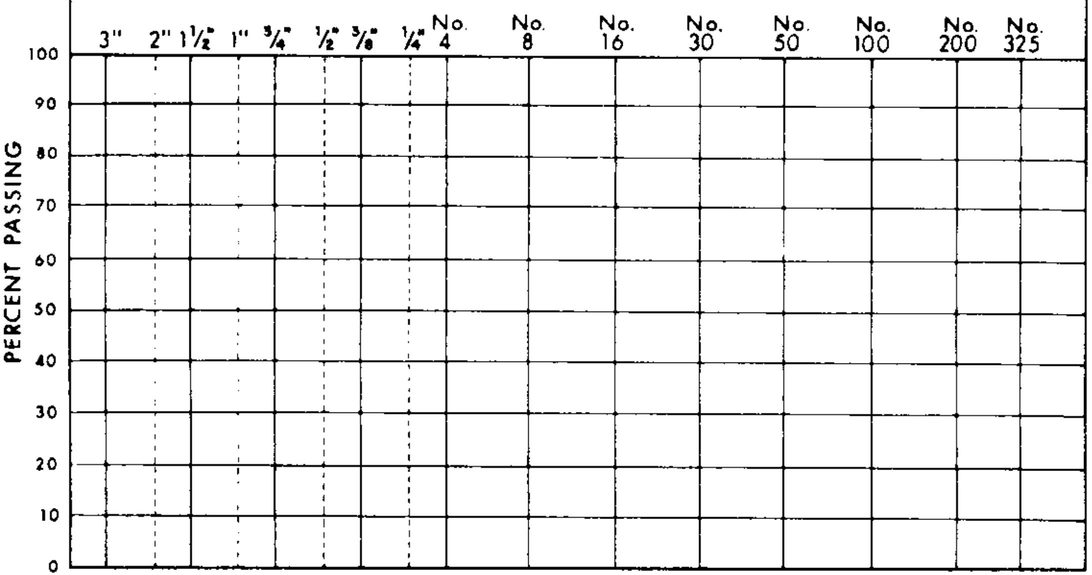
OVERSIZE (>3") = 13.8 %

SAMPLE ______ DEPTH ______

DATE SAMPLED ______ SAMPLED BY ______

R.M.HARDY REPORT NUMBER ______

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services
Company Limited

DEPOSIT No.
N75-117A-B9

PAGE
374

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. : N75-117A-B9-2 DATE SAMPLED : August 3, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1 - 7 DATE TESTED : January, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 4.85 %
FINE AGGREGATE : LOSS = 28.91 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 19.2 %

ORGANIC IMPURITIES TEST

NUMBER : 4+
COAL REMOVED : 3+
COAL & ROOTLETS REMOVED : 3
COAL CONTENT : 0.01%
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Medium strong to strong, Good to very good	6.45
Granite		0.1
Sandstone		45.8
Siltstone		4.3
Chert	Potentially reactive, Fair	0.25
Flint		0.75
Ironstone		0.45
Friable Sandstone	Weak, Poor	1.1
Friable Limestone		0.05
Schist		0.05
PN = 115	INTERPRETATION : Good quality coarse aggregate	59.3

COMMENTS :

NORTHERN Engineering Services Company Limited

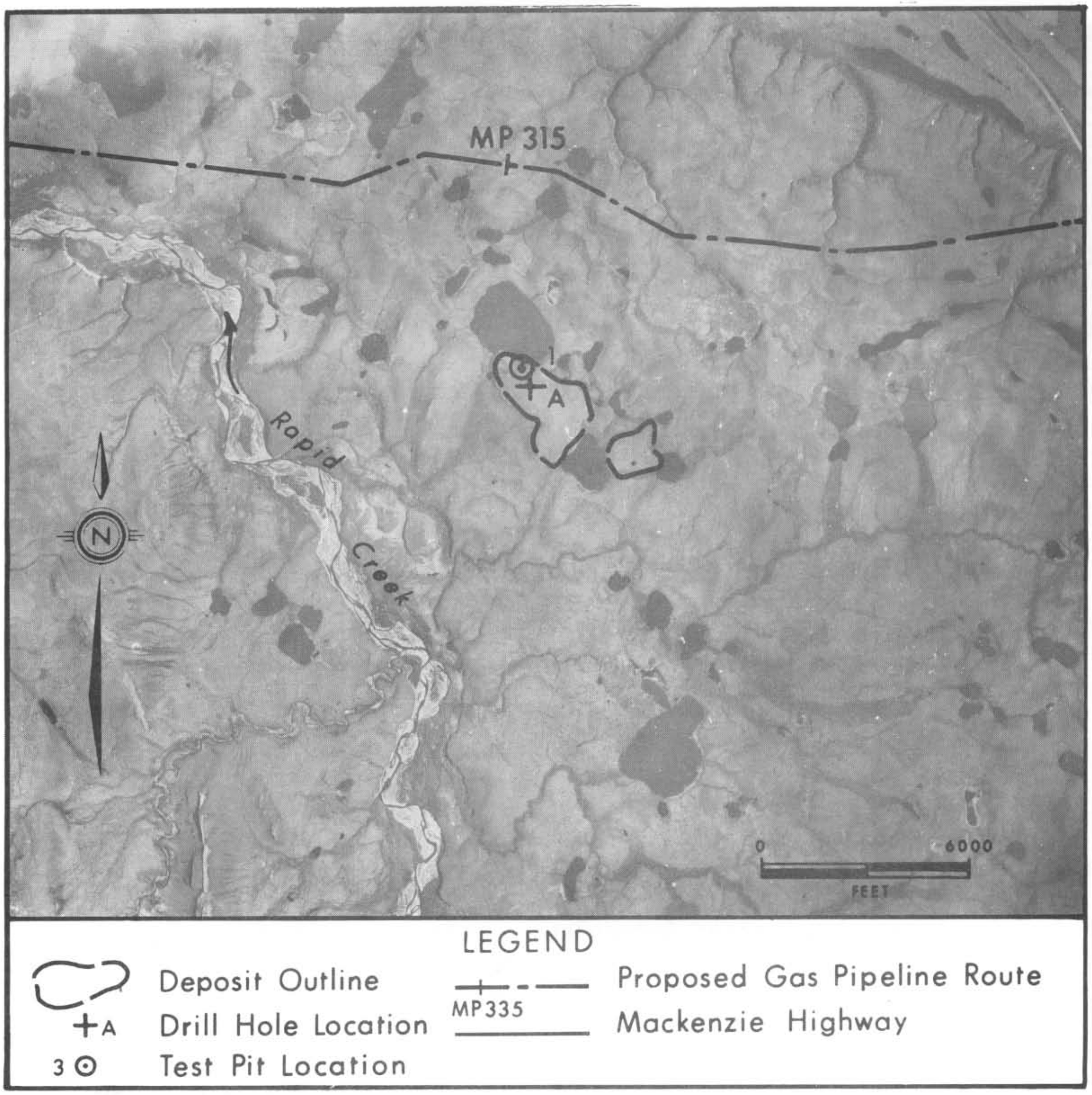
R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

DEPOSIT No. N75-117A-B9

PAGE 375

DEPOSIT 117A-B10

Physical Setting:	Deposit 117A-B10 consists of remnants of two kame deltas located between Rapid Creek and the Mackenzie Delta, 1½ miles south of mile 316 of the proposed gas pipeline.
Material:	Gravel; well graded, some coarse, medium, and fine sand, trace fines.
Volume:	3,500,000 cubic yards.
Assessment:	Deposit 117A-B10 is a good source of granular material but the available volume may be limited by drainage and overburden thickness. Distance of haul to the proposed gas pipeline exceeds 1½ miles. Material from this deposit is suitable for general fill, backfill in pipeline construction, and subgrade for building pads.



Airphoto No. A13232-51

Approximate Scale: 1" = 5250'

Latitude: 68° 46' N

Longitude: 136° 51' W

DEPOSIT 117A-B10

PHYSICAL SETTING

Deposit 117A-B10 consists of the remnants of two kame deltas located between Rapid Creek and the Mackenzie Delta 1½ miles south of mile 316 of the proposed pipeline.

These kame deltas are 30 to 70 feet high, with broad crests sloping gently to the southwest. Side slopes on the broad crests are moderate to steep. The kame to the west is approximately ½ mile long by ¼ mile wide, and the eastern kame is approximately ¼ mile square.

The outwash gravel and sand in the kames overlies preglacial sediments which range from silt and clay to gravel. Ice contents in the outwash are generally low.

The kame deltas are well drained on side slopes and imperfectly drained on the gently sloping crests. The side slopes and edges of the crests have less than 1 foot of peat cover with gravel exposed in scattered patches. Peat and silt on the crests of the kame deltas range from 2 to 10 feet. The active layer is from 12 to 18 inches on areas with organic cover to more than 4 feet on exposed gravel areas. The terrain between the kame deltas and the proposed pipeline is rolling to hummocky with frequent lakes and areas of ice-wedge polygons. Ice-rich substrata is are common in these areas.

BIOLOGICAL SETTING

Tundra vegetation consisting primarily of sedges, mosses and lichens cover the deposit. Dwarf birch and willow 7 feet high are present on protected slopes and around the lakeshores.

Swans and other waterfowl nest on the nearby lakes in the summer. These lakes do not provide suitable habitat for fish. Snow geese have previously been sighted in the area and could be expected to use the area again.

MATERIALS

The outwash is good quality granular material consisting of stratified, dense, subangular, well graded gravel with numerous cobbles, a trace of silt, and scattered rootlets down to 18 inches. Occasional boulders to 18 inches in diameter are present at the surface on the north slope, although none were encountered in either the test pit or the drill hole.

VOLUME

The depth of the deposit varies between 20 and 30 feet. The western portion includes about 110 acres and has a total volume of approximately 2,500,000 cubic yards. The eastern portion extends for 50 acres and has a total volume of approximately 1,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B10 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Excavations would be kept away from the lakes surrounding the deposits. Granular material from this deposit could be used for general fill, backfill in pipeline construction, and building pads. The gravel would require further testing before being considered for use in concrete production.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize enviornmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

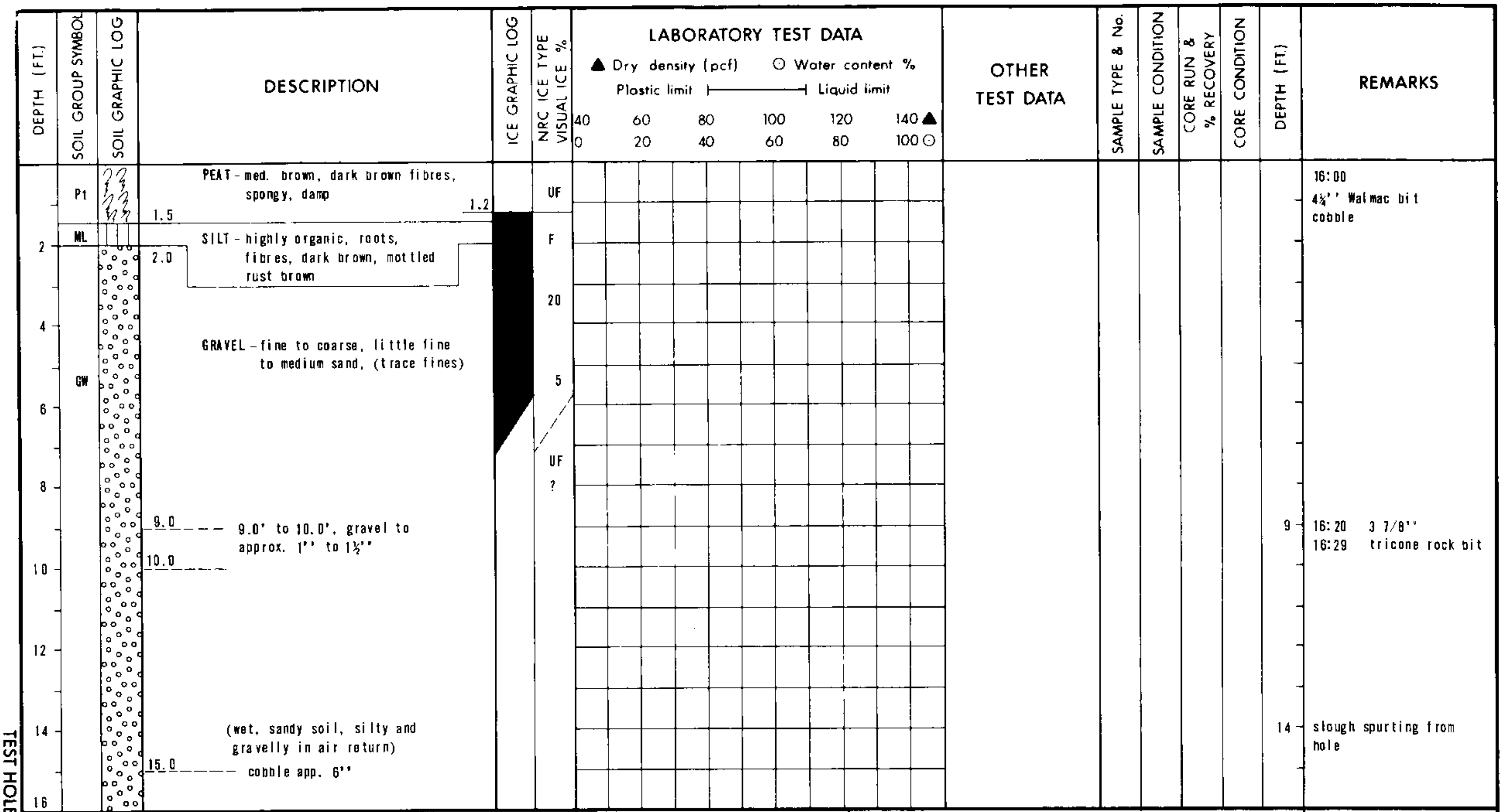
Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled separately around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from well drained areas so that good drainage would be established over the deposit. This type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artifically dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be carried out to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment, and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG



DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT - med. brown, dark brown fibres, spongy, damp	1.2	UF								16:00 4¾'' Walmac bit cobble
1.5	ML		SILT - highly organic, roots, fibres, dark brown, mottled rust brown		F								
2 / 2.0	GW		GRAVEL - fine to coarse, little fine to medium sand, (trace fines)		20								
4													
6					5								
8					UF ?								
9.0			9.0' to 10.0', gravel to approx. 1'' to 1½''									9	16:20 3 7/8'' 16:29 tricone rock bit
10 / 10.0													
12													
14			(wet, sandy soil, silty and gravelly in air return)									14	slough spurting from hole
15.0			cobble app. 6''										
16													

LOGGED BY: J.J.S.
CHKD: D.O.
DRWN. BY: J.M.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°46'17''N, 136°51'13''W
AIRPHOTO No.: A 13232-50
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 8°C

START: D 03 M 08 Y 75 TIME: 16:00
FINISH: D 03 M 08 Y 75 TIME: 19:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B10-A

SHEET 1 OF 2

PC-9,SK373

TEST HOLE No. N75-117A-B10-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GW		(GRAVEL) cont'd		UF ?								
18													
												19	16:57 tricone bit 17:13 jamming on downhole - possibly 2' of slough in hole
20													
22													
24			24.0 — fine to coarse									24	17:40 jumped pulley 18:30 while reaming
28												28	18:45 - high sand content in air return
32												32	slough?
	(GM)		(33.0) GRAVEL - fine, possibly silty and clayey										
34												34	
38			38.0 End of hole									38	inadequate circulation - plugging 19:30

LOGGED BY: J.J.S.
CHKD: D.C.
DRWN. BY: J.M.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: $68^0$46'17''N, $136^0$51'13''W
AIRPHOTO No.: A 13232 - 50
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 6^0C

START: D 03 M 08 Y 75 TIME: 16:00
FINISH: D 03 M 08 Y 75 TIME: 19:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B10-A

SHEET 2 OF 2

PC-9,SK373

TEST HOLE No. N75-117A-B10-A

TEST HOLE LOG

LABORATORY TEST DATA
▲ Dry density (pcf) ○ Water content %
Plastic limit ├───┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.4	Pt		PEAT - trace fine sand, dark brown, dry, fibrous		UF								Using hand tools
	GW		GRAVEL - coarse and fine, subangular, some sand, fine to coarse, trace silt, light brown, moist, stratified, numerous cobbles to 8'', dense										
1								B1	☒			1	using jack-hammer
2								B2	☒			2	
2.3			and sand, greyish brown, very dense, damp										
3								B3	☒			3	
4								B4	☒			4	
5												5	
5.7					Vx 5			B5	☒				
6 6.0			Bottom of pit					B6	☒			6	

LOGGED BY:	J.G.R.	FACILITY:		PROJECT:	13011
CHKD:	D.O.	LAT. & LONG	68°46'24''N, 136°51'17''W	ELEVATION:	
DRWN. BY:	A.J.B.	AIRPHOTO No.:	A 13232-50	PIPE MILEAGE:	
CHKD:	D.O.	RIG:		AIR TEMP:	10°C
		METHOD:	TEST PIT		

START: D 03 M 08 Y 75 TIME: 16:45
FINISH: D 03 M 08 Y 75 TIME: 20:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B10-1
SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B10-1

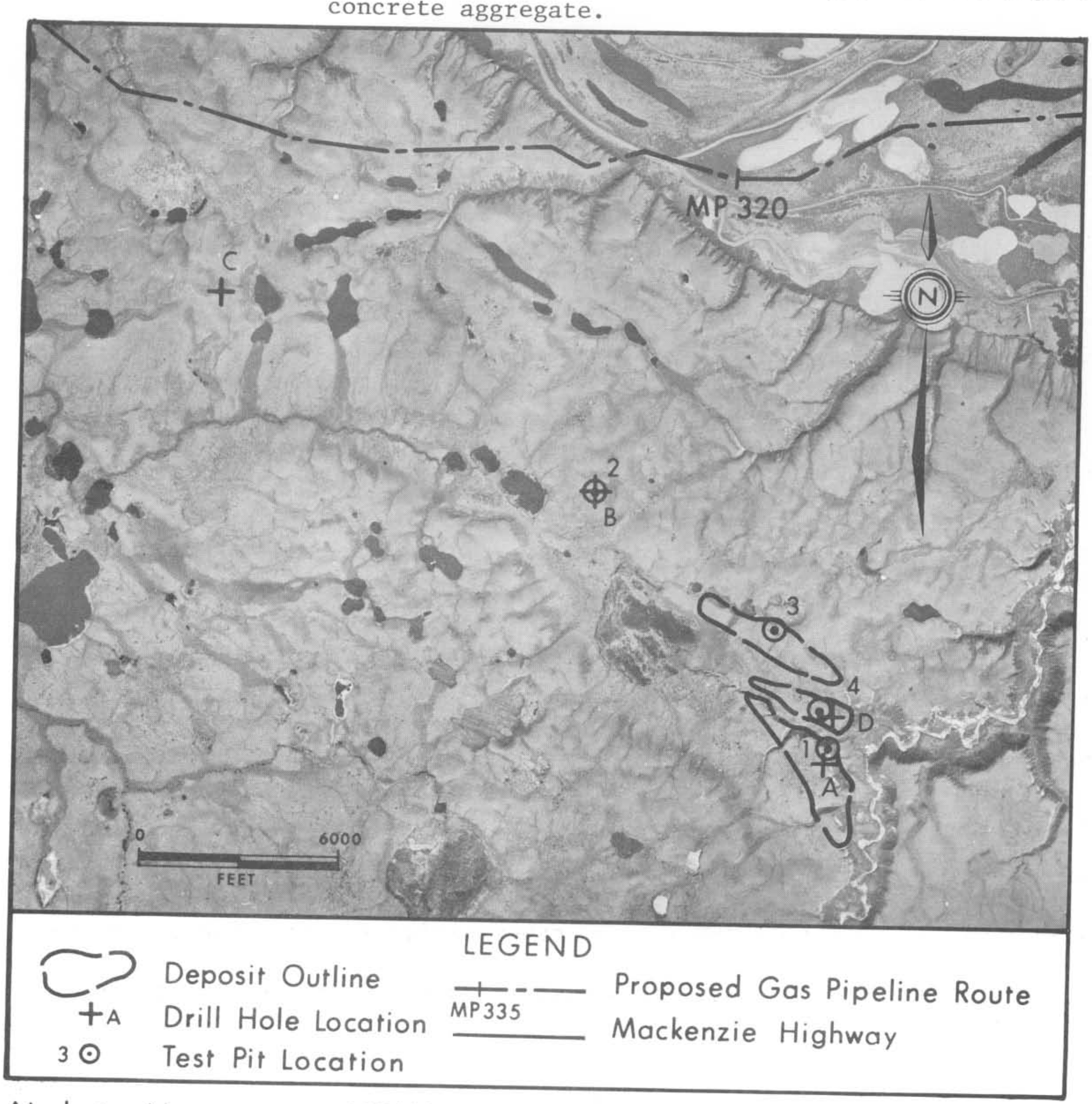
DEPOSIT 117A-B11

Physical Setting: Deposit 117A-B11 consists of remnants of coalescing outwash fans and a valley train. It is located 5 miles east of Rapid Creek and 2½ miles south of the western edge of the Mackenzie Delta.

Material: Gravel; coarse to fine, coarse, medium, and fine sand, trace to little fines.

Volume: 7,500,000 cubic yards.

Assessment: Deposit 117A-B11 is a good source of granular material but the available volume may be limited by drainage and overburden thickness. Haul distance from the deposit to the proposed gas pipeline is 3 miles. Material from this deposit is suitable for general fill, backfill in pipeline construction, subgrade for building pads, and asphalt and concrete aggregate.



Airphoto No.	A15462-22	Latitude:	68° 43' N
Approximate Scale:	1" = 5250'	Longitude:	136° 39' W

DEPOSIT 117A-B11

PHYSICAL SETTING

Deposit 117A-B11, situated 2½ miles south of the western edge of the Mackenzie Delta and 5 miles east of Rapid Creek, consists of remnants of coalescing outwash fans and a valley train. The deposit is 3 miles south of Mile 321 of the proposed pipeline route.

The fan remnants form broad mounds which stand 50 to 100 feet above a flat-bottomed valley in which the valley train has been deposited. They are present in an area approximately 5000 feet long and 1000 feet wide, and are moderately well drained. Gravel is exposed in patches on the mound crests. Peat and silt cover thickens downslope. The outwash overlies till and fine-grained preglacial deposits which have high ice contents. The depth of outwash in the fan remnants is probably about 10 feet, but has not been proven by drilling. Ice content in the outwash sediments is low.

The valley train is contained in a valley trending northwest-southeast, and is truncated at its southeast end by a creek valley. The deposit designated on the airphoto (see facing page) is that part of the valley train having the thinnest cover of peat and silt. A gulley bisects the deposit and 40 feet of gravel is exposed in its walls. The outwash gravel overlies till of variable thickness which is underlain by weathered shale. Drill hole data indicates that the depth of gravel is variable and that thick silt layers may be present. Near the creek and gulley, the outwash material is well drained and has less than 6 inches of peat cover. Elsewhere the deposit is poorly drained, and has up to 15 feet of peat and ice-rich silt overlying the gravel. Ice contents in the gravel are low.

The valley beyond the deposit is marshy with extensive areas of ice-wedge polygons and numerous ponds and lakes. The terrain between the outwash fan remnants and the pipeline is gently rolling with many small lakes and streams. Access to the right of way would be across some ice-rich terrain.

BIOLOGICAL SETTING

Well drained areas near the creek and on ridge crests support tundra vegetation including dwarf birch, sedge, moss, lichen and scattered grasses. Dwarf willow, labrador tea, and sedge tussocks occur in wetter areas.

The stream valley to the east provides habitat for furbearers and big game, such as moose, and the stream provides spawning and rearing grounds for grayling. Borrow activities should be controlled to protect the stream environment. It is preferable to develop outwash fan remnants rather than the valley train deposit because it borders on the stream.

Snow geese have previously been sighted in the area and could be expected to use the area again.

MATERIALS

The outwash consists of dense, subrounded, stratified gravel and sand containing isolated cobbles, traces of silt, and occasional stringers of clay. The quality of the granular material and the content of fines varies significantly between strata. The deposit contains good quality material, but care should be taken to delineate possible thick silt layers if the deposit is exploited.

VOLUME

The outwash fans cover about 130 acres and have a total volume of approximately 1,500,000 cubic yards. The valley train covers about 250 acres and has a total volume of 6,000,000 cubic yards based on an estimated average thickness of 20 feet.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B11 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, environmental considerations, and material requirements. Excavations would be carried out so that siltation of the stream to the east is avoided. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the pipeline right of way.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled separately around the edge of the excavation away from the natural drainage channels.

Development of this deposit would involve excavating borrow material evenly so that good drainage would be established over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artifically dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		**PEAT** – roots and fibres, dark brown, moist 1.0		UF							1.0	4 1/4"; Walmac At 1.0'; boulder to 10"
2	OL		**SILT**-(organic) low plastic, dark brown, mottled light brown . oxidized pockets. 3.0 3.0	1.1	F 45								
4	ICE		ICE 4.5 4.5		ICE								
6	ML		**SILT** – trace gravel, trace fine sand, dark to medium grey 6.0		F 35								
8	GW-GP		**GRAVEL** – fine, trace coarse to fine sand, trace silt, pebbles to approx 3"		10							8 9	18:21 3 7/8" Walmac hole, getting wet 11.0 to Tricone
13			13.0 – – – pebbles to approx 2"										
16			16.0 – – pebbles to approx 3"										Slough to 5' in hole
18													
19			19.0 End of hole									19	Abandoned

LOGGED BY: J.J.S.
CHKD: D.O.
DRWN. BY: J.W.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°43'34"N, 136°38'35"W
AIRPHOTO No.: A15462-22 23
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 18°C

START: D 05 M 08 Y 75 TIME: 18:10
FINISH: D 05 M 08 Y 75 TIME: 19:10

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B11-A

SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.8 PEAT,-dark brown, wet, spongy		UF								19:00 4 1/4'' Walmac
2	OL		SILT-(organic) fibres and rootlets, low plastic, dark grey mottled with light brown	■	F 35								
4	ML		4.0 SILT,- trace fine sand, low plastic, dark grey	■									
6				■									
8				■	25							9	19:16 to 3 7/8'' Walmac
10			increasing content of plastic fines	■									
12			12.0 ---- dark grey, clayey.	■	15							12	to new 3 7/8'' Walmac cuttings not regular
21			21 0 End of hole	■	10							21	Sticking to stem, lost circulation
			Abandoned. Sticking										

LOGGED BY: J J S	FACILITY:	PROJECT: 13011
CHKD: D.O.	LAT. & LONG: 68°44'59''N, 136°41'53''W	ELEVATION:
DRWN. BY: J, M. B.	AIRPHOTO No.: A15462-22, 23	PIPE MILEAGE:
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 16°C
	METHOD: AIR	

START: D 04 M 08 Y 75 TIME: 19:00

FINISH: D 04 M 08 Y 75 TIME: 19:50

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B11-B

SHEET 1 OF 1

TEST HOLE No. N75-117A-B11-B

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├───┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.5 PEAT - medium fibrous, med. to dark brown, damp.		UF								
	ML				1.0								
					F								3'' pebble 4 1/4'' Walmac
2			SILT - trace fine gravel, pebbles to 1'' low plastic, dark brown mottled by light brown. Oxidized pockets.		20								
4													
6													
8					15								
			Clayey, possible trace gravel									9	20:50 to 3 7/8'' 20:53 Walmac
10			10.5										
			ICE 0.5' 11.0		ICE								
12													
					40								
14													
			Increasing ice content with depth										
16					50							16	

LOGGED BY: J.J.S
CHKD: D.O.
DRWN. BY: J.M.B.
CHKD: D.O.
FACILITY:
LAT. & LONG: 68°46'00"N, 136°47'48"W
AIRPHOTO No.: A 15462-22,23
RIG: HELI-DRILL
METHOD: AIR
PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 16°C
START: D 04 M 08 Y 75 TIME: 20:48
FINISH: D 04 M 08 Y 75 TIME: 21:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B11-C
SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B11-C

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT)	REMARKS
16			(SILT) cont'd	■	F							16	
18	ML			■	50								
20				■									
			21.0 21.0									21	
22	ICE +	▨	ICE, with silty inclusions approx. 80% ice content.	▨	ICE +								
24		▨		▨									
26		▨		▨									
28		▨		▨								28	21:00 21:06
30		▨	slight increase in soil inclusions	▨									
32												32	

LOGGED BY: J.J.S.
CHKD: D.O.
DRWN. BY: J.M.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°46'00"N. 136°47'48"W
AIRPHOTO No.: A15462-22,23
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 16°C

START: D 04 M 08 Y 75 TIME: 20:48
FINISH: D 04 M 08 Y 75 TIME: 21:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B11-C

SHEET 2 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B11-C

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	ICE +		(ICE+) cont'd		ICE +							32	
34													
36													
												38	21:08 21:11
38													
40													
42													
			43.0 ------ approx. 80% ice										
44													
46													
48			48.0 End of hole									48	21:13

LOGGED BY: J.J.S
CHKD: D.O.
DRWN. BY: J.M.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: $68^0 46' 00'' N$, $136^0 47' 48'' W$
AIRPHOTO No.: A15462-22,23
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 16^0C

START: D 04 M 08 Y 75 TIME: 20:48
FINISH: D 04 M 08 Y 75 TIME: 21:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B11-C

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B11-C

TEST HOLE LOG

LABORATORY TEST DATA
▲ Dry density (pcf) ○ Water content %
Plastic limit ├──┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt	0.5 PEAT - fibrous, dark brown, wet, spongy.	UF							4 1/4" Walmac
		1.0							1 0	13:20
2	OL	SILT-(organic) dark brown with light brown mottling, odourous	F 30							acrid odour (vinegar-like)
4		5.0 5.0								
6	ICE	ICE clear 6.0 6.0	ICE							
8	OL	SILT-(organic) low plastic, black, high organic content, strong organic odour.	F							
									9	13:25 3 7/8" Walmac
10										
12										
14		14.2 ——— pebble? to app. 3" 15.0							14	13:26 13:34
16	GW-GP	GRAVEL							16	To tricone rock bit

LOGGED BY:	J.J.S.	FACILITY:		PROJECT:	13011
CHKD:	D.O.	LAT. & LONG:	68°43'48"N 136°38'40"W	ELEVATION:	
DRWN. BY:	J.M.B.	AIRPHOTO No.:	A15462-22 23	PIPE MILEAGE:	
CHKD:	D.O.	RIG:	HELI-DRILL	AIR TEMP.	≈ 13°C
		METHOD:	AIR		

START: D 05 M 08 Y 75 TIME: 13:20
FINISH: D 05 M 08 Y 75 TIME: 15:35

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B11-D

SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B11-D

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	DEPTH (FT.)	REMARKS
16	GW-GP	cont'd GRAVEL - fine to coarse, trace fine sand/silt	F	16	
18			15		
				19	13:55 hole getting wet
20		20.0 increasing coarse gravel			drill rig bouncing
		21.5 0.5' layer of silt/fine sand		21.5	14:05
22		23.0			
24	ML	SILT - little fine sand, low plastic, dark grey		24	water not returned with air and cuttings
26			30		
28		slight clay		28	14:21 14:24
30			15		
32		32.0		32	

LABORATORY TEST DATA: ▲ Dry density (pcf) 40 60 80 100 120 140 ▲; ⊙ Water content % 0 20 40 60 80 100 ⊙; Plastic limit ├───┤ Liquid limit

OTHER TEST DATA

SAMPLE TYPE & No. | SAMPLE CONDITION | CORE RUN & % RECOVERY | CORE CONDITION

LOGGED BY: J.J.S	FACILITY:	PROJECT: 13011
CHKD: D.D.	LAT. & LONG: 68°43'48''N 136°38'49''W	ELEVATION:
DRWN. BY: J.M.B.	AIRPHOTO No.: A15462-22 23	PIPE MILEAGE:
CHKD: D.D.	RIG: HELI-DRILL	AIR TEMP: 13°C
	METHOD: AIR	

START: D 05 M 08 Y 75 **TIME:** 13:20 **FINISH:** D 05 M 08 Y 75 **TIME:** 15:35

1975 BORROW INVESTIFATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B11-D

SHEET 2 **OF** 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBO	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32	GP	○	GRAVEL to 2'' 34.0	■	F							32 33	to Tricone 3 7/8'' sticking at 25'
34	ML	‖	SILT – little fine sand, dark grey 35.5	■								35	cuttings, approx.50% water content. 15:25
36	?	▨	(BEDROCK or large boulder) ? 37.0 End of hole		?							37	15:35
			REFUSAL too hard, no cutting return										

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	
CHKD: D.O.	LAT. & LONG: 68°43'48''N 136°38'49''W	ELEVATION:	
DRWN. BY: J.M.B.	AIRPHOTO No.: A15462-22 23	PIPE MILEAGE:	
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 13°C	
	METHOD: AIR		

START: D 05 M 08 Y 75 TIME: 13:20 **FINISH:** D 05 M 08 Y 75 TIME: 15:35

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES
COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B11-D

SHEET 3 **OF** 3

PC-9,SK373

TEST HOLE No. N75-117A-B11-D

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.1	Pt	PEAT – black, dry, fibrous		UF								Using shovels and
1.5	SW	SAND – coarse to fine, and gravel coarse and fine, subrounded, light brown, moist, stratified few fibres , dense.									1	
3.0	GP	GRAVEL – coarse, subrounded, to rounded; trace sand, coarse; light brown, damp, isolated cobbles to 6'', dense.					B1 B2	☒ ☒			2	
4.0	GW	GRAVEL – coarse to fine, subrounded, little sand, coarse to fine, dark grey, damp, numerous cobbles to 8'', dense				MA, 3'–4' Oversize = 10.3% G = 80% S = 17% F = 3% (GW)	B3	☒				
6.0	GW–GM	GRAVEL – coarse to fine, some medium sand, trace fines. 5.7 Bottom of pit.	▨	Nb		MA, combined samples 4'–6' Oversize = 5.8% G = 70% S = 24% F = 6%	B4 B5 B6 B7	☒ ☒ ☒ ☒			4 5 6	Using jack-hammer.

LOGGED BY: J.G.R.

CHKD: R.H.

DRWN. BY: R.J.S.

CHKD: D.D

FACILITY:

LAT. & LONG: 68°43'39''N, 136°38'32'' W

AIRPHOTO No.: A 15462-22, 23

RIG:

METHOD: TEST PIT

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP.: 10°C

START: D 05 M 08 Y 75 TIME: 11:15

FINISH: D 05 M 08 Y 75 TIME:

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B11-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B11-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT - black, moist, fibrous		UF								Using shovels
0.5													
1	GW		GRAVEL - coarse and fine, subangular, and sand, coarse to fine, trace silt, dark brown, moist, dense				MA, 1' - 2' G = 56% S = 32% F = 12% (GC) *	B1	☒			1	Using jack-hammer
1.7													
2	CI		CLAY - silty, medium plastic, grey, wet, unstratified, firm									2	
2.5					Vs 35								
3 / 3.0			Bottom of pit									3	* Sample is probably a combination of the gravel and clay strata

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011
CHKD: D.O.	LAT. & LONG: 68°44'59''N, 136°42'10''W	ELEVATION:
DRWN. BY: F.B.	AIRPHOTO No.: A 15462-22, 23	PIPE MILEAGE:
CHKD: D.O.	RIG:	AIR TEMP: 13°C
	METHOD: TEST PIT	

START: D 04 M 08 Y 75 TIME: 18:00

FINISH: D 04 M 08 Y 75 TIME: 21:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B11-2

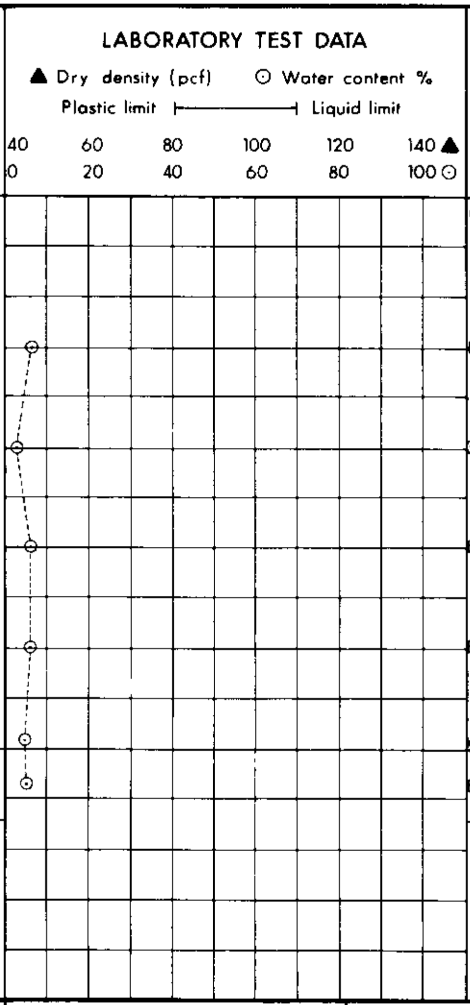
SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B11-2

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.1	Pt	PEAT - black, dry, fibrous		VF	w%						Using shovels and pick-axe
2.4	GM	GRAVEL - coarse to fine (average size 1'' - 0.5''), subangular, little sand, coarse to fine, little silt, light brown, moist, dense 1.5 — little sand			6.9 MA, sample 1 G = 71% S = 16% F = 13%	B1	☒			1 2	
5.4	GC	GRAVEL - fine to coarse, little cmf sand, little silty clay, pebbles sub-angular to 6'', grey, damp, very dense			3.4 MA, combined samples 2 - 6 oversize = 20.1% G = 67% 6.6 S = 19% F = 14% 6.7 5.7	B2 B3 B4 B5	☒ ☒ ☒ ☒			3 4 5	Using jack-hammer
6.2	GP	GRAVEL - coarse to fine, (1'' - 0.5''), 5.5 no clay Bottom of pit	+ + +	Vx 15	6.8	B6	☒			6	



LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: R.H.	LAT. & LONG: 68°44'15''N, 136°39'19''W	ELEVATION:	
DRWN. BY: D.J.M.	AIRPHOTO No.: A 15462-22, 23	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP.: 16°C	
	METHOD: TEST PIT		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 05 M 08 Y 75 TIME: 14:00

FINISH: D 05 M 08 Y 75 TIME: 19:00

TEST HOLE No.

N75-117A-B11-3

SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.1 PEAT - trace sand, black, dry, fibrous		UF								Using shovels. Few fibrous roots to depth 2.5'
	GW		GRAVEL - coarse to fine, subrounded, and sand, coarse to fine, (trace silt), rusty brown, damp, stratified, isolated cobbles to 6'', dense										
1							MA, combined samples 1 - 7 oversize — 98% -3'' material: G — 59% S — 37% F — 4%	B1				1	
2			2.5 no silt, wet, grey					B2				2	
3			3.5 some sand					B3				3	
4								B4				4	
5								B5				5	
6			6.2		Nb			B6				6	Using jack-hammer
7			7.5 Bottom of pit					B7				7	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: A.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°43'51''N, 136°38'31''W
AIRPHOTO No.: A 15462-22, 23
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 16°C

START: D 04 M 08 Y 75 TIME:
FINISH: D 04 M 08 Y 75 TIME:

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR

CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B11-4

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B11-4

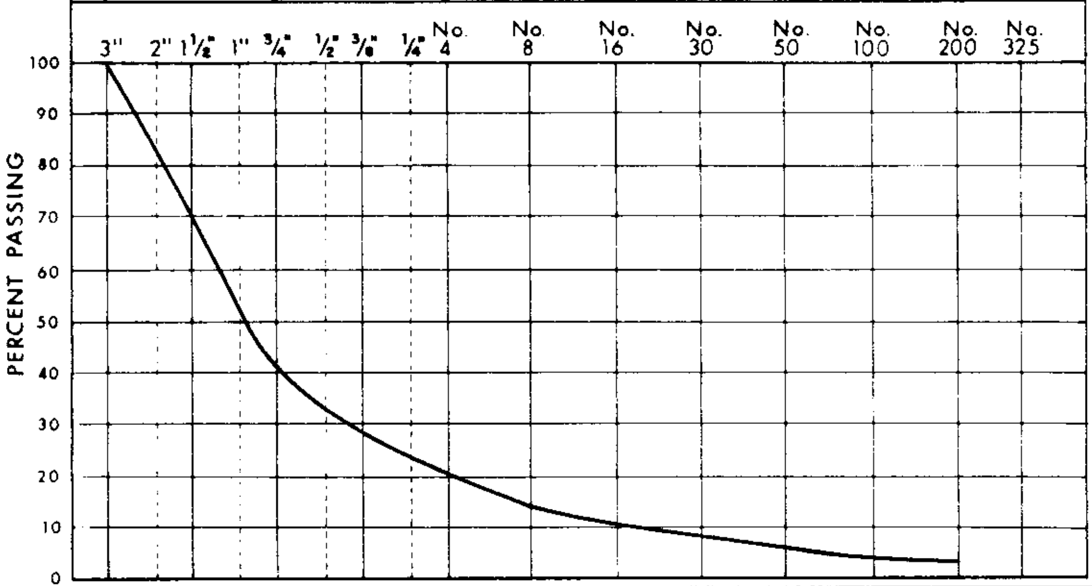
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B11-1 DEPTH 3.0 - 4.0

DATE SAMPLED August 5, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 123

GRAVEL SIZES		SAND SIZES			FINES
58 %	22 %	5 %	8 %	4 %	3 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	84.5
1½"	69.9
1"	51.5
¾"	42.1
½"	33.2
⅜"	28.5
¼"	
No. 4	20.4
No. 8	15.2
No 16	11.0
No. 30	8.6
No. 50	6.4
No. 100	4.3
No. 200	3.2

COMMENTS

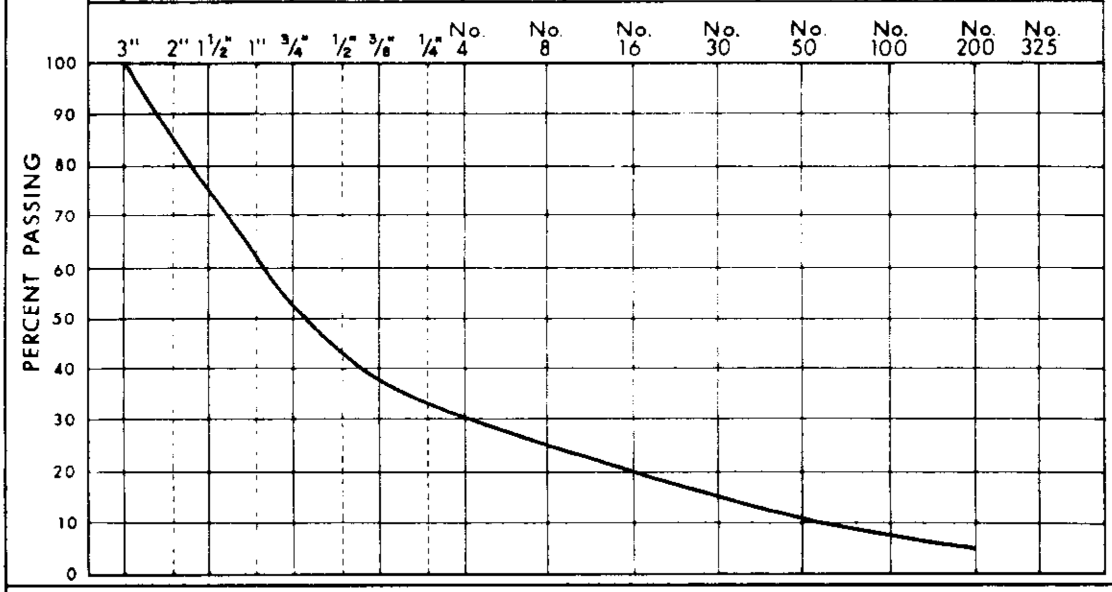
OVERSIZE (>3") = 10.3 %

SAMPLE N75-117A-B11-1 DEPTH 4.0 - 6.0

DATE SAMPLED August 5, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 122

GRAVEL SIZES		SAND SIZES			FINES
47 %	23 %	4 %	14 %	6 %	6 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	87.3
1½"	74.1
1"	62.5
¾"	53.3
½"	43.7
⅜"	38.3
¼"	
No. 4	30.3
No. 8	25.1
No. 16	19.8
No. 30	15.1
No. 50	10.9
No. 100	7.6
No. 200	5.8

COMMENTS

OVERSIZE (>3") = 5.8 %

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117A-B11

PAGE
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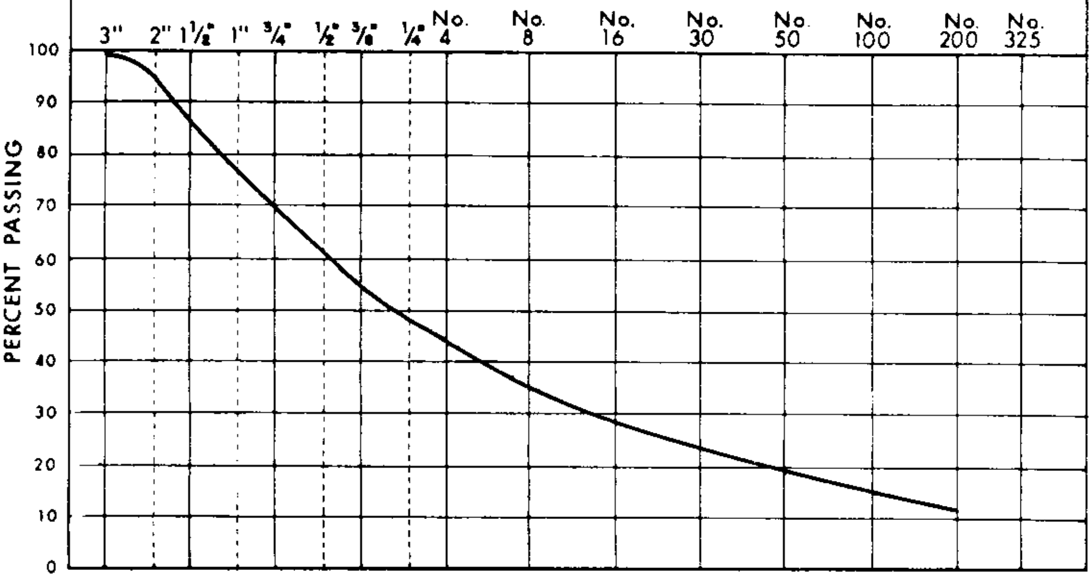
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B11-2 DEPTH 1.0 - 2.0

DATE SAMPLED August 4, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 61

GRAVEL SIZES		SAND SIZES			FINES
30 %	26 %	11%	11 %	10 %	12 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	95.1
1½"	86.9
1"	77.5
¾"	70.1
½"	60.8
⅜"	54.6
¼"	
No. 4	44.4
No. 8	35.1
No. 16	29.2
No. 30	24.1
No. 50	19.1
No. 100	14.8
No. 200	11.7

COMMENTS

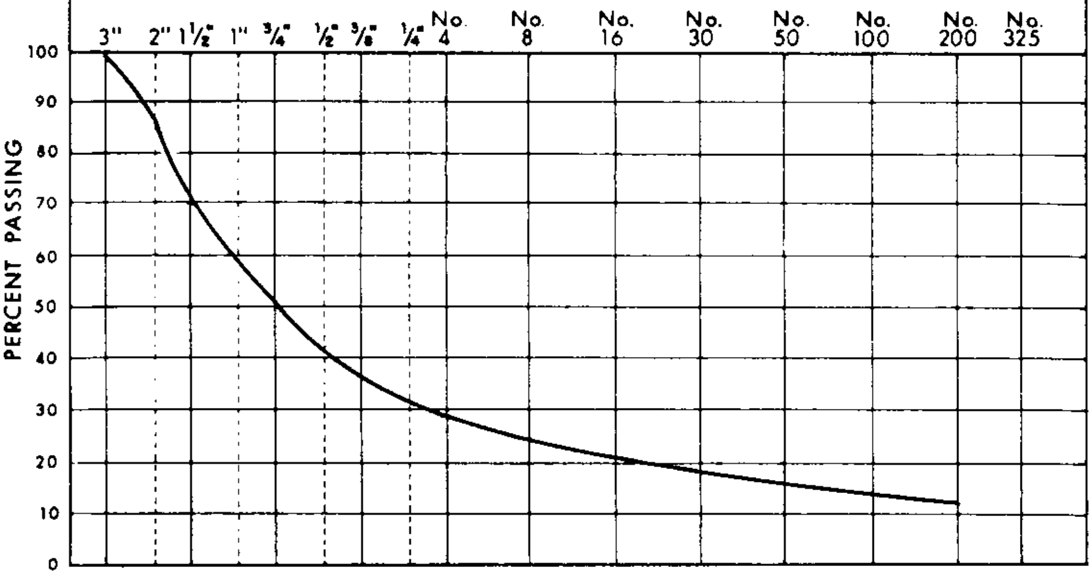
OVERSIZE (>3") = 7.3%

SAMPLE N75-117A-B11-3 DEPTH 1.0 - 2.0

DATE SAMPLED August 5, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 90

GRAVEL SIZES		SAND SIZES			FINES
49 %	22 %	5 %	7 %	4 %	13 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	86.4
1½"	71.0
1"	59.9
¾"	51.2
½"	42.4
⅜"	36.3
¼"	
No. 4	29.0
No. 8	24.0
No. 16	21.3
No. 30	18.5
No. 50	16.0
No. 100	14.1
No. 200	12.6

COMMENTS

OVERSIZE (>3") = 0.0%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services
Company Limited

DEPOSIT No.
N75-117A-B11

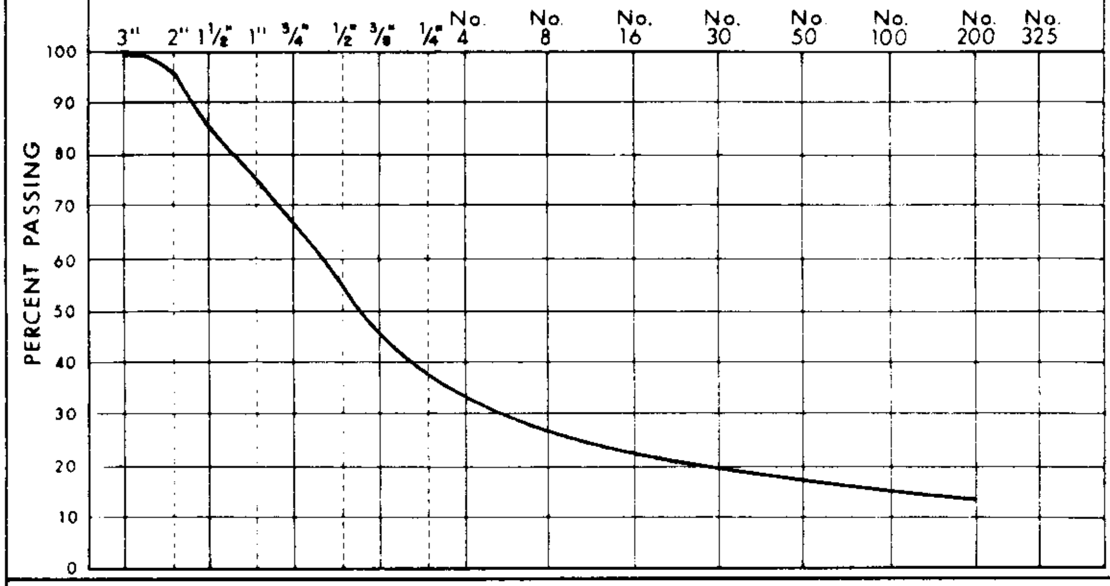
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B11-3 DEPTH 2.0 - 7.0

DATE SAMPLED August 5, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 91

GRAVEL SIZES		SAND SIZES			FINES
32 %	35 %	6 %	9 %	4 %	14 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	96.7
1½"	85.9
1"	76.5
¾"	67.7
½"	55.2
⅜"	46.6
¼"	
No. 4	33.3
No. 8	27.3
No 16	23.8
No. 30	20.5
No 50	17.7
No 100	15.4
No. 200	13.8

COMMENTS

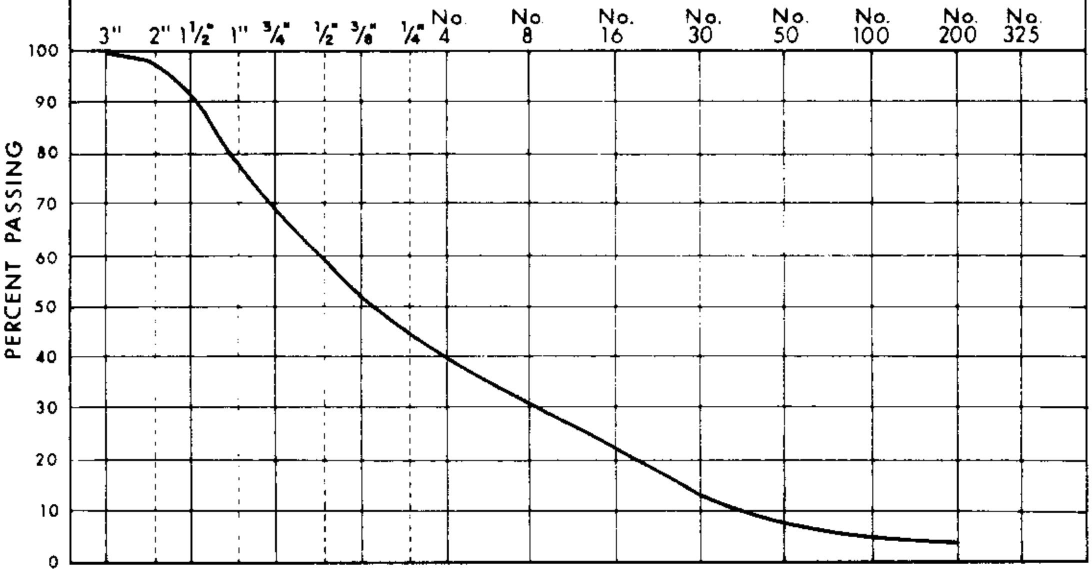
OVERSIZE (>3") = 20.1%

SAMPLE N75-117A-B11-4 DEPTH 1.0 - 7.5

DATE SAMPLED August 4, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 67

GRAVEL SIZES		SAND SIZES			FINES
30 %	29%	10 %	21 %	6 %	4 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	98.1
1½"	92.3
1"	78.7
¾"	69.9
½"	60.0
⅜"	52.7
¼"	
No. 4	40.6
No. 8	31.5
No. 16	22.1
No. 30	14.0
No. 50	8.2
No. 100	5.3
No. 200	4.1

COMMENTS

OVERSIZE (>3") = 9.8 %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No. N75-117A-B11

PAGE 405

The terrain to the north of the kame is hummocky and rolling with frequent ponds, streams and some areas of ice-wedge polygons. The scarp which defines the edge of the Yukon coastal plain has been dissected by many small streams. To gain access to the Mackenzie Delta this scarp would have to be crossed.

BIOLOGICAL SETTING

Tundra vegetation consisting primarily of Dryas, sedges, mosses, lichens, dwarf birch and willow occur on the surface of the kame, whereas dwarf birch and willow are concentrated on protected slopes. A few bare patches of gravel are present. In poorly drained areas, sedge tussocks dominate.

Crests of ridges on the deposit are frequented by Arctic ground squirrels and owls. The stream valley supports fur bearing species such as lynx and marten, and big game like moose. Eagles may use the valley walls as nesting sites. The stream provides spawning and rearing grounds for grayling, and siltation of the stream as a result of borrow activities should be minimized.

MATERIAL

The outwash is good quality granular material consisting of subrounded, stratified, dense gravel with some sand, occasional cobbles and boulders, and a trace of silt in some strata. Boulders exposed on slopes are usually granite or sandstone.

VOLUME

The kame covers about 140 acres. The total volume, based on an estimated average depth of 50 feet, is approximately 7,500,000 cubic yards. Further drilling is required to determine the configuration of the deposit.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B12 is a good source of granular materials. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Excavations would be kept away from the valley wall to prevent siltation of the creek. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation away from natural drainage channels.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be established over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earthmoving techniques depending on the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artifically dry the gravel to obtain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment, and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.5 PEAT - fibrous, spongy, damp, dark brown 1.0		UF								
2	OL		SILT - (organic) dark brown, mottled light brown 2.5		F 60								4 1/4" Walmac
4 6 8 10	ML		SILT - trace fine sand, occasional gravel to 2", low plastic, dark grey 11.0		30							4 6 9	4 1/4" Tricone rock bit - to 4 1/4" Walmac 22:30 22:33
12	ICE		12.0 ICE dirty, traces silt		ICE							11	3 7/8" Tricone rock bit cuttings easily break - some orange sandy conglomerate
14 16	GM		GRAVEL - fine to coarse, silty, little fine sand, pebbles to approx. 2"		F 30							15-	3 7/8" Walmac 22:55

LOGGED BY: J.J.S.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: D.O.	LAT. & LONG: 68°44'00"N. 136°36'17"W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-117A-B12-A
DRWN BY: J.M.B.	AIRPHOTO No.: A 15462-22,23	PIPE MILEAGE:		
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 10°C		
	METHOD: AIR			
START: D 04 M 08 Y 75 TIME: 22:20	FINISH: D 05 M 08 Y 75 TIME: 15:15		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 2

PC-9,SK373

TEST HOLE No. N75-117A-B12-A

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ○ Water content %; Plastic limit ├──┤ Liquid limit; 40 60 80 100 120 140 ▲; 0 20 40 60 80 100 ○

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GM		17.0 some silt, fine sand 17.5 0.5' layer of silt, gravelly.		F							16	
18												18	23:02
20													
			21.0 gravel to 2" trace fine sand, silt. trace coarse sand, (orange rock cuttings)									21	04/08/75 23:04 05/08/75 11:19 ream hole with 4 1/4" Walmac, then to 3 1/8" tricone rock bit
22													
24			24.0 gravel to 2", little fine sand, silt.										
												25	Warm air thawing soil, hole getting muddy. Stem sticking.
26													
28												28	11:43 11:53
30			trace silt, fine, to med. sand soft layer at 34'									30	
36			36.0 End of hole									36	
			Sloughing, sticking										Sloughing

LOGGED BY: J.J.S

CHKD: D.D.

DRWN. BY: J.M.B.

CHKD: D.D.

FACILITY:

LAT. & LONG: 68°44'00"N, 136°36'17" W

AIRPHOTO No.: A 15462-22,23

RIG: HELI-DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: 10°C

START: D 04 M 08 Y 75 TIME: 22:20

FINISH: D 05 M 08 Y 75 TIME: 12:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B12-A

SHEET 2 OF 2

PC-9,SK373

TEST HOLE No. N75-117A-B12-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0.1		PEAT - dark brown, dry, fibrous		UF								Using shovels
1.2	GP	GRAVEL - fine, subangular to subrounded, and sand, coarse to fine, trace silt, light brown, moist, <u>stratified</u>, dense									1	
	GW	GRAVEL - coarse to fine, subrounded, some sand, coarse to fine, dark grey, moist, stratified, isolated cobbles to 7'', dense				MA, combined samples 1 - 8 oversize = 3.9% G = 64% S = 31% F = 5%	B1	☒				
2							B2	☒			2	
3							B3	☒			3	
4											4	
4.5		damp, very dense					B4	☒				
4.6		thin layer of poorly graded gravel at 4.6'										
5							B5	☒			5	
6							B6	☒			6	Using jack-hammer
7							B7	☒			7	
							B8	☒				
8.0		Bottom of pit					B9	☒			8	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: D.J.M.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°45'56''N, 136°38'09''W
AIRPHOTO No.: A 15462-22, 23
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 16°C

START: D 04 M 08 Y 75 TIME: 13:00
FINISH: D 04 M 08 Y 75 TIME: 18:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B12-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B12-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		0.1 PEAT - black, dry, fibrous		UF								Using shovels and pickaxe
	GW-GM		GRAVEL - coarse to fine, subrounded, some sand, trace silt, trace organics. brown, moist, stratified, numerous cobbles to 8'', few fibres, dense										
1							MA, combined samples 1 - 4, oversize = 14.7%, -3'' material: G = 68% S = 25% F = 7% (GW-GM)	B1	☒			1	using jack-hammer
2			2.0 no organics, damp, very dense					B2	☒			2	
3								B3	☒			3	
4								B4	☒			4	
5			5.0 isolated cobbles to 6''					B5	☒			5	
6			6.0 Bottom of pit GWL ▼									6	Water level

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: A.J.B.
CHKD: D.D.

FACILITY:
LAT. & LONG: 68°44'02''N, 136°37'38''W
AIRPHOTO No.: A 15462-22, 23
RIG:
METHOD: TEST PIT

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 13°C

START: D 04 M 08 Y 75 TIME: 20:00
FINISH: D 05 M 08 Y 75 TIME: 13:50

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B12-2

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B12-2

TEST HOLE LOG

LABORATORY TEST DATA: ▲ Dry density (pcf) ⊙ Water content % — Plastic limit ├──┤ Liquid limit — scale 40 60 80 100 120 140 ▲ / 0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt	0.1 PEAT – dark brown, dry, fibrous		UF								Using shovels
	GW–GM	GRAVEL – coarse to fine, subrounded to rounded; some sand, coarse to fine: trace silt, light brown, moist, stratified, frequent cobbles to 8'', isolated boulders to 12'', dense.										Fibres to depth 2'
1						MA, combined samples 1–4 Oversize 6.1% G = 64% S = 26% F = 10%	B1	☒			1	
2							B2	☒			2	
3							B3	☒			3	
4							B4	☒			4	
5		5.0 Bottom of pit									5	Water level

LOGGED BY: J.G.R.

CHKD: R.H.

DRWN. BY: R.I.S.

CHKD: D.O.

FACILITY:

LAT. & LONG: 68°43'55''N, 136°36'45'' W

AIRPHOTO No.: A 15462-22,23

RIG:

METHOD: TEST PIT

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: 16°C

START: D 05 M 08 Y 75 TIME: 14:00

FINISH: D 05 M 08 Y 75 TIME: 18:15

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B12-3

SHEET 1 OF 1

PC-9,SK373

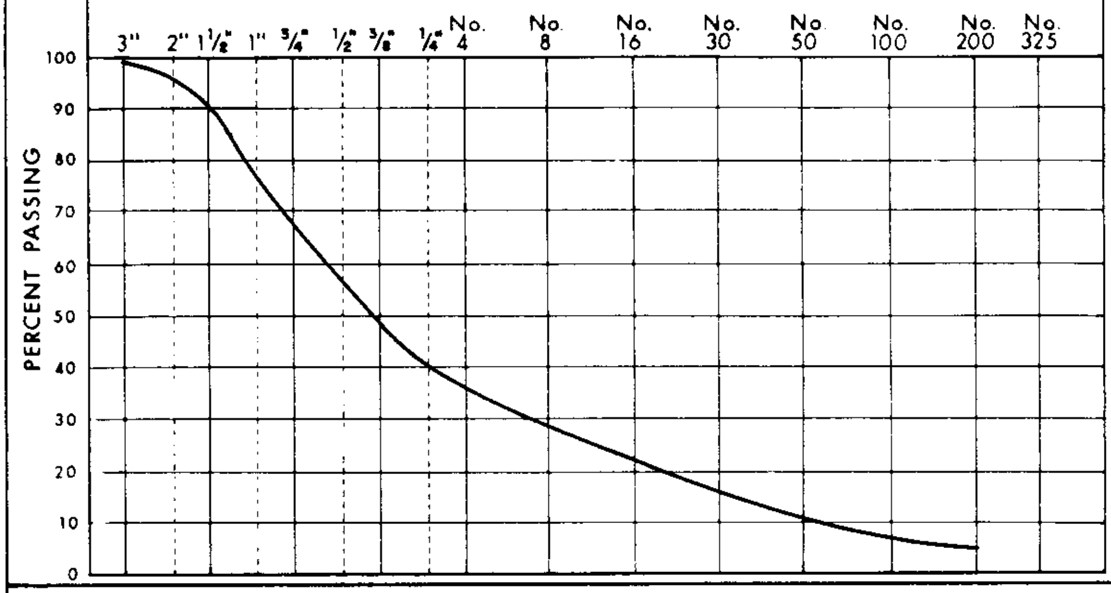
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B12-1 DEPTH 1.0 - 9.0

DATE SAMPLED August 4, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 94

GRAVEL SIZES		SAND SIZES			FINES
32 %	32 %	9 %	14 %	8 %	5%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	96.0
1½"	90.7
1"	77.5
¾"	68.1
½"	56.7
⅜"	48.3
¼"	
No. 4	36.4
No. 8	28.5
No. 16	22.5
No. 30	16.3
No. 50	10.5
No. 100	6.9
No. 200	4.9

COMMENTS

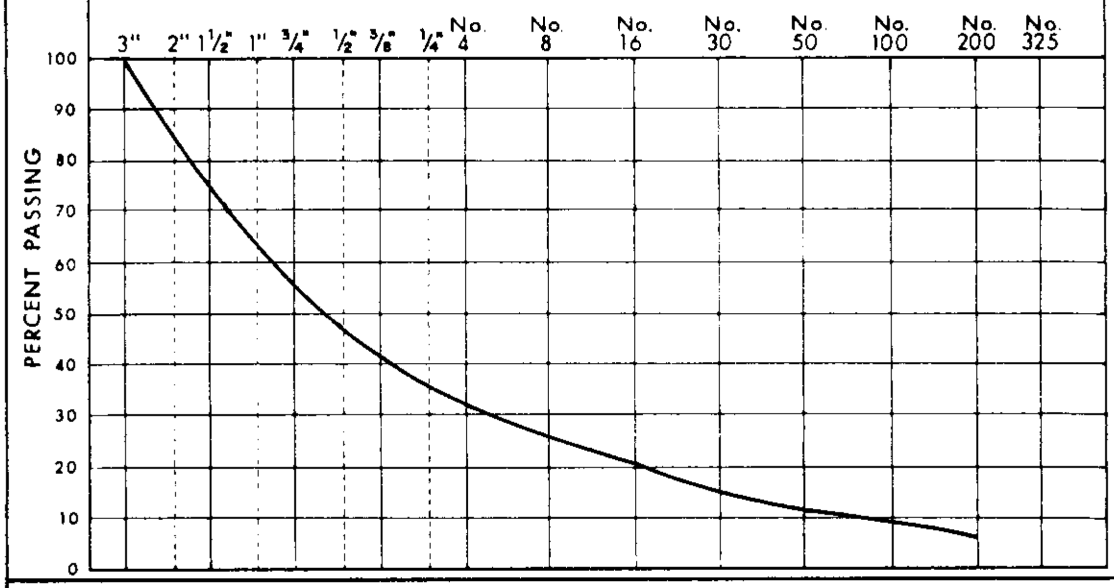
OVERSIZE (>3") = 3.9%

SAMPLE N75-117A-B12-2 DEPTH 1.0 - 5.0

DATE SAMPLED August 4, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 211

GRAVEL SIZES		SAND SIZES			FINES
45 %	23 %	7 %	10 %	8 %	7 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	85.7
1½"	74.3
1"	63.1
¾"	55.3
½"	46.8
⅜"	41.6
¼"	
No. 4	31.8
No. 8	25.6
No. 16	20.6
No. 30	16.5
No. 50	12.2
No. 100	8.9
No. 200	6.6

COMMENTS

OVERSIZE (>3") = 14.7%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No. N75-117A-B12

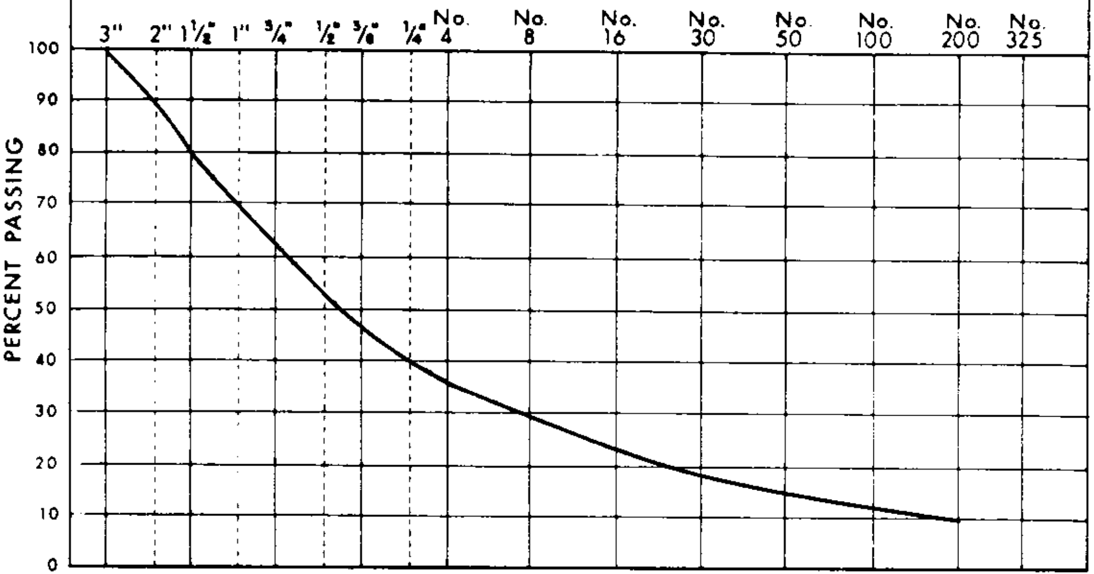
PAGE 417

SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B12-3 DEPTH 1.0 - 5.0
DATE SAMPLED August 5, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 121

GRAVEL SIZES		SAND SIZES			FINES
38 %	26 %	9 %	11%	6 %	10 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	89.1
1½"	79.6
1"	70.4
¾"	62.3
½"	52.9
⅜"	47.0
¼"	
No. 4	35.8
No. 8	29.4
No. 16	23.6
No. 30	19.0
No. 50	15.1
No. 100	12.0
No. 200	9.9

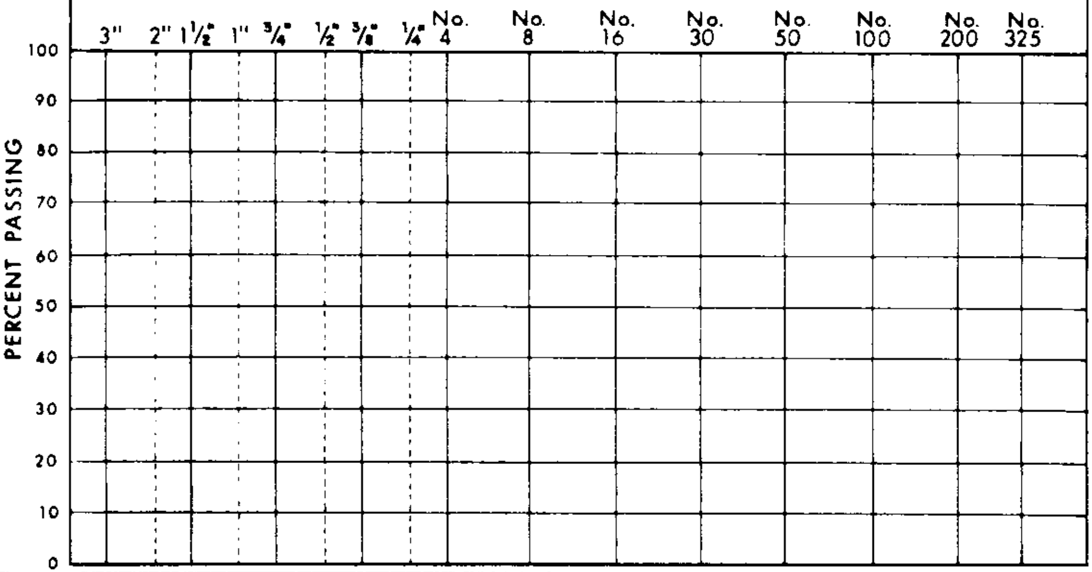
COMMENTS

OVERSIZE (>3") = 6.1%

SAMPLE DEPTH
DATE SAMPLED SAMPLED BY

R.M.HARDY REPORT NUMBER

GRAVEL SIZES		SAND SIZES			FINES
%	%	%	%	%	%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	
2"	
1½"	
1"	
¾"	
½"	
⅜"	
¼"	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	
No. 200	

COMMENTS

OVERSIZE (>3") = %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117A-B12

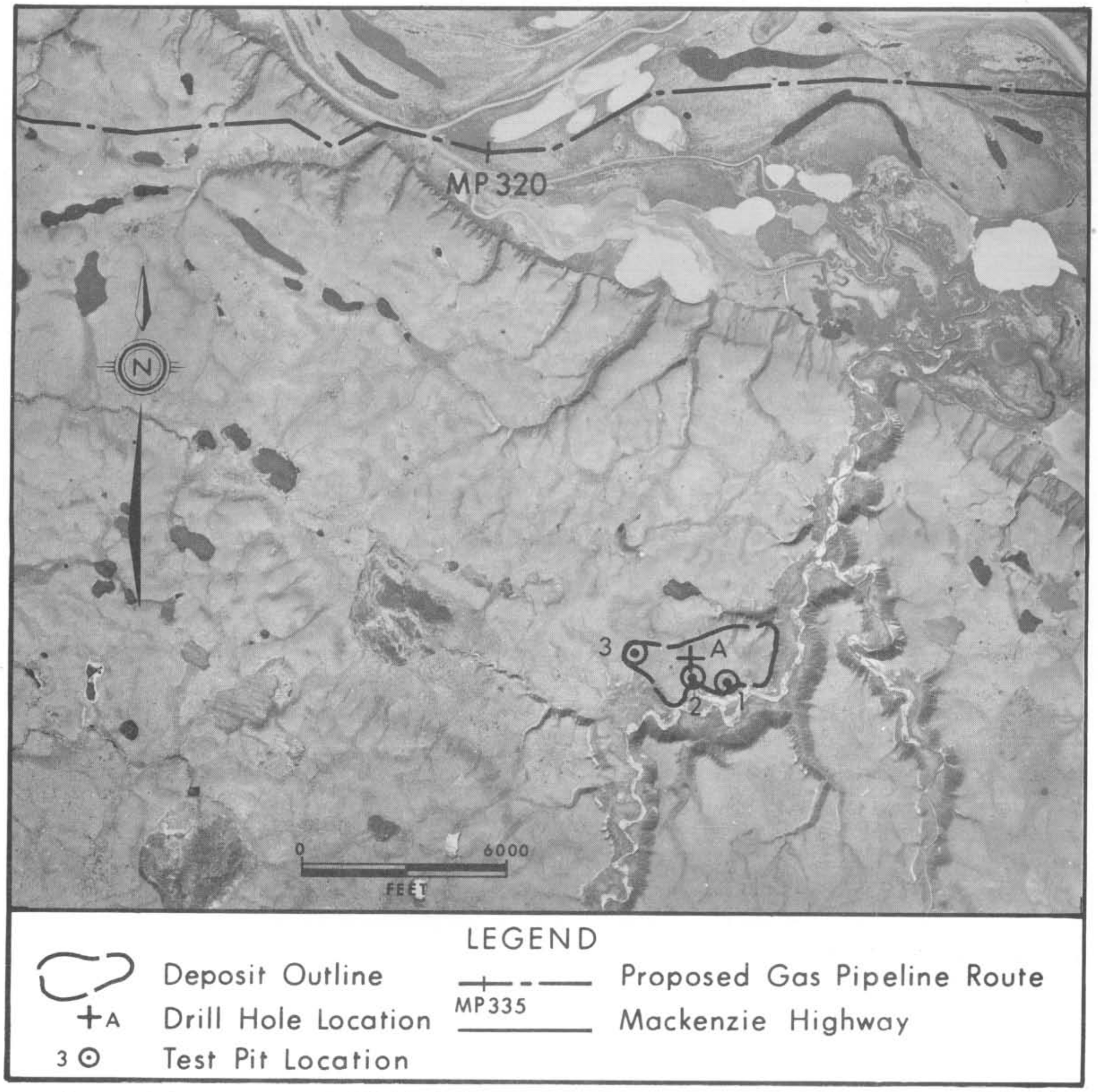
DEPOSIT 117A-B12

Physical Setting: Deposit 117A-B12 is a kame located 2 miles south of the west edge of the Mackenzie Delta and 7 miles east of Rapid Creek.

Material: Gravel; well graded, coarse to fine, some coarse, medium and fine sand, trace fines.

Volume: 7,500,000 cubic yards.

Assessment: Deposit 117A-B12 is a good source of granular material. Distance to the proposed pipeline is 3 miles. Material from this deposit is suitable for general fill, backfill in pipeline construction, subgrade for building pads, and asphalt and concrete aggregate.



Airphoto No. A23816-174

Approximate Scale: 1" = 4500'

Latitude: 68° 44' N

Longitude: 136° 38' W

DEPOSIT 117A-B12

PHYSICAL SETTING

Deposit 117A-B12 is a kame located 2 miles south of the west edge of the Mackenzie Delta and 7 miles east of Rapid Creek. Mile 322 of the proposed pipeline route is 3 miles north of the deposit.

The kame is about 4000 feet long by 2000 feet wide and has a broad, gently rolling surface. On the south and east it is bounded by very steep stream-cut banks 200 feet high. The north and west edges of the kame merge with the rolling moraine covering most of the area.

The outwash material in the kame overlies preglacial gravel. A thin layer of till may be present within the outwash sediments and isolated pockets of silt and ablation till may be scattered over its surface. Stream-cut slopes at the south edge of the kame expose 100 feet of gravel over shale. The gravel probably thins to the northeast.

The deposit is generally well drained and has low ice contents. The active layer is 12 to 18 inches thick in areas of peat cover, and considerably thicker (4 feet plus) in bare gravel areas near the banks on the south and east sides of the kame. Peat and silt overburden is generally less than 1 foot in depth, except for occasional thicker pockets of silt or till.

SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No. N75-117A-B12-1 DATE SAMPLED : August 5, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 2 - 8 DATE TESTED : February, 1976 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 1.46 %
FINE AGGREGATE : LOSS = 14.26 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 16.5 %

ORGANIC IMPURITIES TEST

NUMBER : 2+
COAL REMOVED : nil
COAL & ROOTLETS REMOVED : nil
COAL CONTENT : nil
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Very strong, Good	5.51
Sandstone	Strong, Good	36.63
Siltstone		17.7
Chert	Potentially reactive, Fair	0.6
Flint		0.18
Soft Sandstone	Friable, Weak, Poor.	1.02
PN = 109	INTERPRETATION : Very good quality aggregate	61.1

COMMENTS :

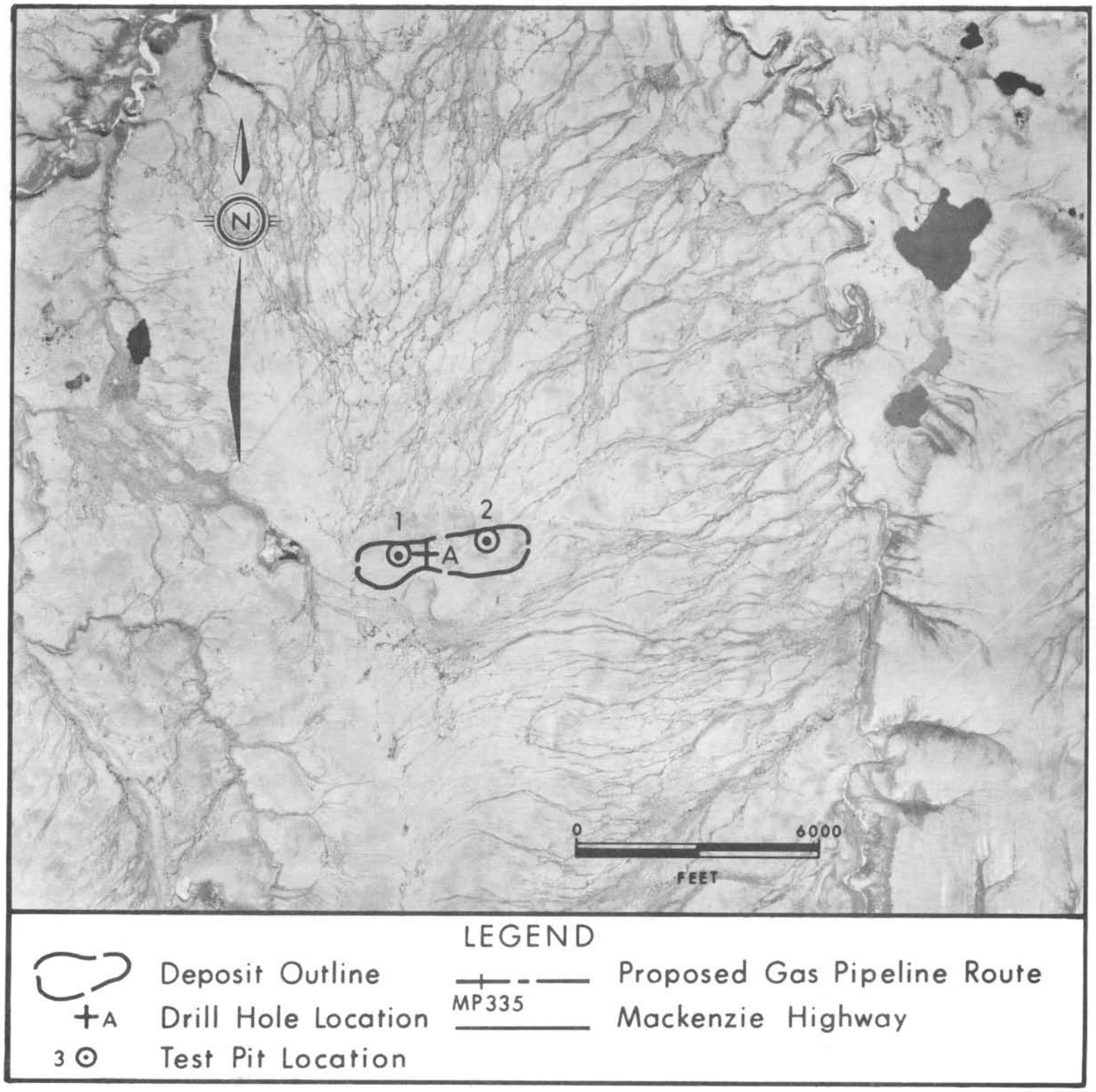
NORTHERN
Engineering Services Company Limited

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

DEPOSIT No. N75-117A-B12

DEPOSIT 117A-B13

Physical Setting:	Deposit 117A-B13 is a series of round-crested kames located 5 miles east of Rapid Creek and 8 miles south of mile 322 of the Cross Delta pipeline route.
Material:	Gravel; well graded, coarse to fine, some coarse, medium and fine sand.
Volume:	1,000,000 cubic yards.
Assessment:	Deposit 117A-B13 is a good source of granular material. Haul distance to the proposed pipeline right of way exceeds 8 miles. Valleys and rolling terrain must be crossed between the deposit and the pipeline. Materials are suitable for general fill and backfill in pipeline construction, as well as building pad subgrades.



Airphoto No.	A23816-175	Latitude:	68° 40' N
Approximate Scale:	1" = 4500'	Longitude:	136° 36' W

DEPOSIT 117A-B13

PHYSICAL SETTING

Deposit 117A-B13 is a series of round-crested kames located about 5 miles east of Rapid Creek and 8 miles south of mile 322 of the Cross Delta route of the proposed pipeline.

The kames are present in an east-west trending area approximately 1 mile long and 1000 feet wide. These kames stand about 50 feet above the surrounding terrain and have moderately steep to gentle slopes. Isolated gravelly mounds are present on the crests and upper slopes of the kames.

Upper slopes are well drained with less than 18 inches of peat cover. Overburden increases on the poorly drained, gently sloping flanks and may reach depths of 5 feet in places. The kames are composed of outwash materials with occasional lenses of silt and thick layers of massive ice, as shown by the drill hole which encountered massive ice at a depth of 11 feet. The ice may exist as continuous layers or as isolated lenses. Further drilling is necessary to determine the extent of the ice. The ice content in the upper 10 feet is low, and the active layer varies between 18 inches and in excess of 5 feet depending on cover conditions. The terrain surrounding the deposit is poorly drained and marshy with extensive areas of ice-wedge polygons and thick peat cover.

BIOLOGICAL SETTING

Vegetation is sparse on ridge crests and gravelly hummocks. It generally consists of batches of moss, lichen and sedge. The lower slopes support tundra vegetation dominated by sedge tussocks, moss, dwarf birch, and willow. Arctic ground squirrels and occasional owls frequent the hill crests. Snow geese have previously been sighted in the area and could be expected to use the area again.

MATERIALS

The outwash is good quality granular material consisting of subrounded, stratified, dense gravel with scattered cobbles, a trace of silt in some strata, and occasional sand layers. Sand content varies between strata. Some boulders are exposed at the surface along the ridge crests.

VOLUME

The deposit covers approximately 80 acres and has a total volume, based on an estimated depth of 10 feet, of approximately 1,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B13 is a good source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, and material requirements. Haul distances to the proposed pipeline right of way are greater than 10 miles. Granular material from this deposit could be used for general fill, backfill in pipeline construction, building pads, and concrete and asphalt aggregate production. The gravel would require further testing before being used in concrete.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit. In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. Creeks would have to be crossed in order to get the borrow material to the pipeline.

Where necessary the peat cover and overburden would be stripped from the area to be excavated, and stockpiled separately around the edge of the excavation.

Development of this deposit would involve excavating borrow material evenly from the higher, well drained areas so that good drainage would be maintained over the area. This type of development could be accomplished by blasting or conventional earthmoving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditons might also make it necessary to artifically dry the gravel to gain the quality needed for certain types of construction aggregates, e.g. concrete and asphalt.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural condition. The pit area and haul road would be inspected for any damage to the environment, and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

LABORATORY TEST DATA
▲ Dry density (pcf) ⊙ Water content %
Plastic limit ├───┤ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt	0.8 PEAT - fibrous, dark brown, moist	UF							20:20,, 4 1/4 Walmac bit
2	ML	SILT - little gravel, low plastic, medium brown, mottled, light brown. 1.5 3.0	F 30							
4	GM	GRAVEL - fine to coarse, silty. 5.0	10							
6	GW	GRAVEL - fine to coarse, trace fine to med. sand.	10							
8									8.5	20:32 To tricone rockbit 20:40
10	GM	GRAVEL (cuttings show high silt content) 11.0							9.5	To 3 7/8'' Walmac bit 20:45
12	ICE +	ICE with approx. 10% silt and approx. 5% fine sand	ICE +							
14										
16										

LOGGED BY: J.J.S.
CHKD: D.O.
DRWN. BY: J.M.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°39'52''N. 136°36'03''W
AIRPHOTO No.: A 15462-24
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 13°C

START: D 05 M 08 Y 75 TIME: 20:26
FINISH: D 06 M 08 Y 75 TIME: 11:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B13-A

SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B13-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	ICE +		(ICE +)		ICE +							16	
18													
20												20	
												21	ice cuttings in air return
22			22.0										
	GW		GRAVEL - fine to coarse, (trace silt)		F							23	Walmac bit worn completely. To Tricone rock bit
24			(24.0) trace fine to med. sand									24	21:10
	GM		GRAVEL - fine to coarse, silty, trace fine sand		10								
26													
28			28.0									28	05/06-08-75 21:23 To Walmac bit 11:10 Rig not bouncing ream hole
	SM		SAND - fine to medium, silty, (approx. 10%)										
30													
32			32.0										Airtemp to approx. 33^0F on 06/08/75

LOGGED BY: J.J.S

CHKD: D.O.

DRWN. BY: J.M.B.

CHKD: D.O.

FACILITY:

LAT. & LONG: $68^0 39' 52''$ N, $136^0 36' 03''$ W

AIRPHOTO No.: A 15462-24

RIG: HELI-DRILL

METHOD: AIR

PROJECT: 13011

ELEVATION:

PIPE MILEAGE:

AIR TEMP: 13^0C

START: D 05 M 08 Y 75 TIME: 20:26

FINISH: D 06 M 08 Y 75 TIME: 11:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B13-A

SHEET 2 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
			GRAVEL – to 1 5" silty, trace fine sand		10								
33	GM	33.0											
			SAND – silty										
34	SM				F							34	
36													
38		38.0	End of hole									38	11:37

LOGGED BY: J.J.S
CHKD: D.O.
DRWN. BY: J.M.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: 68°39'52''N, 136°36'03''W
AIRPHOTO No.: A15462-24
RIG: HELI-DRILL
METHOD: AIR

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 13°C

START: D 05 M 08 Y 75 TIME: 20:26
FINISH: D 06 M 08 Y 75 TIME: 11:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B13-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE LOG

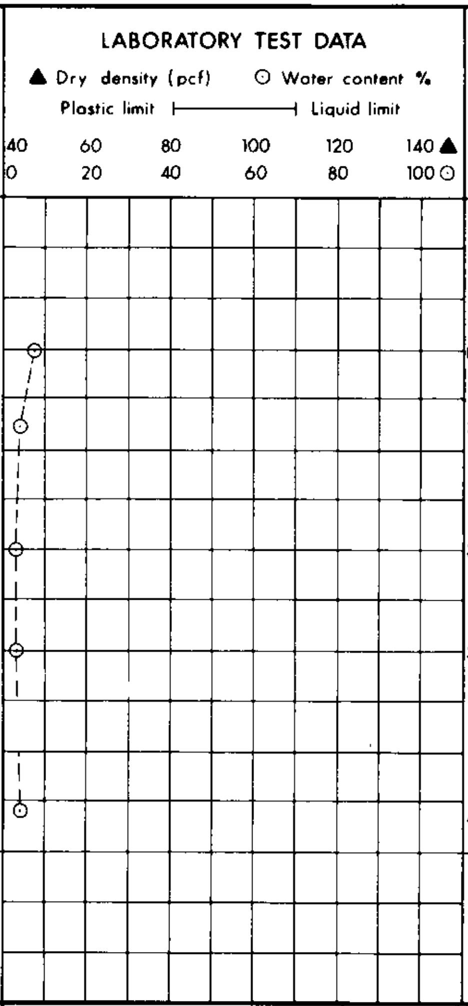
DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0 – 1.2	GW		GRAVEL - coarse and fine, subrounded, and sand, coarse to fine, trace silt, rusty brown, moist, isolated cobbles to 4'', medium dense.		UF								½'' peat cover on surface Using shovels
1.2 – 4.5	GW		GRAVEL - coarse to fine, rounded, some sand, light brown, damp, stratified, isolated cobbles to 8'', medium dense.				MA, combined samples 1 - 6 Oversize = 4.6% G = 68% S = 28% F = 4% (GW)	B1 B2 B3 B4 B5	☒ ☒ ☒ ☒ ☒			1 2 3 4	
4.5 – 6.0	GW		GRAVEL - coarse and fine, subrounded, little sand, coarse to fine, light brown, damp, stratified, isolated cobbles to 8'', dense. Bottom of pit					B6	☒			5 6	

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 130 11	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: R.H.	LAT. & LONG: 68°39'53''N, 136°35'42''W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-117A-B13-1
DRWN. BY: G.C.B.	AIRPHOTO No.: A 15462-24	PIPE MILEAGE:		
CHKD: D.O.	RIG:	AIR TEMP.: 16°C		
	METHOD: TEST PIT			
START: D 05 M 08 Y 75 TIME: 18:00	FINISH: D 05 M 08 Y 75 TIME: 21:00		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 1 OF 1

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	w%	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	REMARKS
	GW	GRAVEL - fine to coarse, subrounded, some sand, coarse to fine, trace silt, light brown, moist, stratified, isolated cobbles to 8'', few fibres, dense	UF					½'' peat cover on surface
1.5		depth 1.5', little sand, no silt, no fibres, isolated boulders to 12''		6.1	MA, combined samples 1 - 6 G = 66% S = 30% F = 4%	B1	☒	
				3.6		B2	☒	
						B3	☒	
3.7		trace sand		3.3				
				3.7		B4	☒	
						B5	☒	
5.5		little sand						
				4.5		B6	☒	
6.5		Bottom of pit				B7	☒	



LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: D.J.M.
CHKD: D.O.
FACILITY:
LAT. & LONG: 68°38'51''N, 136°38'27''W
AIRPHOTO No.: A 15462-24
RIG:
METHOD: TEST PIT
PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP.: 19°C
START: D 05 M 08 Y 75 TIME: 18:00
FINISH: D 05 M 08 Y 75 TIME: 21:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B13-2

SHEET 1 OF 1

PC-9,SK373

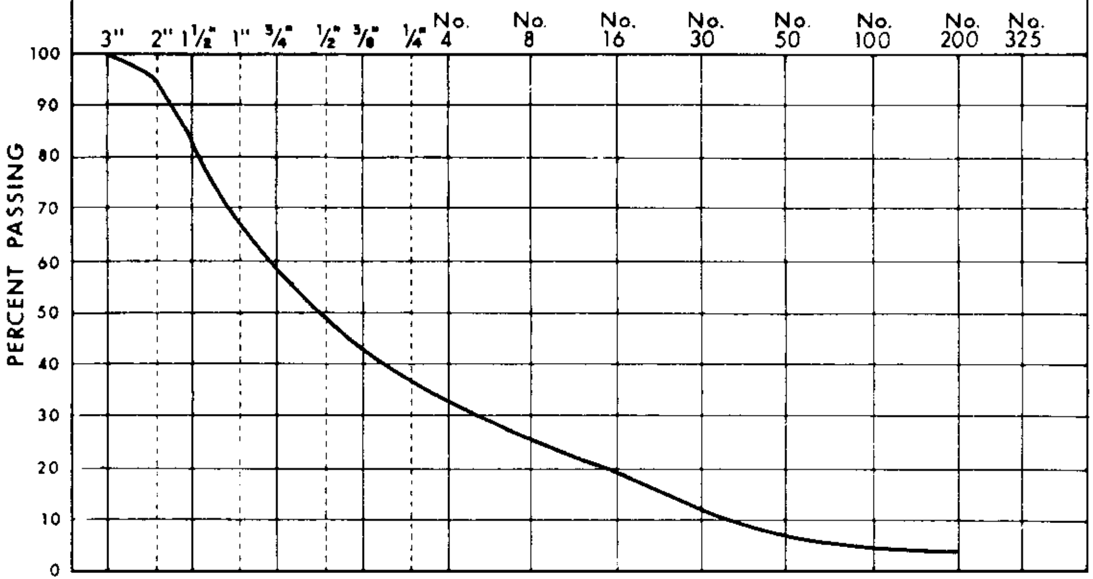
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B13-1 DEPTH 1.0 - 6.0

DATE SAMPLED August 5, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 103

GRAVEL SIZES		SAND SIZES			FINES
41 %	27 %	7 %	16 %	5 %	4 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	94.6
1½"	84.4
1"	67.7
¾"	59.2
½"	49.6
⅜"	42.5
¼"	
No. 4	32.2
No. 8	25.0
No. 16	19.0
No. 30	12.1
No. 50	6.8
No 100	4.6
No. 200	3.6

COMMENTS

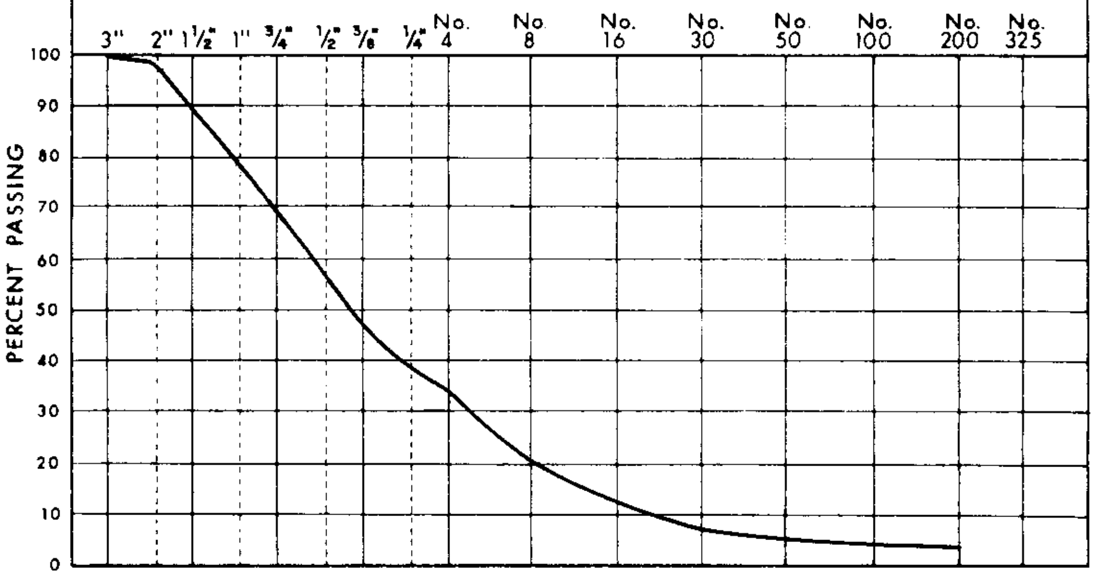
OVERSIZE (>3") = 4.6 %

SAMPLE N75-117A-B13-2 DEPTH 1.0 - 6.0

DATE SAMPLED August 5, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 95

GRAVEL SIZES		SAND SIZES			FINES
30 %	36 %	15 %	13 %	2 %	4%
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	97.7
1½"	89.8
1"	78.6
¾"	69.9
½"	56.9
⅜"	47.1
¼"	
No. 4	34.1
No. 8	20.9
No. 16	12.9
No. 30	7.8
No. 50	5.7
No.100	4.6
No. 200	3.9

COMMENTS

OVERSIZE (>3") = 0.0 %

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN Engineering Services Company Limited

DEPOSIT No.
N75-117A-B13

PAGE
431

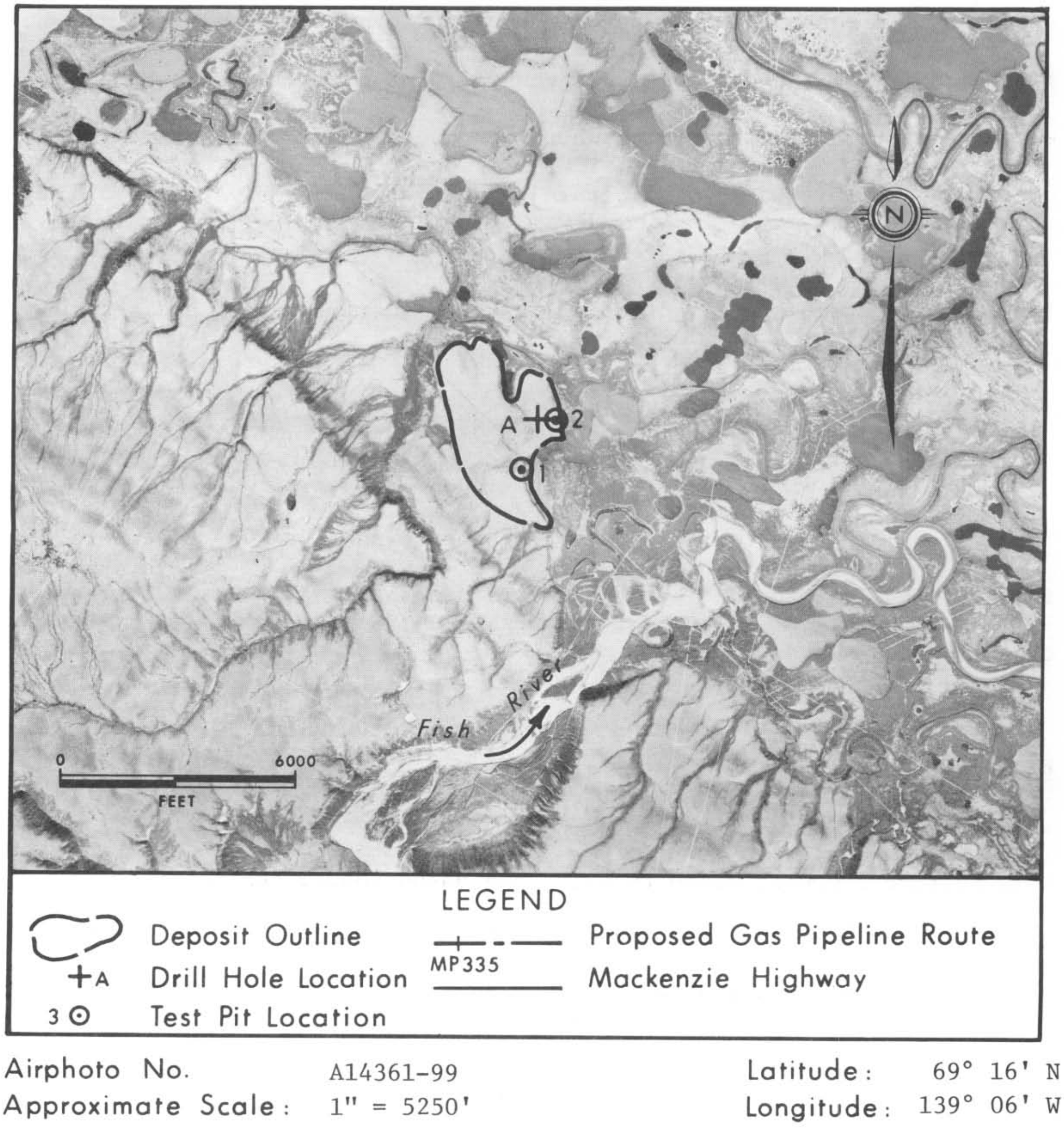
DEPOSIT 117A-B14

Physical Setting: Deposit 117A-B14 is fluvial terrace on the west side of the Mackenzie Delta, 1 mile northwest of the mouth of Fish River and 11 miles south of mile 334 of the Cross Delta route of the proposed gas pipeline.

Material: Gravel; well graded, (boundary classification) some coarse, medium, and fine sand, trace fines.

Volume: 4,000,000 cubic yards.

Assessment: Deposit 117A-B14 is a fair source of granular material but the available volume may be limited by drainage and overburden thickness. Haul distance from the deposit to the proposed pipeline right of way is at least 10 miles over flat deltaic terrain. Materials are suitable for general fill, backfill in pipeline construction and subgrade material for building pads.



Airphoto No. A14361-99

Approximate Scale: 1" = 5250'

Latitude: 69° 16' N

Longitude: 139° 06' W

DEPOSIT 117A-B14

PHYSICAL SETTING

Deposit 117A-B14 is a fluvial terrace on the west side of the Mackenzie Delta, 1 mile northwest of the mouth of Fish River. Mile 334 of the Cross Delta pipeline route is 11 miles north of the deposit.

This flat-lying fluvial terrace is approximately 1 mile long and ½ mile wide and stands 35 feet above the Mackenzie Delta. Gravels and sands in the deposit are about 15 to 20 feet thick and overlie deltaic silts and fine sands. The fluvial sediments generally have a low ice content except beneath polygonal ground where ice wedges may be present. The underlying deltaic materials contain some layers of massive ice.

The terrace is imperfectly drained with some poorly drained areas and has between 5 and 10 feet of peat and ice-rich silt overlying the deposit. The active layer is 1 to 3 feet thick.

The west side of the terrace borders on the Yukon Plateau. Elsewhere, the deposit is surrounded by delta terrain consisting of lakes, stream channels and islands.

BIOLOGICAL SETTING

This terrace supports sedge tussocks and shrub tundra dominated by willow, dwarf birch, Labrador tea and lichen. Small sedge meadows are present in poorly drained areas.

Caribou and Arctic ground squirrels use the terrace to a limited extent. The adjacent delta has excellent habitat for moose and furbearers, and provides nesting grounds for many bird species.

MATERIALS

The fluvial deposit consists of fair quality granular material, including stratified, dense, subangular to subrounded gravel with isolated cobbles and occasional thin layers of sand. The upper 4 feet of gravel or sand contain a trace of silt. Some sand layers are clayey. The gravel generally is well-graded but falls in the boundary classification because of the varying amount of fines.

VOLUME

The terrace covers an area of 180 acres and has a total volume, based on an average depth of 17.5 feet, of approximately 4,000,000 cubic yards.

DEVELOPMENT AND REHABILITATION

Deposit 117A-B14 is a fair source of granular material. Location of areas to be exploited would be dictated by haul distances, insitu material quality, overburden thicknesses, and material requirements. Granular material from this deposit could be used for general fill, embankment fill in berm construction and building pads.

Access to the deposit with equipment could be achieved by barge to Shingle Point and overland from there to the deposit. Alternatively, the equipment could be staged via the pipeline right of way to the deposit.

In order to minimize environmental damage, snow roads would be built to transport the borrow material from the deposit to haul points on the right of way. The western part of the Mackenzie Delta would have to be crossed during development in order to haul borrow material from the deposit to the pipeline right of way.

Initially the peat cover and overburden would be stripped from the area to be excavated, and stockpiled around the edge of the excavation away from the Mackenzie Delta.

Development of this deposit would involve excavating borrow material evenly so that drainage would be established over the deposit. Alternatively, dugout pit development could be established. Either type of development could be accomplished by blasting or conventional earth-moving techniques depending on site drainage and the degree of ice cementation. The excavated material might have to be stockpiled, thawed, and drained before it is used. Natural mixing during excavation would be adequate to obtain good gradations. Crushing and/or screening of the material might be required to produce quality construction aggregates. Harsh climatic conditions might also make it necessary to artificially dry the gravel to gain the quality needed for certain types of construction aggregates.

Equipment required for development would be dozers, rippers, end dump trucks, and front end loaders, as well as screening, drying, crushing, concrete, and asphalt plants, if required.

Following the removal of borrow material, the site would be recontoured to establish drainage compatible with natural drainage of the adjacent terrain. The stockpiled stripping would then be replaced. Reseeding and revegetation of the recontoured pit areas may be used to return the area to its natural conditions. The pit area and haul road would be inspected for any damage to the environment and remedial measures would be effected before the site was abandoned.

TEST HOLE LOG

LABORATORY TEST DATA
▲ Dry density (pcf) ⊙ Water content %
Plastic limit ⊢——⊣ Liquid limit
40 60 80 100 120 140 ▲
0 20 40 60 80 100 ⊙

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt	PEAT – fibrous, dark brown, moist 0.5	UF							Walmac
2	OL	SILT – (organic), trace fine sand low plastic, dark brown, mottled light brown 3.0	3 0							
4 6	ML	SILT – some fine to med. sand dark to med grey, oxidized rust pocket at 3.0', roots 1/6'' to depth 4.0' 7.5	F							
8 10 12	GW	GRAVEL – coarse, little fine to medium sand, (trace silt) pebbles to 3'' 11.0 ——— cobble, 5'' 13.5	5–10						9 12	13:23 13:26 to tricone rock bit easier drilling
14 16	GP	GRAVEL – little sand, pebbles to 1½''.	15						14	3 7/8'' Walmac

LOGGED BY: J.J.S	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°39'17''N, 136°06'58''W	ELEVATION:	
DRWN. BY: J.M.B.	AIRPHOTO No. A 13470-43	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 0°C	
	METHOD: AIR		CANADIAN ARCTIC GAS STUDY LIMITED

START: D 07 M 08 Y 75 TIME: 13:15 FINISH: D 07 M 08 Y 75 TIME: 14:40

TEST HOLE No. N75-117A-B14-A

SHEET 1 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B14-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	GP		(gravel) cont'd 17.0		F							17	3 7/8'' Tricone (Walmac completely worn)
18	GW		**GRAVEL**- coarse to fine, little medium to coarse sand, pebbles to 3'', occas. cobble (yellow-orange)										
20			21.0										
22	ML		**SILT**- little fine to med. sand, medium grey (trace clay) 23.0									23	14:09 Walmac 14:15
24	SM ?		**SAND** - silty with ICE approx. 85% ice, possible lenses of ice to 1/8'' at approx. 1/8'' spacing		(Vs) 85							24	14:27
26													
28			28.0 — decreasing ice content		50							28	14:25 cuttings flat, 1/8'' 14:29 circular, stem sticking on withdrawal
30			hard ice										
32												32	

LOGGED BY: J J S	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION	TEST HOLE No.
CHKD: D.O.	LAT. & LONG: 68°39'17''N, 136°06'58''W	ELEVATION:		
DRWN. BY: J.M.B.	AIRPHOTO No. A 13470-43	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR	N75-117A-B14-A
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP: 0°C		
	METHOD: AIR			
START: D 07 M 08 Y 75 TIME: 13:15	FINISH: D 07 M 08 Y 75 TIME: 14:40		CANADIAN ARCTIC GAS STUDY LIMITED	SHEET 2 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B14-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
32			(SAND – silty)		(Vs)							32	
			33 _ ice chips in air return possible thicker lenses										
34			34 _ _ _ _										
			(fine sand)										
36													
					20								
38												38	14:35
	SM												
40													
42													
44													
46													
48			48 0 End of hole									48	

LOGGED BY: J.J.S.	FACILITY:	PROJECT:	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°39'17''N, 136°08'58''W	ELEVATION:	
DRWN. BY: J.M.B.	AIRPHOTO No. A 13470-43	PIPE MILEAGE:	
CHKD: D.O.	RIG: HELI-DRILL	AIR TEMP.: 0°C	
	METHOD: AIR		

START: D 07 M 08 Y 75 TIME: 13:15 **FINISH:** D 07 M 08 Y 75 TIME: 14:40

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B14-A

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B14-A

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
	Pt		PEAT - black, damp, fibrous.		UF								Using shovels and pick-axe
1	GW-GM		1.0 GRAVEL - coarse to fine, subangular, and sand, coarse to fine, trace silt, grey, damp, stratified, isolated cobbles to 5'', dense.	1.4	Vx 20							1	Using jack-hammer
2												2	Occasional ice coatings (Vc)
							MA, combined samples 1 - 6 Oversize = 7.2% G = 45% S = 45% F = 10%	B1	☒				
3								B2	☒			3	
								B3	☒				borderline silty gravel, silty sand
4			4.0 — — no silt.					B4	☒			4	
5								B5	☒			5	
								B6	☒				
6			6.5 Bottom of pit									6	

LOGGED BY: J.G.R.
CHKD: R.H.
DRWN. BY: G.C.B.
CHKD: D.O.
FACILITY:
LAT. & LONG: 68°39'02''N, 136°07'12''W
AIRPHOTO No.: A 13470-43
RIG:
METHOD: TEST PIT
PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 4°C
START: D 07 M 08 Y 75 TIME: 10:30
FINISH: D 07 M 08 Y 75 TIME: 17:30

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No. N75-117A-B14-1

SHEET 1 OF 1

PC-9,SK373

TEST HOLE No. N75-117A-B14-1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
0 – 1.0	Pt	PEAT - black, damp, fibrous		UF								Using shovels
1.0 – 6.2	GW-GC	GRAVEL - coarse and fine, subrounded, and sand, coarse to fine, trace silt, light brown, damp, stratified, isolated cobbles to 5'', dense				MA, combined, samples 1 - 5 G = 61% S = 33% F = 6% (GW-GC) oversize = 2.6%	B1	☒				Clay lumps noted in combined bulk sample
							B2	☒				
							B3	☒				
4.5		no silt, no fine sand, grey					B4	☒				
5.7		trace fine sand, rusty brown					B5	☒				
6.2 – 7.3	GP	GRAVEL - fine, little sand, coarse particles only, dark grey, no silt, no cobbles										
7.3 – 8	SC	SAND - medium to fine, little clay, (trace silt), grey, damp										

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°39'17''N, 136°06'43''W	ELEVATION:	
DRWN. BY: F.B.	AIRPHOTO No.: A 13470-43	PIPE MILEAGE:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
CHKD: D.O.	RIG:	AIR TEMP.: 4.5°C	
	METHOD: TEST PIT (EXPOSURE)		CANADIAN ARCTIC GAS STUDY LIMITED
START: D 07 M 08 Y 75 TIME: 10:30	FINISH: D 07 M 08 Y 75 TIME: 15:45		

TEST HOLE No.

N75-117A-B14-2

SHEET 1 OF 3

PC-9,SK373

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
8	SC	▨	SAND (cont'd) stratified, firm		UF								Using shovels
9.3	SP	▒	SAND - fine, trace silt, nonplastic, dark grey, damp, dense										
9.5		▒	SAND - medium to fine, light brown, damp, stratified, isolated fine gravel, dense										
12.7	GW	⁘	GRAVEL - coarse and fine, subrounded, and sand, coarse to fine, trace silt, nonplastic, light brown, damp, dense										
14.0	SP	▒	SAND - medium, light brown, damp, stratified, dense										
16													

LOGGED BY: J.G.R.	FACILITY:	PROJECT: 13011	1975 BORROW INVESTIGATION
CHKD: D.O.	LAT. & LONG: 68°39''17''N, 136°06'43''W	ELEVATION:	NORTHERN ENGINEERING SERVICES COMPANY LIMITED CALGARY ALBERTA ENGINEERS FOR
DRWN. BY: F.B.	AIRPHOTO No.: A 13470-43	PIPE MILEAGE:	
CHKD: D.O.	RIG:	AIR TEMP.: 4.5°C	
	METHOD: TEST PIT (EXPOSURE)		
START: D 07 M 08 Y 75 TIME: 10:30	FINISH: D 07 M 08 Y 75 TIME: 15:45		CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

N75-117A-B14-2

SHEET 2 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B14-2

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ⊙ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ⊙	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
16	SP		SAND (cont'd) 17.0		UF								Using shovels
17	GW		GRAVEL - coarse and fine, subrounded, and sand, coarse to fine, light brown, damp, stratified, isolated cobbles to 4'', dense 18.0										
18	SC		SAND - medium to fine, little silt; trace gravel, fine, subrounded; nonplastic grey, damp, stratified, dense										
19													
20			20.0 Bottom of pit										

LOGGED BY: J.G.R.
CHKD: D.O.
DRWN. BY: F.B.
CHKD: D.O.

FACILITY:
LAT. & LONG: $68^{0}39'17''$N, $136^{0}06'43''$W
AIRPHOTO No.: A 13470-43
RIG:
METHOD: TEST PIT (EXPOSURE)

PROJECT: 13011
ELEVATION:
PIPE MILEAGE:
AIR TEMP: 4.5^{0}C

START: D 07 M 08 Y 75 TIME: 10:30
FINISH: D 07 M 08 Y 75 TIME: 15:45

1975 BORROW INVESTIGATION

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
N75-117A-B14-2

SHEET 3 OF 3

PC-9,SK373

TEST HOLE No. N75-117A-B14-2

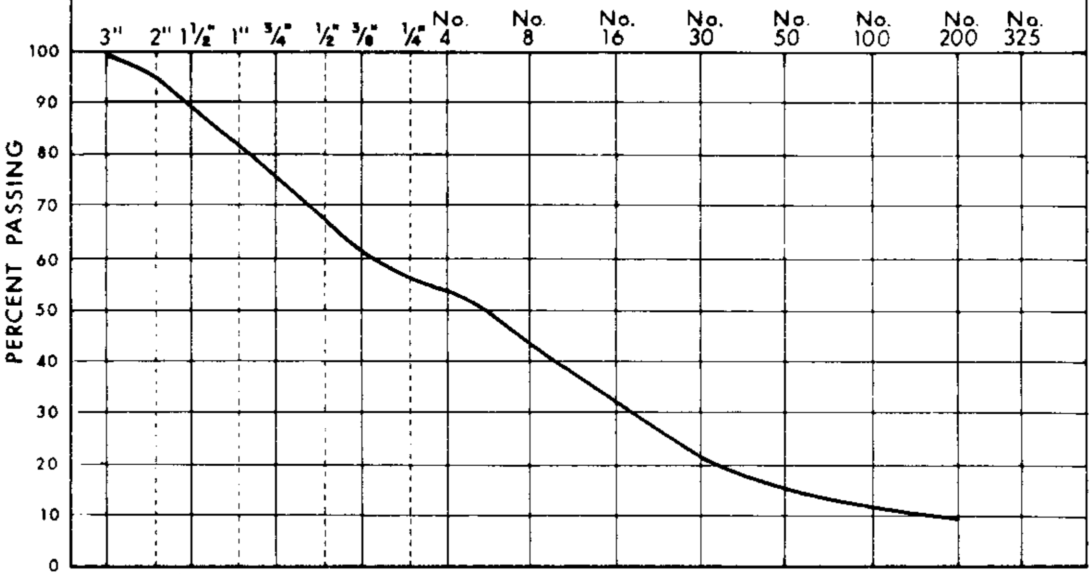
SIEVE ANALYSIS REPORT

SAMPLE N75-117A-B14-1 DEPTH 1.0 - 6.0

DATE SAMPLED August 7, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 100

GRAVEL SIZES		SAND SIZES			FINES
24 %	21 %	14 %	22 %	9 %	10 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	96.2
1½"	89.9
1"	82.1
¾"	76.3
½"	68.2
⅜"	61.8
¼"	
No. 4	54.8
No. 8	43.4
No. 16	32.8
No. 30	22.1
No. 50	16.4
No. 100	12.5
No. 200	9.5

COMMENTS

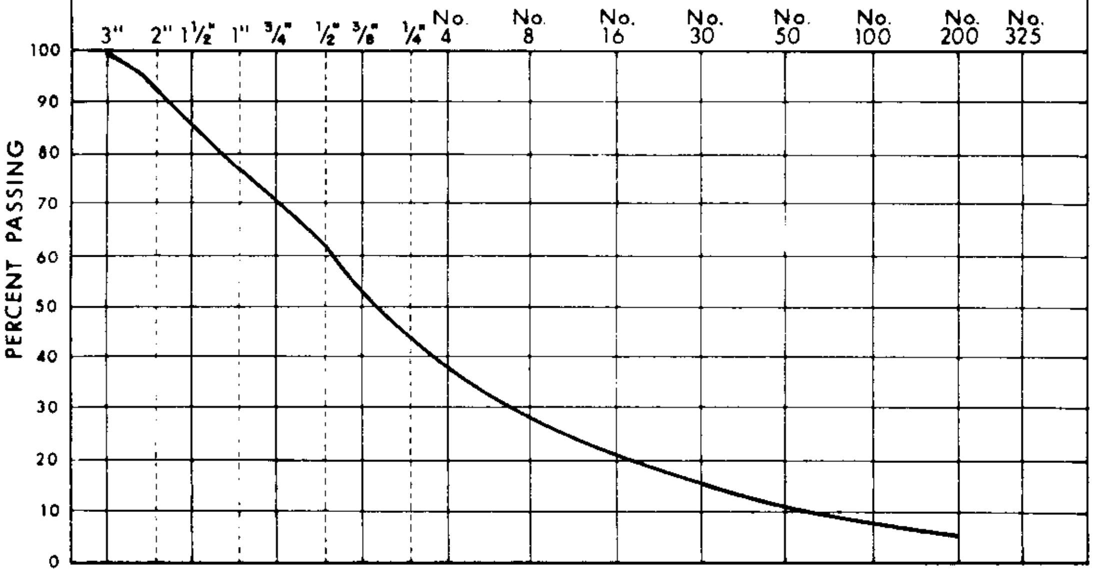
OVERSIZE (>3") = 7.2%

SAMPLE N75-117A-B14-2 DEPTH 1.0 - 7.0

DATE SAMPLED August 7, 1975 SAMPLED BY NESCL

R.M.HARDY REPORT NUMBER 6

GRAVEL SIZES		SAND SIZES			FINES
30 %	31 %	11 %	15 %	7 %	6 %
COARSE	FINE	COARSE	MEDIUM	FINE	



SIEVE SIZE	PERCENT PASSING
3"	100.0
2"	92.8
1½"	86.9
1"	77.2
¾"	70.3
½"	61.8
⅜"	53.7
¼"	
No. 4	38.7
No. 8	29.2
No. 16	22.4
No. 30	16.7
No. 50	11.4
No. 100	7.9
No. 200	5.7

COMMENTS

OVERSIZE (>3") = 2.6%

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & TESTING

NORTHERN
Engineering Services Company Limited

DEPOSIT No.
N75-117A-B14

PAGE
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SUMMARY OF LABORATORY TEST DATA
FOR
SUITABILITY OF AGGREGATES IN CONCRETE

SAMPLE No.N75-117A-B14-2 DATE SAMPLED : August 7, 1975 SAMPLED BY : NESCL
DEPTH (FT.) : 1 - 6.5 DATE TESTED : December, 1975 TESTED BY : RMHA

SOUNDNESS OF AGGREGATE SULPHATE TEST

COARSE AGGREGATE : LOSS = 15.5 %
FINE AGGREGATE : LOSS = 17.83 %

LOS ANGELES ABRASION TEST

PERCENT LOSS = 30.9 %

ORGANIC IMPURITIES TEST

NUMBER : 3+
COAL REMOVED : 3
COAL & ROOTLETS REMOVED : 3
COAL CONTENT : Trace
SIGNIFICANCE :

SUMMARY OF ROCK TYPES, COARSE AGGREGATE. (PETROGRAPHIC ANALYSIS)

ROCK TYPE	CLASSIFICATIONS	TOTAL WEIGHTED COMPONENT %
Quartzite	Very strong, Good	17.5
Granite		0.5
Sandstone	Medium strong, Good	17.4
Siltstone		18.5
Pyrrhotite		1.0
Limestone		0.3
Chert	Potentially reactive, Fair	0.75
Flint		2.5
Friable Sandstone	Weak, Poor	3.9
Ironstone		0.1
Clay Lumps		0.2
PN = 144	INTERPRETATION : Poor quality	62.3

COMMENTS :

NORTHERN Engineering Services Company Limited

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DEPOSIT No. N75-117A-B14

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APPENDIX A

Terms and Symbols

APPENDIX A - EXPLANATION OF TERMS AND SYMBOLS

1. General

The terms and symbols used on the test hole logs to summarize the results of the field investigation and of subsequent laboratory testing are described in detail below and are illustrated in the appended exhibit test hole log (Plate 1).

General information, such as test hole number, test hole location, and rig type is noted in the lower portion of the test hole log. Detailed sub-surface information observed at each test hole location and laboratory test data, are presented in columnar form on the test hole log. Each column used is described in detail below using the reference numbers shown on the appended blank test hole log (Plate 2).

It should be noted that the soil type, stratigraphic boundaries, and in situ conditions have been established only at the test hole location and that they are not necessarily representative of subsurface conditions elsewhere across the site.

Columns 1 and 13: Depth: The depth of test hole below existing ground surface is shown in these columns.

Column 2: Soil Group Symbol: A soil classification symbol in accordance with a modification of the Unified Soil Classification System[1] is noted in this column. A definition of each Group Symbol is given in Table 1 "Soil Classification System".

Column 3: Soil Graphic Log: Soil strata are depicted graphically in accordance with the "Graphic Symbol" column of Table 1 "Soil Classification System".

---

(1) References are listed on page A-17.

Column 4: Description: A detailed engineering description of each soil stratum encountered is noted in this column. This description is given in accordance with the criteria outlined in Section 2.3 "Soil Description". A description of the ground ice is included in this column according to the NRC procedures[2] which are explained in Section 2.4 "NRC Ice Type". The depths to ground water level, seepage, and the interface between different soil strata are indicated in this column. The interface between soil strata is shown as a single continuous line. A broken line indicates a change in soil type where the location of the interface between the strata is uncertain or inferred. A double line at the bottom of the test hole log indicates "Refusal" which may be defined as "further penetration was not possible with the equipment used".

Column 5: Ice Graphic Log: The various types of ground ice are depicted graphically according to Table 2 "Ground Ice Classification".

Column 6: NRC Ice Type: (Visual Ice %): Abbreviated symbols for the forms of ground ice are noted in this column. A description of the NRC classification[2] is contained in Section 2.4 "NRC Ice Type", and in Table 2 "Ground Ice Classification". The volume of ground ice is estimated visually and expressed as a percentage of the total volume of soil and ice.

Column 7: Laboratory Test Data: The results of laboratory determinations of water content, Atterberg limits and dry density are plotted against depth. These are described in Section 2.5 "Test Data Summary".

Column 8:	Other Test Data: Test data additional to those represented in Column 7 are noted in this column at the appropriate depth. The symbols used to represent the more common engineering laboratory tests are given in Section 2.5 "Test Data Summary". The results of specialized testing are also indicated in this column using an abbreviated written form.
Column 9:	Sample Type and Number: The type and reference number of each sample attempted, whether it was recovered or lost, are recorded at the appropriate depth. The system used is described in Section 2.1 "Soil Sample Data".
Column 10:	Sample Condition: The condition of each sample, whether it was recovered or lost, is recorded against depth. A description of the graphic representation and abbreviations used is given in Section 2.1 "Soil Sample Data".
Column 11:	Core Run and % Recovery: The length of core recovered is expressed as a percentage of the total length attempted. The depths to the top and bottom of the core run are recorded as described in Section 2.2 "Core Data".
Column 12:	Core Condition: The condition of the core, or segments of the core, is assessed visually and assigned a rating of I to V. The ratings and nomenclature used are given in Section 2.2 "Core Data".

Column 14: <u>Remarks:</u> Additional pertinent information and comments such as in situ drilling conditions, sampling criteria, and instruments installed are noted in this column.

2. Description Details

The various terms, symbols, and abbreviations are discussed in detail to facilitate interpretation and understanding of the data presented on the test hole logs.

2.1 Soil Sample Data

(a) Sample Type and Number (Column 9)

Each sample attempted, whether it is recovered or lost, is assigned a reference number. The series of soil samples from each test hole is numbered in a sequentially increasing numerical order with increasing depth below ground surface.

The type of sample attempted is indicated using one of the following letters:

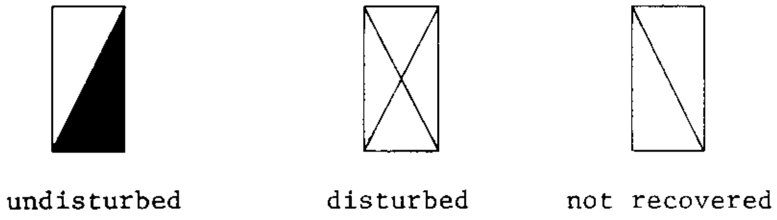
A	Auger sample
B	Bulk sample
C	Core sample
D	Drive sample (thick-walled tube, unless otherwise noted)
P	Pitcher tube sample
R	Block sample
S	Split spoon standard penetrometer sample
U	Tube sample (thin-walled unless otherwise noted)
W	Wash or Air Return sample
X	Other samples

The sample type and number are recorded at the appropriate depth on the test hole log.

Example: Sample A2: - designates the second sample attempted in the test hole. This sample was taken off an auger.

(B) Sample Condition (Column 10)

The condition of each sample attempted is designated by one of the following symbols at the appropriate depth interval:



2.2 Core Data

The details relating to length of core attempted and the percentage of core recovered are presented as follows:

(a) Core Run and % Recovery (Column 11)

The length of core attempted is shown by recording the top and bottom depth measurements for each core run. The recovered core length is expressed as a percentage of the total core run attempted.

(b) Core Condition (Column 12)

The condition of each core, or segments of core recovered, together with any unrecovered portions of the core, are recorded. The nomenclature in the following table is used to describe the conditions of the core:

Condition of Soil Cores

Rating	Recovered Condition	Disturbance or Remolding	Suitability For Testing
I	Excellent	Negligible	Representative
II	Good	Slight	Representative
III	Fair	Considerable	Use Judgment
IV	Poor	Complete	Equivalent to Disturbed Samples
V	No recovery	-	-

2.3 Soil Description (Column 4)

Soils are classified and described according to their engineering properties and behaviour.

2.3.1 Soil Description System

The following properties are described for a comprehensive soil classification system:

> Grain size distribution or plasticity, colour, moisture, sensitivity, structure, foreign materials, and consistency or strength.

The soil in each stratum is described on the test hole logs using the Unified Soil Classification System[1] modified slightly so that an inorganic clay of "medium plasticity" is recognized. Selected adjectives are used to define the actual or estimated percentage range by weight of the various components. The use of the modifying adjectives is similar to a system developed by D.M. Burmister[3].

The identification of soil components and fractions is defined by the Modified Unified Soil Classification System which classifies soils into three major divisions:

Coarse-grained soils	-	gravel and sand
Fine-grained soils	-	silt and clay
Highly organic soils	-	peat

Classification of soils is based on the grain size distribution of that portion of the soil smaller than the 3-inch U.S. Standard sieve size.

Soils with 50 percent or more of the components coarser than the No. 200 U.S. Standard sieve size (0.074 mm) are described as COARSE-GRAINED (or granular) soils. Coarse-grained soils (gravel and sand) are classified by grain size distribution and are subdivided into coarse and fine gravel, and coarse, medium, and fine sand.

Soils with 50 percent or more of the components finer than the No. 200 sieve size are described as FINE-GRAINED soils. These may be cohesive or non-cohesive. Note that for visual classification the No. 200 sieve size is about the smallest size of particle that can be distinguished individually by the unaided eye.

Fine-grained soils (silt and clay) are classified by behaviour on the basis of the liquid limit and plasticity index of the fraction finer than the No. 40 U.S. Standard sieve size. The boundaries defining the fine-grained soil groups are shown on the Plasticity Chart in Table 1 "Soil Classification System". The Plasticity Chart is also used to determine the behaviour of the fines content of coarse-grained soils.

Particle size and shape are usually described for coarse-grained soils, and plasticity is usually described for fine-grained soils. An exception to this rule applies when describing glacial till, then plasticity, particle size, and shape are all included in the description.

The principal component of the fraction of the soil passing the 3-inch U.S. Standard sieve size is shown capitalized on the test hole logs.

The proportions by weight of the minor components are defined according to the following descriptors:

Descriptor	Proportion
"and"	50 to 35 percent
"some"	35 to 20 percent
"little"	20 to 10 percent
"trace"	10 to 1 percent

The descriptors used must not contradict the classification by the Modified Unified Soil Classification System.

The terms given above are used to define proportions by weight of granular components, but they may also be used to define the proportion of minor components of fine-grained material, according to the subdivisions of the Plasticity Chart, Table 1 "Soil Classification System". The adjectives are not used to subdivide a principal fine-grained component. The modifier "y" or "ey" (i.e. SILT, clayey) is used when the liquid limit and plasticity index plot close to the "A-line" on the Plasticity Chart.

Peat and other highly organic soils are classified under the Group Symbol "Pt". Peat may be categorized and described using the Radforth Classification System.[4]

The soil is described first by identifying the principal component, followed by the minor components in order of decreasing proportion by weight. This is followed by other signficant identifying features such as plasticity, colour, moisture, structure, and strength.

2.3.2 Typical Example of a Complete Soil Description

"CLAY, silty, little medium sand, trace coarse gravel, medium plasticity, yellow-brown", describes a yellow-brown fine-grained silty clay soil containing 50 percent or more of components finer than the No. 200 U.S. Standard sieve size with minor components of sand and gravel. The fraction passing the No. 40 U.S. Standard sieve size plots above, and close to the "A-line" on the Plasticity Chart. The soil contains between 10 percent and 20 percent of sand particles generally in the size range No. 10 to No. 40 (i.e. finer than the No. 10 Standard sieve size and larger than the No. 40 Standard sieve size) and between 1 percent and 10 percent of gravel in the size range 3/4 inch to 3 inch. The identifying feature "medium plasticity" indicates that the liquid limit plots between 30 and 50 on the Plasticity Chart. Such a soil is classified as CI by the Modified Unified Soil Classification System.

2.3.3 Typical Examples of the Use of Modifiers and Descriptors

(a) Fine-grained soil with a minor coarse-grained component:

"CLAY, silty, some fine sand", describes a fine-grained soil having a fines content in excess of 50 percent (i.e. 50% of material finer than the No. 200 U.S. Standard sieve size), which plots above the "A-line", on the Plasticity Chart, with a liquid limit less than 50 on the Plasticity Chart, and has a minor component of fine sand.

"CLAY, some silt, some fine sand", would not be used as the fines are classified by behaviour (plasticity) and not by particle size. Such a soil would be classified as CI or CL according to the Unified Soil Classification System.

(b) Coarse-grained soil with minor fine-grained component:

"GRAVEL, fine, some silty clay", describes a coarse-grained soil with a minor component of fines, which has a liquid limit and plasticity index that plot above and close to the "A-line" on the Plasticity Chart. Such a soil is classified as GC by the Unified Soil Classification System.

"SAND, some silt," is correct in that "silt" in this case is a minor component of non-plastic fines which plot below the A-line on the Plasticity Chart.

2.3.4 Glacial Till

The term "glacial till" is in widespread use in present engineering practice, however, because it is a mode of deposition, there is no provision in the Unified Soil Classification System for this term.

The term "till" is used on the test hole logs in its most general form, which has been defined by ASTM Designation D 653 as:

> "A material deposited by glaciation, usually composed of a wide range of particle sizes, which has not been subjected to the sorting action of water."[5]

Glacial till is described on the test hole logs as "TILL", followed by the principal soil component also capitalized.

Example: "TILL, CLAY, silty, little fine gravel, low plastic, rust-brown--".

A loose, soft, or slightly stratified deposit believed to be transported or reworked material of glacial deposition, or of uncertain glacial origin, is described as "till-like" at the end of the soil description.

Example: "CLAY, silty,little fine gravel, low plastic, rust-brown, till-like."

2.3.5 Fill

"Fill" is material placed by artificial means, whether or not its placement was controlled.

It is described on the test hole logs as "FILL", followed by the principal soil component also capitalized.

Example: "FILL, SILT, clayey, some fine gravel".

Well-compacted fill, placed some considerable time before the test hole investigation, may be difficult to distinguish from natural material unless the history of the site is known. Such material is indicated as "FILL?" on the test hole logs.

2.4 NRC Ice Type and Estimated Visual Ice (Column 6)

Ground ice is divided by the NRC system on the basis of examination by the unaided eye into the three major categories shown below. A complete description of this system is contained in the NRC "Guide to a Field Description of Permafrost for Engineering Purposes".[2]

2.4.1 Ground Ice Classification Categories

Non-visible ice	N
Visible ice less than one inch thick	V
Visible ice greater than one inch thick	ICE or ICE + soil type

Table 2 "Ground Ice Classification" shows the various types of ground ice recognized by the NRC classification system. Graphic symbols for ground ice have been devised to complement the graphic soil log.

Frozen soils in the N group may, on close examination, indicate presence of ice within the voids of the material by crystalline reflections or by a sheen on fractured or trimmed surfaces. The impression received by the unaided eye, however, is that the ice does not occupy space in excess of the original voids in the soil. Excess ice in the N group can be identified by use of a hand magnifying lens, or by placing some frozen soil in a small jar, allowing it to melt and observing the supernatant water. To the unaided eye, ice in frozen soils in the V group appears to occupy space in excess of the original voids in the soils.

The volume of ground ice can be described quantitatively in two ways. "Excess ice" is the volume of supernatant water expressed as a percentage of the total volume of the thawed soil and water. This quantity is often referred to as "excess moisture". "Visual ice" is the estimated volume of segregated ice discernible by eye in the frozen sample and is expressed as a percentage of the total volume of the frozen soil. By these definitions the quantity "excess ice" and "visual ice" are not necessarily the same for a given frozen soil. Care is taken when estimating the volume of ice coatings on granular material (Vc). The ice is usually obvious, giving the impression of "excess ice", which may not necessarily be the case.

2.4.2 Ice Description Terminology

The following terminology used in Column 4 "Description" has been generally taken from Table II of the NRC Guide.[2]

"Ice Coatings on Particles" are discernible layers of ice found on or below the larger soil particles in a frozen soil mass. They are associated sometimes with hoarfrost crystals that have grown into voids produced by the freezing action.

"Ice Crystal" is a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in combination with other ice formations.

"Clear Ice" is transparent and contains only a moderate number of air bubbles.

"Cloudy Ice" is relatively opaque due to entrained air bubbles or other reasons, but is essentially sound and non-pervious.

"Porous Ice" contains numerous voids, usually interconnected, and generally results from melting at air bubbles or along crystal interfaces, from presence of salt or other materials in the water, or from the freezing of saturated snow; though porous, the mass retains its structural unity.

"Candled Ice" is ice that has rotted or otherwise formed into long columnar crystals very loosely bonded together.

"Granular Ice" is composed of coarse, more or less equidimensional ice crystals weakly bonded together.

"Ice Lenses" are lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss and commonly in repeated layers.

"Ice Segregation" is the growth of ice as distinct lenses, layers, veins, and masses in soils, commonly but not always oriented normally to direction of heat loss.

"Well-bonded" signifies that the soil particles are strongly held together by the ice and that the frozen soil possesses relatively high resistance to chipping or breaking.

"Poorly-bonded" signifies that the soil particles are weakly held together by the ice that the frozen soil possesses poor resistance to chipping or breaking.

"Friable" denotes extremely weak bonds between soil particles. The material is easily broken up.

The symbols "UF" or "F" may be used in the Column 6. "UF" is added to indicate unfrozen zones in areas of generally frozen ground and also to avoid possible errors of omission. "F" is used in certain cases along with the corresponding graphic representation for "Undifferentiated" permafrost or frozen active layer soils. It may be used:

(i) Where temperature sensors (thermistors) have been installed which indicate that the formation temperature is below $0^{o}C$ but the material in the field has the texture of unfrozen material.

(ii) Where temperature sensors have not been installed but the soil temperature is suspected to be below $0^{o}C$. The soil is deformable because of the high unfrozen water content but is neither "friable" nor "bonded".

(iii) Where the soil is known to be frozen but, due to circumstances beyond field control, the ice type cannot be determined because of grinding or temporary thawing of the material by the drilling operation.

(iv) Where, for reasons of economy or expediency, the hole was neither logged nor sampled, e.g. where instrumentation is installed adjacent to a previous test hole and soil stratigraphy is known to an acceptable degree.

2.5 Test Data Summary

(a) Test Data (Column 7)

The results of laboratory determinations of water content, together with Atterberg limits, and dry density (dry unit weight) are plotted symbolically against depth in this column.

Water content is determined in accordance with ASTM Designation D 2216, "Standard Method of Laboratory Determination of Moisture Content of Soil".[5] The water content of highly organic material is determined by similar procedure except that the material is oven-dried to constant weight at 85°C instead of 105°C.[6]

Liquid limit and plastic limit are determined in accordance with ASTM Designations D 423 and D 424, respectively.[5]

In situ density is determined from the weights and volumes of intact samples, and is usually reported as "dry density" which is the weight of soil solids per unit volume.

(b) Other Test Data (Column 8)

Tests and test data other than, or additional to, those shown in column 7 are indicated in column 8.

The more common engineering tests are denoted using the following symbols:

γ	dry unit weight
D_{10}	grain size at 10% passing
D_{30}	grain size at 30% passing
D_{60}	grain size at 60% passing
C	consolidation
Cc	coefficient of curvature $(D_{30})^2/D_{10} \times D_{60}$
Cu	coefficient of uniformity D_{60}/D_{10}
Gs	specific gravity of soil solids
H	hydrometer analysis
k	permeability
MA	mechanical analysis (sieve analysis)
N	the penetration resistance, ie. the number of blows required for the second and third 6-inches of penetration during a Standard Penetration Test (SPT) in accordance with ASTM Designation D 1586. (see also SPT).
NP	non-plastic
OC	organic content
pp	pocket penetrometer
P200	percent passing the No. 200 sieve size
Q	triaxial test
q	unconfined compressive strength
S	shear test
SO_4	water soluble sulphate
SPT	standard penetration test (blow counts for 6-inches, 12-inches 18-inches penetration are shown sequentially)
TC	thaw consolidation
w	water content
W_L, W_P, I_P	liquid limit, plastic limit, and plasticity index respectively.

2.6 Classification of Construction Materials

Granular Material Uses - The following is a description of materials that was used within the "Materials" and "Development and Rehabilitation" selections of Individual Site Reports. Material classification has been based on the potential construction usage of the granular material for each deposit.

(1) Excellent quality material consisting of well graded, medium-grained gravel suitable for concrete aggregate, with a minimum of processing.

(2) Good-quality material generally consisting of fine to medium-grained, well graded sandy gravel with varying quantities of silt occurring either as narrow interbeds or dispersed throughout the material. The frequent occurrence of deleterious materials such as weathered stones or shale fragments may negate its use as concrete aggregate. This material will provide good quality embankment fill for pipeline berms and building pads; base course and surface aggregates; or possible production of concrete aggregate with extensive processing.

(3) Fair quality material consisting generally of poorly graded, silty, gravelly sand. This material will provide fair quality general fill.

(4) Poor quality material consisting generally of fine-grained, poorly graded silty sand with minor gravel. These deposits usually contain minimal quantities of sand and gravel, are very thin, or are overlain by extensive thicknesses of overburden. Fine-grained dune sand is included in this category. These materials are considered unsuitable for construction except as marginal fill.

(5) Bedrock consisting of:

(a) Limestone and dolomite which would be suitable for manufacturing various types of construction aggregates.

(b) Shale and siltstone with small varying quantities of limestone and dolomite which could be exploited only for fair quality general fill useful primarily in the construction of sub-grades. This category also includes talus slopes containing a mixture of limestone, dolomite and shale blocks and fragments.

2.7 Soil Drainage Classes

Drainage - The soil Drainage Classes were used in describing the drainage of each deposit that was looked at. The following set of definitions was used to determine the drainage of each site.

The following is extracted from pages 215 and 216 of National Soil Survey Committee, 1970 "The System of Soil Classification for Canada", Canada Department of Agriculture, Ottawa. The system, although devised primarily for agricultural purposes is suitable for engineering purposes and should be employed when describing soil drainage at testhole site locations. The soil drainage classes are defined in terms of:

(i) actual moisture in excess of field moisture capacity, and
(ii) the extend of the period during which such excess water is present in the plant-root zone.

Permeability, groundwater levels and seepage affect the moisture status but these are not easily observed in the field and therefore cannot generally be used as criteria for moisture status. The recommended definitions are as follows:

(1) Rapidly drained - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water conditions

(2) Well drained - The soil moisture content does not normally exceed field capacity in any horizon for a significant part of the year. ("significant" - as used in the definitions is considered in relation to plant growth)

(3) Moderately well drained - The soil moisture in excess of field capacity remains for a small but significant period of the year

(4) Imperfectly drained - The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year

(5) Poorly drained - The soil moisture in excess of field capacity remains in all horizons for a large part of the year

(6) Very poorly drained - Free water remains at or within 12 inches of the surface most of the year

Identification - commonly found morphological features associated with a particular drainage class.

Drainage Class

(1) free of any evidence of gleying (grey color, reducing conditions)
coarse texture
steep slopes

(2) free of mottling in upper 3 feet
may be mottled below 3 feet

(3) commonly mottled in the B and C horizons
or below a depth of 2 feet

(4) commonly mottled in the B and C horizons,
matrix generally has lower chroma than in the well-drained soil on similar parent material

(5) usually strongly gleyed
matrix colors of low chroma, faint mottling may occur throughout

(6) usually strongly gleyed,
subsurface horizons are of low chroma and yellowish to blueish hues,
mottling may be present at depth in the profile

Note: "Gley" - a soil usually grey or blueish in color, generally oxygen-deficient i.e. reducing conditions prevail. Low chroma are associated with ions of lower valency eg. ferrous iron, Fe^{++}, (Fe^{+++} is associated with rusty deeper colors)

Just above the zone of contact with excess field moisture and groundwater the soil may be "mottled". This is associated with a fluctuating oxidising and reducing conditions. The soil often appears to have patchy reddish zones or concretions within a blueish grey matrix.

2.8 Topography

Slopes - The topography of each deposit was described using the following table of terms in the Individual Site Reports.

Topography is described in the following terms:

Single Slopes	Complex Slopes	Slope %	Slope °
flat	flat depressional	0 - 2	0 - 1
gently sloping	undulating, smoothly rounded	2 - 5	1 - 3
moderately sloping	rolling ridgy, choppy	5 - 15	3 - 8
steeply sloping	kettled, knobby	15 - 60	8 - 31
precipitous	precipitous	> 60	> 31

"Region" is general area around the site location and is generally within 1500' of the test hole(s).

"Site" refers to the area within 100' of the test hole(s).

The degree of slope should be measured whenever possible by hand-level or inclinometer even if the site is to be surveyed accurately at a later date.

REFERENCES

1. "Unified Soil Classification System" Technical Memorandum 3-357 prepared for Office, Chief of Engineering, by Waterways Experimental Station, Vicksburg, Mississippi, Corps of Engineers, U.S. Army. Volume I, March 1953.

2. National Research Council, Canada, "Guide to a Field Description of Permafrost for Engineering Purposes", prepared by Pihlainen, J.A. and Johnston, G.H., Technical Memorandum 79, NRC 7576, Ottawa, 1963.

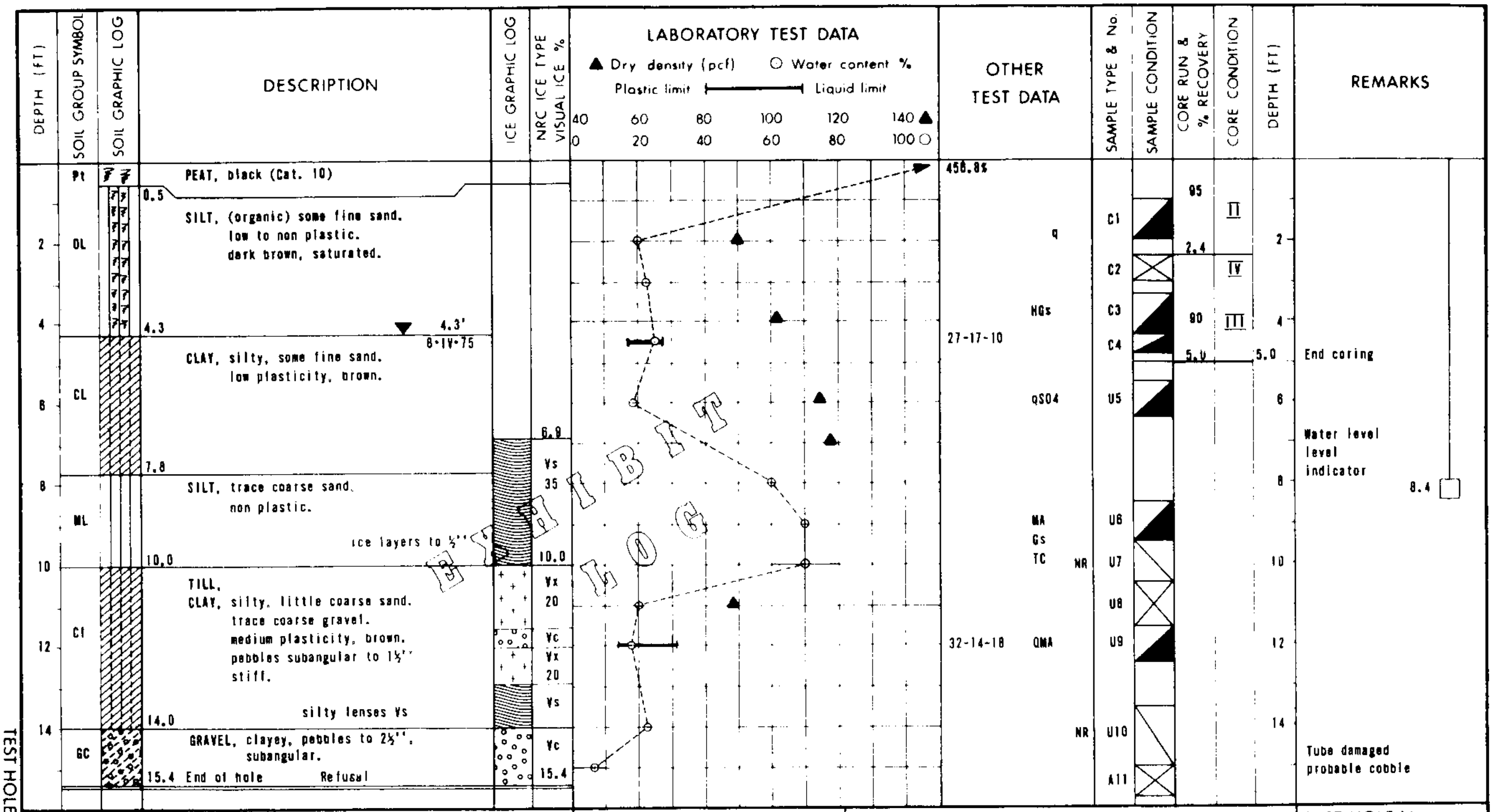
3. American Society for Testing and Materials, Procedures for Testing Soils, "Suggested Methods of Testing for Identification of Soils", Fourth Ed. pp 221-233, December 1964.

4. National Research Council, Canada "Guide to a Field Description of Muskeg", (Based on the Radforth Classification System) compiled by MacFarlane, I.C. Technical Memorandum 44 (Revised Edition) NRC 4214, Ottawa, 1958.

5. American Society for Testing and Materials, "Annual Book of Standards", (Part 19, 1974 or latest Standard) Philadelphia, Pa., U.S.A.

6. Goodman L.J. and Lee, C.N. 1962 "Laboratory and Field Data on Engineering Characteristics of Some Peat Soils", Proc. 8th Muskeg Res. Cong. NRC ACSSM Tech. Memo 74 pp 107-129.

TEST HOLE LOG



DEPTH (FT)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE %
	Pt	PEAT, black (Cat. 10)	
0.5	OL	SILT, (organic) some fine sand. low to non plastic. dark brown, saturated.	
4.3		4.3' 8·IV·75	
4.3	CL	CLAY, silty, some fine sand. low plasticity, brown.	6.9
7.8	ML	SILT, trace coarse sand. non plastic. ice layers to ½''	Vs 35
10.0	CI	TILL, CLAY, silty, little coarse sand. trace coarse gravel. medium plasticity, brown. pebbles subangular to 1½'' stiff. silty lenses Vs	10.0 Vx 20 Vc Vx 20 Vs
14.0	GC	GRAVEL, clayey, pebbles to 2½''. subangular.	Vc
15.4		End of hole Refusal	15.4

OTHER TEST DATA	SAMPLE TYPE & No.	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT)	REMARKS
456.8%					
q	C1	95	II	2	
	C2	2.4	IV		
HGs	C3	90	III	4	
27-17-10	C4	5.0		5.0	End coring
qSO4	U5			6	
				8	Water level level indicator 8.4
MA Gs	U6				
TC NR	U7			10	
	U8				
32-14-18 QMA	U9			12	
NR	U10			14	
	A11				Tube damaged probable cobble

LOGGED BY
CHKD
DRWN BY
CHKD
FACILITY
LAT & LONG
AIRPHOTO No.
RIG
METHOD
PROJECT
ELEVATION
PIPE MILEAGE
AIR TEMP
START D M Y TIME
FINISH D M Y TIME

EXHIBIT LOG

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.
102
SHEET 1 OF 1

TEST HOLE No. 102
PLATE 1

TEST HOLE LOG

DEPTH (FT.)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	ICE GRAPHIC LOG	NRC ICE TYPE VISUAL ICE %	LABORATORY TEST DATA ▲ Dry density (pcf) ○ Water content % Plastic limit ├──┤ Liquid limit 40 60 80 100 120 140 ▲ 0 20 40 60 80 100 ○	OTHER TEST DATA	SAMPLE TYPE & No.	SAMPLE CONDITION	CORE RUN & % RECOVERY	CORE CONDITION	DEPTH (FT.)	REMARKS
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭

LOGGED BY

CHKD

DRWN BY

CHKD

FACILITY

LAT & LONG

AIRPHOTO No

RIG:

METHOD:

PROJECT:

ELEVATION:

PIPE MILEAGE

AIR TEMP

START: D M Y TIME:

FINISH: D M Y TIME:

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
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ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TEST HOLE No.

SHEET OF

TEST HOLE No.
PLATE 2

SOIL CLASSIFICATION SYSTEM

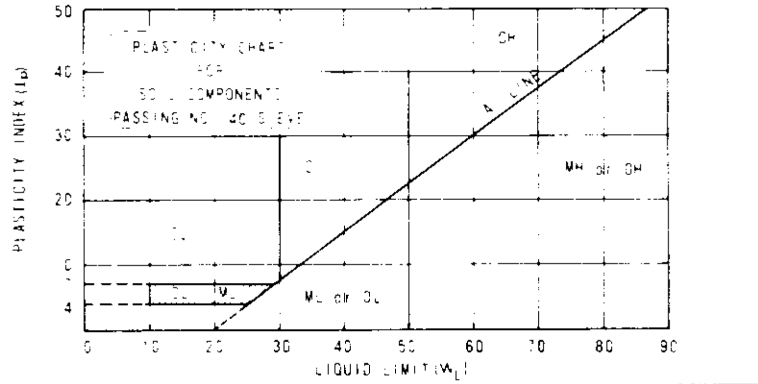
MAJOR DIVISION			GROUP SYMBOL	GRAPHIC SYMBOL	TYPICAL MATERIALS	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO 200 SIEVE)	GRAVELS MORE THAN HALF OF COARSE FRACTION LARGER THAN NO 4 SIEVE	CLEAN GRAVELS (NO APPRECIABLE FINES)	GW	○ ○ ○	WELL GRADED GRAVELS AND GRAVEL SAND MIXTURES LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP	○ ○ ○	POORLY GRADED GRAVELS AND GRAVEL SAND MIXTURES LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH FINES)	GM	○ | ○ |	SILTY GRAVELS GRAVEL SAND SILT MIXTURES	CONTENT OF FINES EXCEEDS 12	ATTERBERG LIMITS BELOW A LINE AND I_p LESS THAN 4
			GC	ø / ø /	CLAYEY GRAVELS GRAVEL SAND (SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE A LINE OR I_p MORE THAN
	SANDS MORE THAN HALF OF COARSE FRACTION SMALLER THAN NO 4 SIEVE	CLEAN SANDS (NO APPRECIABLE FINES)	SW	· · ·	WELL GRADED SANDS GRAVELLY SANDS LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP	· · ·	POORLY GRADED SANDS LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH FINES)	SM	| · | ·	SILTY SANDS SAND SILT MIXTURES	CONTENT OF FINES EXCEEDS 12	ATTERBERG LIMITS BELOW A LINE AND I_p LESS THAN 4
			SC	/ / /	CLAYEY SANDS SAND (SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE A LINE OR I_p MORE THAN 7
FINE GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES NO 200 SIEVE)	SILTS BELOW A LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50$	ML	| | |	INORGANIC SILTS AND VERY FINE SANDS ROCK FLOUR SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS ACCORDING TO PLASTICITY CHART (SEE BELOW)	
		$W_L > 50$	MH	/ | / |	INORGANIC SILTS MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE A LINE ON PLASTICITY CHART NEGLIGIBLE ORGANIC CONTENT	$W_L < 30$	CL	/ / /	INORGANIC CLAYS OF LOW PLASTICITY GRAVELLY SANDY OR SILTY CLAYS LEAN CLAYS		
		$30 < W_L < 50$	CI	/ / /	INORGANIC CLAYS OF MEDIUM PLASTICITY SILTY CLAYS		
		$W_L > 50$	CH	/ / /	INORGANIC CLAYS OF HIGH PLASTICITY FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW 'A' LINE ON CHART	$W_L < 50$	OL	₹ | ₹ |	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY		
		$W_L > 50$	OH	₹ / ₹ /	ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt	₹ ₹ ₹ ₹	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR AND OFTEN FIBROUS TEXTURE	

SOIL COMPONENTS

FRACTION	U S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
	PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL				
coarse	3 inch	3/4 inch	50 35	and
fine	3/4 inch	No 4		
SAND			35 20	some
coarse	No 4	No 10		
medium	No 10	No 40	20 10	little
fine	No 40	No 200	10 1	trace
SILT (non plastic) or CLAY (plastic)	No 200			

OVERSIZE MATERIAL

Rounded or subrounded	Not rounded
COBBLES 3 inch to 8 inch	ROCK FRAGMENTS > 3 inch
BOULDERS > 8 inch	ROCKS > 1 cubic yard in volume



1 ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U S STANDARD A S T M E 11

2 BOUNDARY CLASSIFICATIONS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN COMBINED GROUP SYMBOLS e g GW GC IS A WELL-GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5 AND 12

3 TOUGHNESS AND DRY STRENGTH INCREASE WITH INCREASING PLASTICITY INDEX WHEN COMPARING SOILS AT EQUAL LIQUID LIMIT

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ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

TABLE
1

TABLE 2

GROUND ICE CLASSIFICATION

Category	Group Symbol	Subgroup Symbol	Graphic Symbol	Description
		F	▓	Undifferentiated
Non-visible Ice	N	Nf	⁄	Poorly bonded or friable frozen soil
		Nbn	⁚	Well bonded frozen soil with no excess ice
		Nbe	∴	Well bonded frozen soil with excess ice. Free water present when sample thawed
Visible Ice less than one inch thick	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 one inch thick	ICE	ICE + soil type	▒	Ice greater than one inch thick with soil inclusions
		ICE	■	Ice greater than one inch thick without soil inclusions

Adapted from NRC 7576

APPENDIX B

Location Maps of 1975
Summer Borrow Investigations

LEGEND

●	DEPOSIT OUTLINE
96E-B1	NESCL DEPOSIT NUMBER
107B-B17 (R)	RECONNAISSANCE SITE - SOME DETAILED WORK DONE BY NESCL
Ⓡ	RECONNAISSANCE SITE - NO DETAILED WORK
200	PROPOSED GAS PIPELINE ROUTE (MARCH 1976) WITH MILE POST.

LOCATION MAPS
1975 SUMMER BORROW INVESTIGATION

THIS MAP HAS BEEN TAKEN FROM ORIGINAL PRINTED BASE MAPS PREPARED AND SUPPLIED BY THE DEPARTMENT OF MINES AND RESOURCES ONTO WHICH THE APPLICANT HAS SUPERIMPOSED THOSE INSTALLATIONS AND FACILITIES RELEVANT TO THIS APPLICATION.

MAY 1975

SCALE 1:250,000

MILES 5 0 5 10 15 20

KILOMETRES 5 0 5 10 15 20 25 30

DESIGNED BY:
CHECKED BY:
APPROVED BY:
PROJ. MANAGER:

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
CALGARY ALBERTA
ENGINEERS FOR
CANADIAN ARCTIC GAS STUDY LIMITED

REVISED:
DATE:
PROJ. NO.: 13011
DWG. NO.: 1K-0211-1001

LEGEND

●	DEPOSIT OUTLINE
96E-B1	NESCL DEPOSIT NUMBER
107B-B17 (R)	RECONNAISSANCE SITE - SOME DETAILED WORK DONE BY NESCL
Ⓡ	RECONNAISSANCE SITE - NO DETAILED WORK
200	PROPOSED GAS PIPELINE ROUTE (MARCH 1976) WITH MILE POST.

THIS MAP HAS BEEN TAKEN FROM ORIGINAL PRINTED BASE MAPS PREPARED AND SUPPLIED BY THE DEPARTMENT OF MINES AND RESOURCES ONTO WHICH THE APPLICANT HAS SUPERIMPOSED THOSE INSTALLATIONS AND FACILITIES RELEVANT TO THIS APPLICATION.

MAY 1975

SCALE 1:250,000

5 0 5 MILES 10 15 20

5 0 5 10 15 20 25 30
KILOMETRES

LOCATION MAPS
1975 SUMMER BORROW INVESTIGATION

DESIGNED BY:
CHECKED BY:
APPROVED BY:
PROJ. MANAGER:

NORTHERN ENGINEERING SERVICES COMPANY LIMITED
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REVISED:
DATE:
PROJ. NO.: 13011
DWG. NO.: 3A-0211-1004

APPENDIX C

List of Scientific Names for Biological Species

Appendix C. List of scientific names of biological species.

VEGETATION

Common Name	Scientific Name*
Cotton grass	*Eriophorum vaginatum spp. spissum* *Eriophorum angustifolium spp. subarcticum*
Mountain avens	*Dryas integrifolia*
Dwarf birch	*Betula nana*
Pussytoe	*Antennaria friesiana spp. alaskana*
Alpine bearberry	*Arctostaphylos rubra*
Green alder	*Alnus crispa*

*Hulten, E. 1968. Flora of Alaska and Neighboring Territories.

MAMMALS

Common Name	Scientific Name*
Barren ground caribou	*Rangifer tarandus granti*
Moose	*Alces alces*
Arctic fox	*Alopex lagopus*
Grizzly bear	*Ursus arctos*
Wolf	*Canis lupus*
Red fox	*Vulpes vulpes*
Wolverine	*Gulo gulo*
Arctic ground squirrel	*Spermophilus parryii*

*Banfield, A.W.F. 1974. The Mammals of Canada.

BIRDS

Common Name	Scientific Name*
Ptarmigan	*Lagopus lagopus* *Lagopus mutus*
Gryfalcon	*Falco rusticolus*
Black Brant	*Branta bernicla nigricans*
Swan	*Olor columbianus* *Olor buccinator*
Pintail	*Anas acuta*
Oldsquaw	*Clangula hyemalis*
Lapland longspur	*Calcarius lapponicus*
Jaegers	*Stercorarius parasiticus* *Stercorarius longicaudus* *Stercorarius pomarinus*
Plovers	*Charadrius semipalmatus* *Pluvialis dominica*
Snow goose	*Chen caerulescens*
Bald eagle	*Haliaeetus leucocephalus*
Golden eagle	*Aquila chrysaetos*

*Godfrey, W.E. 1966. The Birds of Canada.

FISH

Common Name	Scientific Name*
Arctic char	*Salvelinus alpinus*
Arctic grayling	*Thymallus arcticus*
Whitefish	*Prosepium cylindraceum* *Coregonus clupeaformis* *Coregonus nasus*

*Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada

Common Name	Scientific Name
Cisco	*Coregonus autumnalis* *Coregonus sardinella* *Coregonus artedii*